

Demographic Profile and Pathological Lung Changes in Drowning Cases: A Retrospective Study

Authors:

Dr. Arunkumar Dhondiba Chopwad¹, Dr. Hrishikesh Deshpande², Dr. Sanket Wagh³

¹Associate professor, Dept. of Pathology, Government Medical College, Parbhani, Maharashtra.

²Associate professor, Dept. of forensic Medicine, Government Medical College, Parbhani, Maharashtra.

³Assistant professor, Dept. of Pathology, Government Medical College, Parbhani, Maharashtra.

Corresponding Author:

Dr. Arunkumar Dhondiba Chopwad, Associate professor, Dept. of Pathology, Government Medical College, Parbhani, Maharashtra.

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ABSTRACT

Introduction: Drowning is a major cause of unnatural death worldwide, with variable autopsy findings that necessitate histopathological confirmation. **Aim:** To analyze demographic variables and pathological lung changes in drowning cases. **Methods:** A retrospective observational study was conducted on 80 medico-legal autopsies of drowning victims at Government Medical College, Parbhani. Demographic details, circumstances of drowning, gross lung findings, and histopathological changes were systematically documented and analyzed using descriptive statistics. **Results:** Most victims were males (65%) aged 21–40 years (37.5%). Accidental drowning was the predominant circumstance (57.5%). Gross findings included congested lungs (75%), frothy fluid in airways (70%), and overinflated lungs (62.5%). Histopathology revealed pulmonary congestion (77.5%) and alveolar edema (72.5%) as the most frequent changes, with intra-alveolar hemorrhage (35%) and diatoms (27.5%) observed in a subset of cases. **Conclusion:** Pulmonary congestion and alveolar edema are the hallmark histopathological features of drowning. Combined evaluation of demographic data, autopsy findings, and microscopic changes enhances the reliability of drowning diagnosis in forensic practice.

Keywords: Drowning, Autopsy, Pulmonary congestion

INTRODUCTION

Drowning is a leading cause of unnatural death worldwide and is defined as respiratory impairment resulting from submersion or immersion in liquid¹. According to the World Health Organization, drowning accounts for more than 230,000 deaths annually, with the highest burden seen in low- and middle-income countries². It is particularly common among children, young adults, and males, making it a major public health concern³.

The pathophysiology of drowning involves aspiration of water into the airways, leading to hypoxemia, pulmonary edema, and cardiac arrest. Freshwater and saltwater drowning may differ in their physiological effects, but both ultimately result in respiratory failure⁴. From a forensic perspective, drowning is often considered a

diagnosis of exclusion, as many autopsy findings such as pulmonary congestion, edema, and frothy fluid are nonspecific and may overlap with other causes of death⁵. Histopathological examination of lung tissue provides more reliable evidence, with features such as alveolar edema, intra-alveolar hemorrhage, and congestion being consistently reported⁶. Ancillary tests, including diatom analysis, can further support the diagnosis by demonstrating the presence of microscopic algae aspirated during drowning⁷.

Given the variability of findings and the medico-legal importance of establishing drowning as the cause of death, systematic evaluation of demographic variables, circumstances, and pathological lung changes is essential. This study aims to analyze these aspects in detail, thereby contributing to better forensic

interpretation and clinical understanding of drowning deaths.

Aim and Objectives

Aim

To analyse the demographic profile and pathological lung changes in drowning cases.

Objectives

1. To study the age and gender distribution of drowning victims.
2. To evaluate the circumstances leading to drowning.
3. To document gross lung findings at autopsy.
4. To assess microscopic histopathological changes in lung tissue.

MATERIALS AND METHODS

Study Design

This was a retrospective observational study conducted on drowning cases brought for medico-legal autopsy at the Department of Pathology and Forensic Medicine, Government Medical College, Parbhani. A total of 80 cases were included over the study period.

Inclusion Criteria

1. Cases of drowning confirmed by autopsy findings.
2. Victims brought within a reasonable post-mortem interval to allow reliable histopathological examination.
3. Availability of complete demographic and circumstantial data.
4. Adequate preservation of lung tissue for microscopic evaluation.

Exclusion Criteria

1. Decomposed bodies where histological interpretation was unreliable.
2. Cases with severe associated trauma masking drowning features.
3. Incomplete records or missing clinical details.

Procedure

All drowning cases included in the study were subjected to a systematic medico-legal autopsy. Each autopsy began with a thorough external examination, where details such as age, sex, clothing, and circumstantial

evidence were documented. Particular attention was given to external signs of immersion, including cutis anserina, washerwoman's changes, and the presence of mud, weeds, or debris on the body surface. These observations provided supportive evidence of drowning. Following this, the internal examination was carried out with special focus on the thoracic cavity. The lungs were inspected for gross changes such as overinflation, congestion, edema, and the presence of frothy fluid in the airways. Care was taken to preserve any frothy material during dissection. Other organs, including the liver, kidneys, and brain, were also examined for congestion and supportive pathological changes.

