



Drowning Deaths: A Literature Review

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ABSTRACT

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Background: The process of drowning begins with respiratory distress either because a person's airway is below the surface of the liquid (submersion) or the water only covers the face (immersion) (Putra, 2020). In a body submerged in water and suspected of having died from drowning, it is necessary to determine whether the victim was still alive at the time of the drowning. The probability was marked by intravital signs, whether there were other signs of violence or the cause of death. All these things can be determined through an external and internal body examination of the corpse and are supported by supporting examinations. With this series of examinations, the diagnosis of drowning can be established, and the cause and mechanism of death of the bodies found can be estimated. Doctors in forensic medicine have an important role in cases of drowning deaths, such as in helping to identify victims and determine the cause of death. (Armstrong & Erskine, 2018).

Objective: This report aims to learn more about drowning deaths, the classification, the pathophysiology of drowning deaths, and the process of investigating drowning deaths.

Conclusion: Drowning is asphyxia that prevents air entry into the lungs by inhaling fluid into the airways, i.e., nose and mouth. Cases of drowning death are caused by irreversible brain damage in the development of irreversible cerebral anoxia and hypoxia. There are two classifications of drowning, namely Dry Drowning and Wet Drowning. Doctors in the field of forensic medicine have an important role in cases of drowning deaths, such as in helping efforts to identify victims and determine the cause of death. The investigation process includes Pre-Autopsy Preparation and Interest in Victim History, External Findings, Internal Meetings, and Special Tests.

Introduction

Drowning is asphyxia that prevents the entry of air into the lungs through the inhalation of fluids into the airways, namely, the nose and mouth (Chaudary & Dhingra, 2021; WHO, 2021). The process

of drowning begins with respiratory distress either because a person's airway is below the surface of the liquid (submersion) or the water only covers the face (immersion) (Putra, 2020). In drowning cases, death is caused by irreversible brain damage in the

development of irreversible cerebral anoxia and hypoxia. Only a systematic examination and a complete autopsy can determine death as a symptom of drowning asphyxia (Chaudary & Dhingra, 2021).

In a body submerged in water and suspected of having died from drowning, it is necessary to determine whether the victim was still alive at the time of the drowning. The probability was marked by intravital signs, whether there were other signs of violence or the cause of death. All these things can be determined through an external and internal body examination of the corpse and are supported by supporting examinations. With this series of examinations, the diagnosis of drowning can be established, and the cause and mechanism of death of the bodies found can be estimated. Doctors in forensic medicine have an important role in cases of drowning deaths, such as in helping to identify victims and determine the cause of death. (Armstrong & Erskine, 2018).

Objective

This report aims to learn more about drowning deaths, the classification, the pathophysiology of drowning deaths, and the process of investigating drowning deaths.

Discussion

1. Definition

Drowning is defined as an influx of sufficient fluid that is not required. The latest definition adopted by the World Health Organization (WHO) in 2002 states that drowning is a process of respiratory distress due to submersion or immersion in liquid. The process of drowning begins with respiratory distress either because a person's airway is below the surface of the liquid (submersion) or the water only covers the face (immersion) (Szpilman, 2016).

2. Classification

a. Dry Drowning

In this type, the victim does not die from swallowing or inhaling large amounts of water causing obstruction, but death due to laryngeal spasm, immersion syndrome, and submersion due to unconsciousness, called shallow water drowning.

1) Immersion Syndrom/Vagal Inhibition

In this type of drowning, death is not caused by drowning but is caused by cardiac arrest due to vagal inhibition. The sudden contact with cold water on body surfaces, stimulates nerve endings and causes vagal inhibition. Especially the

epigastrium, ears, nasal hairs, larynx, pharynx,

2) Laryngeal Spasm

Water that suddenly enters the larynx can stimulate the occurrence of laryngeal spasm, which aims to inhibit the water to enter the respiratory tract, and death occurs because of asphyxia; after some time after death, water can enter the respiratory tract (lungs).

3) Shallow Water Drowning

The drowning occurred in a small pool of water where the depth was only a few centimeters but deep enough to drown the mouth and nose hairs. This occurrence often occurs in young children and people with disabilities such as epilepsy or coma due to head injury, etc.

b. Wet Drowning

Wet drowning occurs because water is swallowed and inhaled, so the respiratory tract is closed and filled with water. Wet drowning is the most common type of drowning. It mainly occurs in freshwater or salt water.