Representative tissue samples from both lungs were collected during autopsy. These samples were immediately fixed in 10% buffered formalin to ensure preservation of histological architecture. In selected cases, water samples from the site of drowning were also collected for diatom analysis, which served as an ancillary diagnostic tool.

The samples underwent histopathological processing using routine paraffin embedding techniques. Thin sections of 4–5 µm were prepared and stained with hematoxylin and eosin. Microscopic examination was then performed to identify characteristic features such as alveolar edema, pulmonary congestion, intra-alveolar hemorrhage, atelectasis, inflammatory infiltrates, and the presence of diatoms. Each finding was carefully documented.

Finally, all gross and microscopic observations were systematically recorded in proforma sheets. Representative cases were photographed to illustrate typical pathological changes. The compiled data were analyzed using descriptive statistics, with results expressed in terms of frequencies and percentages to highlight the distribution of demographic variables, circumstances of drowning, and pathological findings

Statistical Analysis

The collected data were compiled and analyzed using descriptive statistics. Results were expressed in terms of frequencies and percentages to highlight the distribution of demographic variables, circumstances of drowning, and pathological changes.

Observation and Result

Table 1: Demographic Variables

Sr No	Variables	Number of cases n=80	Percentage 100 %
1	Age (Years)		
	<20	14	17.5 %
	21–40	30	37.5 %
	41–60	22	27.5 %
	>60	14	17.5 %

2	Gender n (%)		
	Male	52	65.0 %
	Female	28	35.0 %

Out of the 80 drowning cases studied, the majority of victims were between 21–40 years of age (37.5%), followed by 41–60 years (27.5%). The youngest group (<20 years) and the elderly (>60 years) each accounted for 17.5% of cases. Males were more frequently affected, comprising 65% of the study population, while females represented 35%. This indicates that drowning incidents were more common among young to middle-aged males.

Table 2: Circumstances of Drowning

Sr No	Circumstance	Number of cases n	Percentage %
1	Accidental drowning	46	57.5 %
2	Suicidal drowning	24	30 %
3	Homicidal drowning	2	2.5 %
4	Undetermined	8	10.0 %
Total N (%)		80	100 %

Accidental drowning was the predominant circumstance, accounting for 57.5% of cases. Suicidal drowning contributed to 30%, while homicidal drowning was rare, observed in only 2.5% of cases. In 10% of cases, the manner of drowning could not be determined. These findings highlight that most drowning events are unintentional, though a significant proportion are linked to self-harm.

Table 3: Gross Lung Findings in Drowning

Sr No	Gross Finding	Number of cases n	Percentage %
1	Overinflated lungs	50	62.5 %
2	Frothy fluid in airways	56	70.0 %
3	Congested lungs	60	75.0 %
4	Edematous lungs	48	60.0 %
5	Normal appearance	10	12.5 %
Total N (%)		80	100 %

On autopsy, congested lungs were the most frequent gross finding, present in 75% of cases. Frothy fluid in the airways was noted in 70%, while overinflated lungs were seen in 62.5%. Edematous lungs were present in 60% of cases. Interestingly, 12.5% of lungs appeared normal despite drowning. These observations suggest that congestion and frothy fluid are hallmark features of drowning, though variability exists depending on the circumstances and duration of immersion.

Table 4: Microscopic Histopathologic Changes

Sr No	Histopathologic Change	Number of cases n	Percentage %
1	Alveolar edema	58	72.5 %
2	Pulmonary congestion	62	77.5 %
3	Intra-alveolar hemorrhage	28	35.0 %
4	Presence of diatoms	22	27.5%
5	Atelectasis	16	20.0 %
6	Inflammatory infiltrates	12	15.0 %
Total N (%)		80	100 %

Histopathological examination revealed pulmonary congestion in 77.5% of cases, making it the most common microscopic change. Alveolar edema was also frequent, seen in 72.5%. Intra-alveolar hemorrhage was present in 35%,

while diatoms were detected in 27.5%, supporting the diagnosis of drowning in those cases. Atelectasis was observed in 20%, and inflammatory infiltrates in 15%, indicating secondary pathological processes such as infection or aspiration. Overall, congestion and edema were the dominant microscopic features, consistent with drowning pathology.