3. PATHOPHYSIOLOGY

a. Mechanism

The mechanism of death in drowning victims can be asphyxia due to laryngeal spasm, asphyxia due to

gagging and choking, vagal reflexes, ventricular fibrillation (freshwater), and pulmonary edema (in salt water) (Forensic Medicine, 2012).

1) Vagal Reflex

The death occurred very quickly, and on post-mortem examination, there were no signs of asphyxia or water in the lungs, so it was often called dry drowning.

2) Laryngeal Spasms

Death from laryngeal spasm in drowning is infrequent. A laryngeal spasm is caused by the stimulation of water entering the larynx. On post-mortem examination, there were signs of asphyxia, but the lungs were not found to contain water or water objects.

3) The effect of water entering the lungs

Hypoxia and acidosis and the multiorgan effects of these processes contribute to the morbidity and mortality of drowning. Central nervous system damage may result from hypoxemia resulting from drowning (primary damage), arrhythmias, pulmonary disorders, or multiorgan dysfunction.

The event of drowning in freshwater will cause anoxia accompanied by

electrolyte disturbances. The fluid that is aspirated and lodged in the lungs produces vagus-mediated vasoconstriction and hypertension. Freshwater moves faster from the capillary-alveoli membrane to the microcirculation. This will result in hemodilution and hemolysis. With the breakdown of electrolytes, the intracellular potassium ions will be released, causing hyperkalemia which will affect the work of the heart (ventricular fibrillation occurs). A post-mortem examination found signs of asphyxia; the right heart's NaCl level was higher than the left heart, and the presence of foam and water objects in the lungs. In addition, freshwater tends to be more hypotonic than the plasma and causes alveolar surfactant disturbance. This will lead to alveolar instability, atelectasis, and decreased lung compliance (Forensic Medicine, 2012; Hussein, 2019).

The event of drowning in salt water will result in anoxia and hemoconcentration. Water will be drawn from the pulmonary circulation into the interstitial lung tissue, which will cause pulmonary edema, hemoconcentration, and hypovolemia—no electrolyte disturbances. On post-mortem examination, there were signs of asphyxia, NaCl levels in the left heart were higher than in the right heart, and foam and watery bodies were found. Death from drowning in salt water is slower than drowning in fresh water. Saltwater, which is

hyperosmolar, will draw fluid into the alveoli and cause dilution of the surfactant. The protein-rich fluid exudes rapidly into the alveoli and the pulmonary interstitium. This causes reduced lung compliance, the capillary-alveolar membrane is damaged, and fluid transfer occurs, resulting in hypoxia (Forensic Medicine, 2012).

b. Wet Drowning

In wet drowning, where the inhalation of liquid occurs, it is known that the victim is holding his breath. Due to increased CO₂ and decreased O₂ levels, gasping and regurgitation, and aspiration of gastric contents may occur. Reflex laryngospasm followed by an influx of water will appear. Then the victim loses consciousness, and apnea occurs. The patient will then gasp again for a few minutes, and even the patient can have seizures. Patients can then end up with a respiratory and cardiac arrest.

c. Dry Drowning

This death usually occurs very suddenly and shows no signs of resistance. The exact mechanism of death remains speculative. The sudden entry of fluids can cause two types of death mechanisms;

- 1) Laryngospasm, which will cause asphyxia and death.
- 2) Activate the parasympathetic nervous system so that a vagal reflex occurs, resulting in cardiac arrest.

Several factors predispose to death due to dry drowning:

- 1) Alcohol intoxication (depresses cortical activity)
- 2) Pre-existing disease, such as atherosclerosis
- 3) Unexpected/ sudden drowning/ submersion

Fear or excessive physical activity increases circulating catecholamines, accompanied by a lack of oxygen, which can lead to cardiac arrest.

4. INVESTIGATION PROCESS

a. Pre-Autopsy Preparation and Importance of Victim History

In the case of death due to drowning, in addition to information obtained from the autopsy results, examination of the crime scene (TKP), investigation of the patient's history before death, and pre-autopsy preparation play an essential role in concluding the cause of death. Dr. Joseph H. Davis proposed an equation called the "sink equation" where drowning is a constant (and a result), while human and factor of environment are variables. From this equation emerge questions that can guide the course of the investigation, which include Was the victim alive or dead before entering the water? Did the victim drown? Why and how did the victim enter the water? Why

can't the victim survive in the water? (Armstrong & Erskine, 2018).

The crime scene investigation and history taking before the victim dies consists of several components—first, an investigation of the location and condition of the water. A corpse found on the beach can raise various questions, whether the corpse was stranded? Was the body moved from another location? Did the corpse initially faint and then die near the water due to some cause? Another example could be a corpse found in a bathroom tub; questions that might arise include Was the death caused by a severe illness, was it caused by drowning, or drowning with other factors such as alcohol or drug intoxication? Drowning can occur in small places with a small volume of water, such as sewers, sinks, hot tubs, or buckets which are usually accessible places if you want to escape. Still, we must suspect other factors that support the drowning incident, such as intoxication and illness: catastrophic injury, disability, and youth (Armstrong & Erskine, 2018).

Second, investigation of the corpse's position, condition, and temperature. Knowing the body's position when it was first discovered is an essential step in determining whether the body is immersion, submersion, or

complete submersion. The corpse's condition and body shape can determine the time of death and the postmortem submersion interval (PMSI). In addition to the condition and integrity of the corpse, there are several things to consider, whether the body is dry or wet and whether clothes are covering it. In the case of sinking in the bathtub, signs of bathing should be found, such as wet towels, proximity to electronic devices, soap-soaked body, etc. Body temperature is palpable and measured compared to the temperature of the water at the crime scene; frigid water can lead to signs of hypothermia (Armstrong & Erskine, 2018).

Third, identification of the victim, which includes medical history, history of medication or substance use, and psychiatric history, can guide investigations and explain the reasons for drowning.

Fourth, gathering evidence. In the case of drowning in a swimming pool, some of the evidence needed includes information on the presence of a lifeguard, video surveillance, eyewitnesses, evidence of access through an emergency exit, and the ability to swim. Meanwhile, in the case of drowning in the open, some of the information needed is the underwater topography and surrounding land,

temperature and water conditions, the presence of safety equipment, signs of intoxication, types of clothing, and signs of trauma to the body.

Fifth, information on the condition of the crime scene, recovery of evidence, recovery of corpses, and resuscitation efforts can help pathological forensic experts to interpret autopsy findings and conclude the cause of death (Armstrong & Erskine, 2018).

Pre-autopsy preparation includes;

- 1) Tracing evidence and collecting evidence,
- 2) Gathering information related to the victim's DNA which includes the body and other foreign objects,
- 3) Imaging which includes postmortem radiographs and CT scans.

DNA information can be obtained from biological fluids such as saliva, blood, and semen; in addition, it can also be found in fingerprints, radiographic documentation, or typical bones such as craniofacial sinuses, as well as odontological examinations. However, the success of DNA identification can be disrupted due to the body undergoing prolonged submersion and decomposition (Armstrong & Erskine, 2018).

b. External Finding

- 1) Body and clothing are usually found in wet conditions and may be accompanied by stains from sand or mud.
- 2) The body's surface or skin feels cold and wet and looks pale, or sometimes it can appear green or brown. In addition, the skin can change texture like goose skin or what is called cutis anserina. This sign is a condition of the skin that looks shriveled with hairs standing on end due to contraction of the erector pylorus muscles due to body contact with cold water.
- 3) Maceration of the skin or washer woman's hand. Submerging conditions for a long time can cause the skin's maceration, especially the feet and hands, and also areas prone to friction. These areas of skin may turn white and wrinkle. After that, the epidermis layer becomes loose and causes the nails to fall out of place. The term washer woman's hand was taken because of the similarity obtained in the hands of women who wash clothes for a long time. This sign cannot explain antemortem or post-mortem conditions but can only estimate the length of time drowning. This sign is caused by the imbibition process where water enters the outermost layer of the skin. These marks appear on the fingertips in the first 3-4 hours after drowning and will cover all parts of the hand after 24 hours. The following changes can determine the length of time to sink:
 - a) Wrinkles on the skin can appear immediately after drowning in cold water.
 - b) Changes in the cuticle to white can occur 12 hours after drowning.
 - c) Wrinkles and changes in skin color to white can be seen within 24 hours.
 - d) The cuticle begins to separate from the palms of the hands and feet within 48 hours of drowning.
- 4) Post-mortem hypostasis will be seen on the chest's head, neck, and front. This process causes some parts of the body to undergo decomposition more quickly. Some will change to a pink color, similar to a victim of carbon monoxide poisoning. In contrast, other body parts are still fresh. This is because the victim drowns. His body will float on the surface of the water, which causes the head and face to be lower than most other body parts because the head is relatively heavier. The chest is the uppermost or protruding part of the body because the lungs and gastrointestinal tract are full of gas.