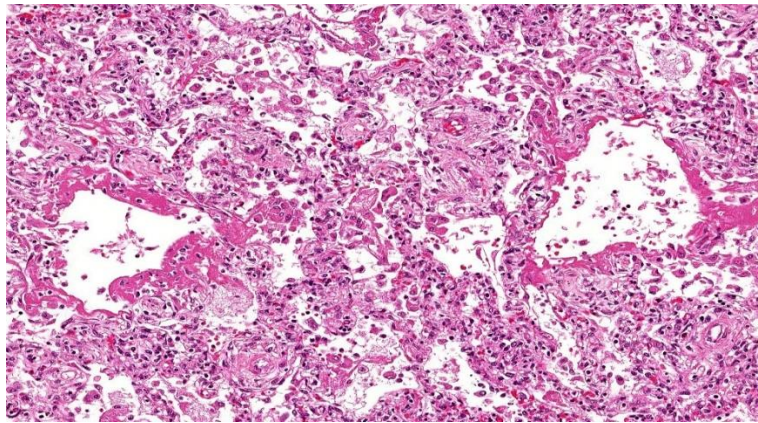


Fig 1: Pulmonary oedema with hyaline membrane disease – ARDS

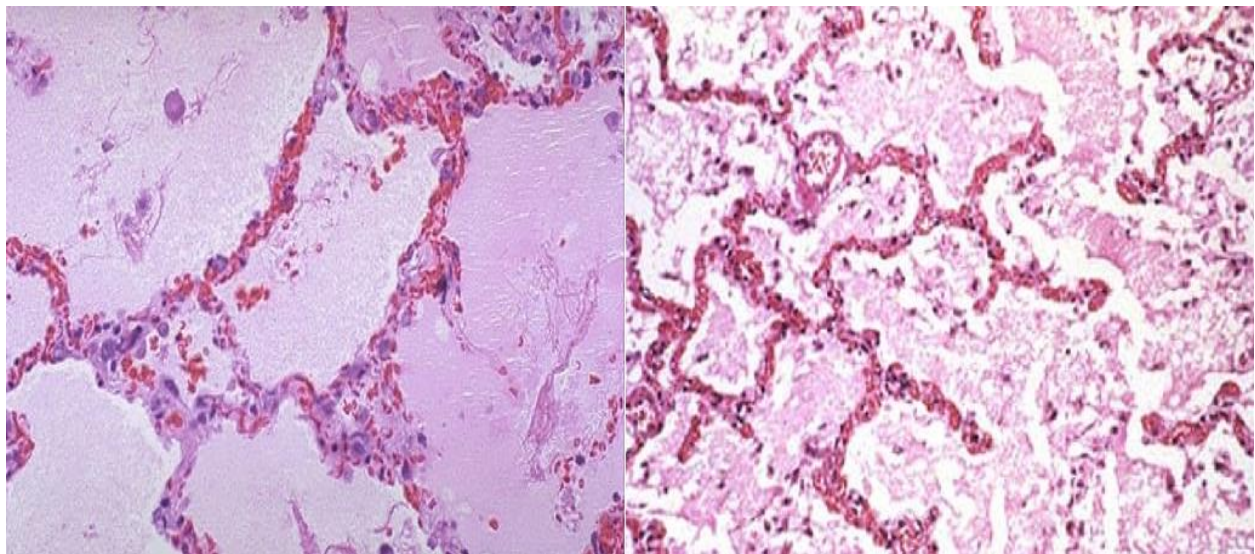


Fig 2: Marked pulmonary vascular congestion with alveolar edema, characterized by dilated blood-filled capillaries and eosinophilic fluid within alveolar spaces.

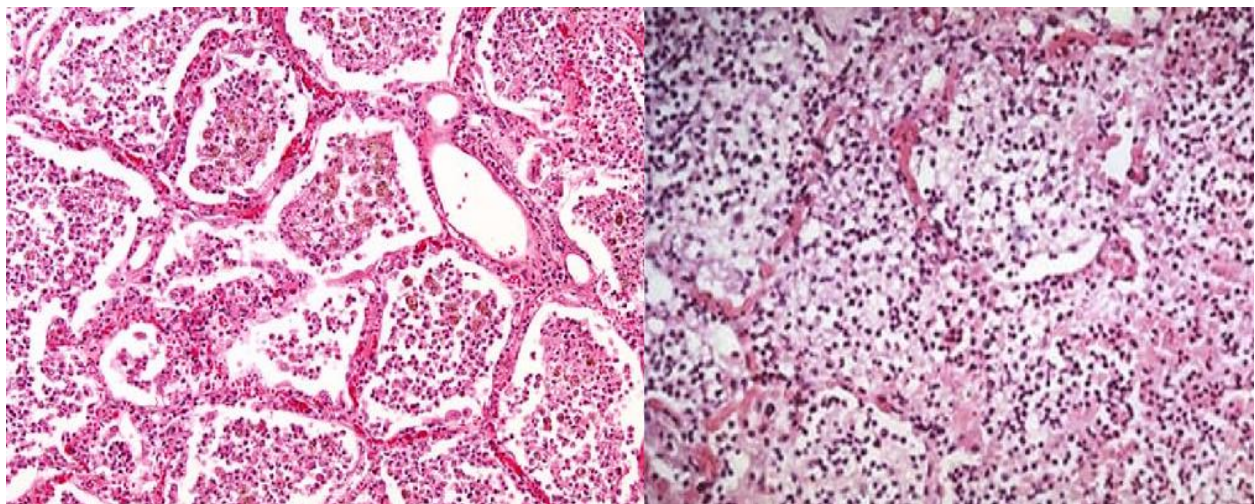


Fig 3: Lung parenchyma shows alveolar spaces filled with neutrophilic inflammatory exudate and fibrin, with alveolar septal congestion and edema, consistent with acute suppurative pneumonia