- 5) In the eyes, especially in the conjunctiva, signs of congestion may appear. Some bleeding spots on the conjunctiva may be seen.
- 6) Rigid corpse. The appearance of a dead body indicates that the victim was still alive when he drowned. Grass, mud, soil, sea algae, or other aquatic vegetation can be found in the victim's hands and gripped tightly due to the stiffness of the corpse.
- 7) Fine white foam or foam coming out of the mouth or nostrils is an important phenomenon. Sometimes, the foam may not appear when the body is found but can appear after pressing on the body's chest. The foam can be vertically elongated or conical and even shaped like a balloon or mushroom. Foam consisting of fine bubbles is not easy to break even if touched by the tip of a knife. This foam is produced from the mixing process between already, mucus and water in the respiratory tract. In addition, the froth or foam can be mixed with blood from lung tissue damage; or mixed with debris and gastric contents (Bardale, 2016; Vij K, 2018).

c. Internal Findings

- 1) Injuries and Injury Patterns

Damages of different types from impact can be found and are essential to document. Such as with the surface of water, a bottom surface, moving or fixed objects, predation, or boat and boat collisions. Resuscitation injuries are frequently recognized by the location and pattern. Such as, sternal fractures, anterior rib fractures, and contusions of the tongue and pharynx. Determination of whether the injury has the potential to be lethal or contributed to the resulting disabling effect is necessary.

Table 15.8: Difference between antemortem and postmortem drowning

Features	Antemortem drowning	Postmortem drowning
Cadaveric spasm	May be seen	Absent
Froth	Fine, whitish, copious, leathery, tenacious, increases on compression of chest	No froth
Stomach and intestine	Water may be present. May also present sand, mud, grit, silt etc	Absent
Respiratory tract	Contains fine froth. May contain mud, sand, vegetations etc	Absent
Middle ear and mastoid air cell	Hemorrhage present	No hemorrhage

(Bardale, 2011)

Table 1. The Difference Between Antemortem and Postmortem Drowning.

2) Decomposition Change

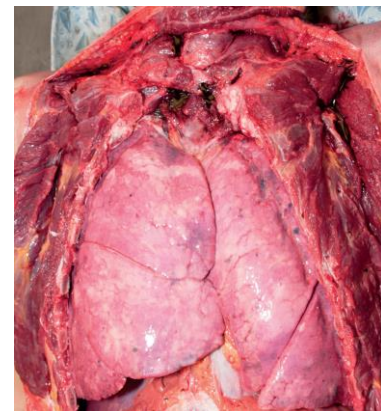
A body in a humid or wet environment for long months until years may generate adipocere, a thick gray-white substance due to bacterial-mediated hydrolysis of body fat. The development time of adipocere varies depending on the factors involved. Attached to other aqueous environments, its preservative qualities are identified, including preservation of anatomy, toxicological evidence, and bone injury (Armstrong & Erskine, 2018).

Colonization by larvae, algae, and bacteria is part of decomposition. It may be seen and has been used in estimating PMSI and time of death. Sometimes it requires expertise in entomology and botany to identify the location of death. Determinations made by a forensic entomologist or botanist can be a critical investigation in the reconstruction of the circumstances leading up to death and identification of the deceased. In the case of prolonged immersion, decomposition is rapid after recovery, and these changes may obscure preexisting antemortem or postmortem findings. Therefore, rapid cooling followed by autopsy performance is required (Armstrong & Erskine, 2018).

3) Drowning Support Findings

a) Changes in The Lungs

(1) **Appearance:** Classically, in situ examination, the lungs will appear thick, boggy, and crepitus with apposition or overlapping of the medial edges (Armstrong & Erskine, 2018). At the cut, out fine foam, a lot. In submerged freshwater, the lungs retain their shape. In saltwater immersion, the lung becomes heavy, slack, and distended. The excised part emits a large amount of foamy fluid, and the cut part does not retain its shape (Bardale, 2016).



(a)



(b)

(Armstrong & Erskine, 2018)

Picture 1. Changes in the Drowning Lung

(a) Thick lung with medial margin apposition & (b) Pulmonary edema with bronchial froth exudation.

(b) Paltauf Bleeding: It is a subpleural hemorrhage that mainly occurs on the anterior surface and edges of the lung, caused by a rupture of the interalveolar portion under the pleura (Bardale, 2016; Putra, 2014; Wulur, 2013).



(Bardale, 2011)

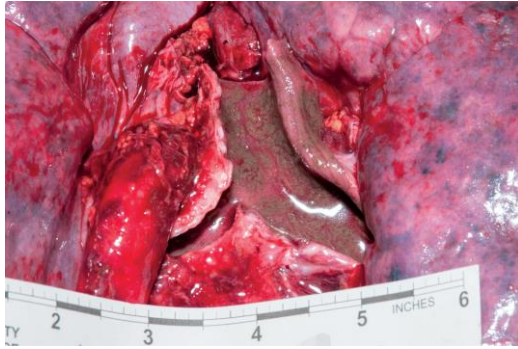
Picture 2. Paltauf Bleeding

(c) Emphysema aquosum: Lungs feel heavy, pale, spongy, and caught in the water. This condition is known as emphysema aquosum. This condition indicates that the person is conscious and struggling to live. Emphysema aquosum is highlighted as an essential sign of drowning. The correct interpretation of lung

changes as emphysema aquosum is important. From the experience of our autopsy material, it shows that hyperinflated lungs often contain additional edema fluid. Edema fluid can also be observed in cases of left heart failure, poisoning, or prolonged resuscitation. Combining these lung markers with foaming in the airways might create higher diagnostic accuracy (Schnepel, Doctors, & Bockholdt, 2020).

(d) Edema aquosum: This condition develops when a person is passively submerged without significant effort to breathe underwater or when the person is unconscious. This is a state of flooding the lungs with water without forming a foam column (Bardale, 2016).

(e) Respiratory tract shows whitish, fine froth and may show sand, silt, grit, vegetation, etc. (Bardale, 2016).



(Armstrong & Erskine, 2018)

Picture 4. The silt in Tracheobronchial

(f) Weight of the lung: The weight of the submerged lung is about 600 to 700 grams, while the non-submerged lung weighs about 370 to 540 grams.

b) Changes in The Heart and Blood Vessels

The obstruction of pulmonary circulation from inhaling water results in distention of the right heart and large vein, which is usually found to be filled with dark blood. Dilution of blood by inhaled water usually prevents coagulation (Vij, 2018).

c) Drowning Stomach

The abdomen may contain water and foreign objects such as sand, mud, weeds, etc., which may be swallowed while drowning while struggling to live. The possibility of the victim

ingesting water before drowning should also be noted. So a chemical analysis of the stomach contents showing a composition identical to the immersion medium is helpful. The presence of unpleasant material such as muddy water, liquid feces, aquatic vegetation, etc., which cannot be swallowed voluntarily, strongly indicates antemortem drowning. The lack of water in the abdomen may indicate sudden death due to vagal inhibition, shock, unconsciousness before falling into the water, death from laryngeal spasm, etc. Microscopic and chemical examinations need to be done as well. Traces of soap are often detected in cases of drowning in bathtubs (Vij, 2018).

In addition, dilution of intestinal contents may be seen, Wydler's sign (depicts three layers of foamy upper phase consisting of a mixture of sinking fluid and tracheal secretions, located in the moderate liquid phase and food particles on the bottom), gastric mucosal lesions, mucosal lesions in the stomach, basically as a localized

longitudinal tear in the body or fundus (Schneppel, Doctors, & Bockholdt, 2020).

d) Bleeding in The Middle Ear

Water can be found in the middle ear and is claimed to be positive evidence of antemortem drowning. Water is forced into the middle ear during a vigorous respiratory effort (Bardale, 2016).