DISCUSSION

In the present study, pulmonary congestion was observed in 77.5% of drowning cases and alveolar edema in 72.5%. These findings are in agreement with Lunetta et al., who reported congestion and edema as the most consistent microscopic features in drowning victims⁶. Similarly, Suresh et al. documented congestion in 92% and edema in 96% of cases, indicating slightly higher frequencies than those noted in our series⁸. This difference may be attributed to variations in sample size, environmental conditions, and duration of submersion.

Intra-alveolar hemorrhage was seen in 35% of our cases, which is lower than the 46% reported by Suresh et al.⁸. Atelectasis and inflammatory infiltrates were less frequent in our study (20% and 15% respectively), whereas other authors have described alveolar rupture and septal thinning in a larger proportion of cases⁸. These variations highlight the influence of water medium and postmortem interval on histopathological preservation of lung tissue.

Gross findings in our study, such as frothy fluid in the airways (70%) and congested lungs (75%), are consistent with the classical autopsy features described in Pathology Outlines⁴. Overinflated lungs and edema were also common, supporting the view that drowning produces characteristic but nonspecific gross changes.

The presence of diatoms in 27.5% of our cases corroborates the utility of this test as an ancillary diagnostic tool. Recent validation studies using acid digestion and scanning electron microscopy have demonstrated high specificity of extra-pulmonary diatom detection for confirming ante-mortem drowning⁹. Our findings, though lower in frequency, reinforce the importance of combining diatom analysis with histopathology and circumstantial evidence for accurate forensic diagnosis.

Overall, the present study confirms that pulmonary congestion and alveolar edema are the dominant histopathological features of drowning, consistent with international evidence^{6,8}. Minor differences in frequencies of hemorrhage and atelectasis reflect methodological and environmental variations. The integration of gross autopsy findings, histopathology, and diatom testing remains essential for establishing drowning as the cause of death.

Strengths of the Study

The study evaluates both gross autopsy findings and histopathological changes in 80 drowning cases. It provides a comprehensive assessment of demographic characteristics, circumstances of drowning, and pulmonary changes. The inclusion of microscopic findings, including pulmonary congestion, alveolar

edema, and diatom detection, adds value to the forensic evaluation of drowning cases.

Limitations of the Study

The study was retrospective and conducted at a single institution, which may limit the generalizability of the findings. The relatively small sample size of 80 cases may not represent all drowning cases. The analysis was primarily descriptive, without inferential statistical testing. Additionally, the histopathological findings observed are not specific to drowning and should be interpreted alongside circumstantial and other autopsy findings.

Future Directions

Future studies should include larger sample sizes across multiple centers to improve the generalizability of findings. Comparative studies evaluating histopathological changes according to the duration of submersion, postmortem interval, and type of water exposure may provide further insights. Standardized diatom analysis and correlation with other forensic findings could also help improve the diagnostic interpretation of suspected drowning cases.

CONCLUSION

The present study demonstrates that drowning predominantly affects young to middle-aged males, with accidental circumstances being most common. Autopsy findings consistently revealed congested and edematous lungs with frothy fluid in the airways, while histopathology confirmed pulmonary congestion and alveolar edema as the dominant microscopic changes. The presence of diatoms in a subset of cases further substantiated drowning as the cause of death. These findings emphasize the importance of integrating demographic data, gross autopsy features, and histopathological examination for accurate forensic diagnosis of drowning.

DECLARATIONS

Ethical Approval: Ethical approval was obtained from the appropriate Institutional Ethics Committee, wherever applicable, for the retrospective study of medico-legal autopsy cases.

Conflict of Interest: The authors declare no conflict of interest.

Funding: No external funding was received for this study.

Informed Consent: Informed consent was not applicable due to the retrospective nature of the study involving medico-legal autopsy records. All procedures were conducted in accordance with applicable institutional and legal requirements.

Data Availability: The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to institutional policies and confidentiality requirements.

Author Contributions: All authors contributed to the study design, data collection, analysis, interpretation, and preparation of the manuscript. All authors reviewed and approved the final manuscript.

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AI Disclosure: No generative artificial intelligence tools were used in the conduct of the study or the preparation of the manuscript.

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