In addition, there may also be bleeding in the middle ear and mastoid air cells, with the pathogenesis of this bleeding unclear. However, it may be caused by barotrauma. Such as, the differences between the pressure of middle ear and the surrounding water, and then it produces a relative vacuum. Negative pressure within this closed cavity causes stretching—of the tympanic membrane inward and bleeding in extreme cases. Haarkoff and Weiler (1971) found bleeding in the tegmen tympani in 80 out of 100 deaths from all causes (Vij, 2018).

4) Natural Diseases with Deadly Potential

Identification of a natural disease entity with apparent mortality (i.e., aortic

dissection with hemoperitoneum) or potentially lethal (e.g., severe coronary atherosclerosis) is sufficient to preclude drowning has a clear cause and manner of the implication of death along with the absence of supporting findings.

5) Postmortem Toxicology Test

Additional testing of body fluids and tissues is essential in all water-related deaths. Including blood (central and peripheral), vitreous fluid, skeletal muscle gastric fluid, urine, visceral, adipose tissue, isolated hematoma, and even body hair can be candidates for submission and analysis. Toxicological analysis of adipocere has yielded valuable results.

The discovery of specific drugs and medications can discern the deceased person's medical record. Moreover, psychiatric history, drug consumption record, the extent of damage around the time of death, and assistance in the reconstruction of the events guiding up to death are specifically relevant in cases where the history of the deceased is unidentified. Depending on the drug or treatment in question and end-organ effects, concentrations may be adequate to prevent drowning, with little or no discoveries supporting drowning noted at autopsy. For example, ethanol and

specific drugs are associated with prolonging the QT interval and, when mixed with holding breath during swimming, can initiate disabling arrhythmias and lead to drowning.

6) Histology

Histological contributions can be made by the changes brought about by the sinking process and the medium in which it occurs. The physical status of the previous victim and injuries (if any) that could have caused death or contributed to its occurrence must be considered. Some statuses are the depth of the water where the corpse is located, water temperature, fresh or salt water, the contaminants in the water, and the general state of preservation of the remains. At least one central and one peripheral section should be examined from each lobe of the lung, and the material should be extracted in such a way as to avoid bruising. In addition to the lungs, the liver, heart muscle, and kidneys can also be checked for signs of acute oxygen deprivation and shortness of breath (Vij, 2018).

Significant lung histologic findings usually appear in the form of distended and fluid-filled lung alveoli with foreign material such as aquatic vegetation. The walls of the alveolar septum appear stretched and thinned by

capillary compression, along with several ruptured alveoli (Bardale, 2016).

Histologically detectable expansion of the alveoli is expected to be most prominent. When drowning occurs over a relatively long period. The victim comes to the surface several times and thus breathes air. Studies of fast and slow sinking differentiation mostly show only quantitative differences. In cases of rapid drowning, there are prominent features such as emphysematous expansion, partial rupture of the alveolar septa, empty alveolar space, and capillary dilatation. Whereas, in the case of slow drowning, the findings are essentially similar, although less quantitatively clear. Janssen has reviewed the subject and concluded that histological changes might aid in the diagnosis of drowning but should be evaluated in conjunction with other findings and the circumstances of the case (Vij, 2018).

Drowning in fresh water indicates a low red blood cell count with hemolysis. In the submergence of seawater, the relative increase in the number of red blood cells with red blood cells looks wrinkled and shrunken (Bardale, 2016).

d. Special Test

Drowning fluid diffuses across the alveolar-capillary membrane and into

the active circulating blood during drowning. Various tests have been developed to measure the amount of diffuse substance to diagnose drowning. In addition, reliable tests that consistently and reliably distinguish freshwater from saltwater sinks remain elusive, which could otherwise be necessary for confirming the location of sinks (Armstrong & Erskine, 2018).

Many laboratory investigations have been reported to diagnose drowning. In 1921, Alexander Gettler, a Toxicologist from the Department of Medical Examiners, New York City, suggested a comparison between the chloride content of blood from the right and left sides of the heart. This test is known as the Gettler test (Vij, 2011). Gettler's tests have historical importance and no practical importance. According to Gettler, hemodilution due to drowning in freshwater reduces the plasma concentration of the chloride content of the blood on the left side of the heart (Bardale, 2011). Usually, the chloride content of the left and right sides of the heart is the same, about 600 mg per 100 ml. The difference between the two chambers should be less than 5 mg/100 ml under normal circumstances. In the case of drowning in fresh water, the chloride content of the left heart is lower than that of the right heart. In the case of

drowning in salt water, the opposite situation is observed (Vij, 2011). So it is said that the difference of 25 mg/100 ml of chloride between the right and left sides of the heart is considered significant (Bardale, 2011). Gettler's observations have been challenged by many workers and are no longer accepted. It has been shown that changes in blood chloride content are a common postmortem phenomenon and occur regardless of drowning. The rate of change may differ on each side of the heart (Vij, 2018).

In addition, there is a strontium test. Namely, the difference in strontium concentration of 75 g/L between the right and left hearts is considered significant in cases of seawater drowning (Bardale, 2016).

In 1944, Mortiz suggested magnesium as more reliable than the chloride, especially for determining the sinking of seawater. In 1955, Freimuth et al., based on the specific gravity of plasma from the two sides of the heart, concluded that a negative difference between the left and right sides could be observed in drowning and non-drowning cases. In contrast, positive values usually indicated that death was caused by means other than drowning. Since then many have worked on changes in serum electrolyte content due to drowning, but

the results have been unsatisfactory. Factors that may obscure the reliability of chemical test results may be the rapid onset of postmortem changes in blood and tissues and the various body conditions to which they are typically exposed (Vij, 2018).

Since the chemical tests portrayed already may not meet the exactness required within the legal field, circumstances required the disclosure of a few more dependable methods. The breakthrough within the determination of passing by drowning was accomplished in 1904 by Revenstorf, who, to begin with, attempted to utilize diatoms as a test for suffocating. However, he expressed that Hofmann, in 1896, was the primary to discover it in lung liquid. Peabody distributed a curious survey of the diatom contention in 1980.

The diatom test is based on the principle of diatom penetration. When a living person is immersed in water, many diatoms will penetrate the walls of the alveolus and be carried to distant organs such as the brain and kidney, liver, bone marrow, etc. Diatoms are unicellular algae found wherever there's adequate water and sunlight for photosynthesis. Diatoms have a place in a class of plants known as Diatomaceae. More than 10,000 species have been portrayed, by

and large, 40 to 200 m in breadth or length (Bardale, 2016). The cell walls are composed of transparent opaline silica and are decorated with intricate and striking silica patterns. Traditionally diatoms are divided into two distinct forms: centric diatoms (Centrales), which are radially symmetrical, and pennate diatoms, which are bilaterally symmetrical (Pennales), but these are further classified into three classes: centric diatoms (Coscinodiscophyceae), pennate diatoms without raphes. (Fragillariophyceae), and pennate diatoms with raphes (Bacillariophyceae). Diatoms are unicellular organizations, but some form colonies (Chaudhary & Dhingra, 2021). Diatoms are classified as follows: 1) Oligohalophilic diatoms: live in freshwater, 2) Mesohalophilic diatoms: live in the sea or brackish water, 3) Polyhalophilic diatoms: live in the sea or brackish water (Bardale, 2016).

The guideline for testing diatoms for drowning is that when a body is kept in water, diatoms can reach the lungs by passive permeation but are not too removed due to the nonappearance of circulation.

The diatom demonstration procedure is that 2-5 grams of tissue or bone marrow are taken, placed in a glass flask, and added to concentrated nitric

acid. Then the preparation is heated for 15-20 minutes, and a transparent yellow liquid is produced. The centrifuged liquid and the precipitate were examined by placing a cover slip.

This diatom test has several interests. The demonstration of a significant number of diatoms indicates death by drowning, the person is still alive when he is submerged in water. The location of drowning can be determined by comparing the diatom species in the body and the source/location of the body being found. The advantage is that diatoms resist decomposition and can be demonstrated even in highly decomposed bodies (Bardale, 2016).

Lung Examination

This examination is a type of microscopic examination where the tissue and fluid contained in the lungs are taken and will be observed under a microscope. Where later will be searched for the presence of foreign objects with the help of a light microscope. The basis of this examination is that fluid entering the lungs can cause foreign objects such as sand, diatoms, and algae to penetrate the circulation through diffusion and osmosis to the blood vessels. The foreign objects that may be found are:

a. Sand

This is often found during inspections because drowning events generally occur in rivers or the sea, where sand is often found at the bottom. These sands also frequently appear on macroscopic internal examination and not only in the lungs and airways but also in the esophagus and stomach.

b. Diatom

Diatoms are unicellular algae found wherever there is water belonging to Bacillariophyta. More than 10,000 species have been found with diameters or lengths ranging from 40-200 m. The shape also varies from needle-like to sphere (ball). The most forensically significant aspect of diatoms is their ability to envelop themselves with a silica-like wall called a frustule. The discovery of diatoms on microscopic examination is the gold standard for diagnosing drowning. The standard principles include qualitative and quantitative analysis of diatoms in organs related to the analysis of diatoms under sinking conditions. However, until now, this examination still has controversy. First, diatoms may be absent when the macroscopic diagnosis of drowning is precise. For example, when the victim is found dead followed by a brief survival struggle or when monthly variations occur due to often

disturbing climatic influences. This can also explain why in the case of drowning in freshwater, only one-third of cases diatoms are found. Although in the open ocean, diatoms cannot be used as the primary benchmark for diagnosing drowning. Diatoms are sometimes found in people who do not drown. It is said that someone who consumes shrimp and oyster shells will consume about 2 million diatoms per year.

Meanwhile, on examination, if five diatom frustules are found in 10 grams of bone marrow, the diagnosis will be positive for drowning. So far, there is no evidence that diatoms cannot enter the circulation through the digestive tract. Of course, it will cause a false positive result. In addition, the method used to examine diatoms, such as highly acidic liquids and Soluene-350 can destroy diatoms found in the sea, which are very fragile. In addition, the number of diatoms on earth will decrease due to pollution on the water's surface. As happened in Belgium, only one species is still alive, namely *Eunotia exigua*. 4 This is why the examination of diatoms is still controversial today.

c. Algae

The discovery of algae can be more informative in the case of drowning in water that has few diatoms. However, destructive methods such as Soluene-

350 as a solvent should be avoided. Chlorophyll can also be found in the lungs using spectrofluorometric methods, but this is still in the experimental phase. Detection of phytoplankton genes can also be helpful. However, in some samples of rabbits that were not drowned, post-mortem penetration of phytoplankton was found in the respiratory system.

d. Worm eggs

Worm eggs may be found where the victim drowned in the water and was contaminated with feces containing this.

Pulmonary Examination

A lung float test is done to determine if the baby being examined was alive. To do this test, the requirements are the same as the air embolism test: the corpse must be fresh (Forensic Medicine, 2012). Remove the tools in the oral cavity, neck, and chest cavity in one unit, the base of the esophagus and trachea can be tied.

- a. Float all the tools in a tub filled with water.
- b. When floating, release the lungs, both left and right.
- c. Float the two lung organs. If floating continues with the separation of each lobe, the right has five lobes, and the left has two lobes.
- d. Float all the lobes. Note which one sinks and which one floats.

- e. The floating lobes were taken partially, i.e., each lobe five pieces with a size of 5 mm x 5 mm, from a separate and peripheral place.
- f. Float the 25 small pieces. If they float, place the pieces on two cartons, do the trampling using the body weight, then put them back in the water.
- g. If floating means a positive pulmonary buoyancy test, the lungs contain air, and the baby is born alive.

If only part of the float, the possibility of partial respiration, the baby was stillborn alive.

Conclusion

Drowning is asphyxia that prevents air entry into the lungs by inhaling fluid into the airways, i.e., nose and mouth. Drowning is the third driving cause of inadvertent harm passing. It accounts for about 4000 deaths annually within the Joined together States, where it is the tenth most common injury-related passing. Cases of drowning death are caused by irreversible brain damage in the development of irreversible cerebral anoxia and hypoxia. There are two classifications of drowning, namely Dry Drowning and Wet Drowning. Doctors in the field of forensic medicine have an important role in cases of drowning deaths, such as in helping efforts to identify victims and determine the cause of death. The

investigation process includes Pre-Autopsy Preparation and Interest in Victim History, External Findings, Internal Meetings, and Special Tests.

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