

Autopsy-Based Study of Drowning and Its Medico-Legal Aspects: Diagnostic Challenges at Patna Medical College and Hospital, Patna

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Abstract:

Background: Drowning is a leading cause of unnatural death in Bihar, particularly during the monsoon and flood seasons. Despite its prevalence, confirming drowning as the cause of death during postmortem examination remains challenging due to decomposition and overlapping asphyxial signs.

Aim: To analyze autopsy findings in drowning deaths and assess their medico-legal implications, with emphasis on diagnostic difficulties.

Materials and Methods: The study was conducted in the Department of Forensic Medicine and Toxicology, Patna Medical College and Hospital, Patna, over 24 months. A total of 170 medico-legal autopsies of alleged drowning were examined. Each case was evaluated for demographic data, circumstances of recovery, autopsy findings, diatom and toxicological results, and medico-legal opinion. Statistical analysis was performed to determine correlations between findings and diagnostic certainty.

Results: Among 170 cases, 123 (72.4%) were males and 47 (27.6%) females, mostly aged 21–40 years. Rivers were the most common sites (48.2%), followed by ponds (28.8%). Monsoon months accounted for 45.3% of cases. Froth at mouth and nostrils was seen in 66.5%, washer-woman changes in 58.8%, and over-inflated lungs in 71.2%. Paltauf's spots were noted in 41.2%. Diatoms were positive in 61.8%, with species correlation in 51.4%. Alcohol was detected in 37.6% of adults. Most deaths were accidental (82.4%). Drowning was certified as certain in 56.5% and probable in 27.6% of cases.

Conclusion: Drowning remains a significant cause of accidental mortality in Patna. Thorough autopsy, scene investigation, and ancillary testing, particularly diatom and toxicological analysis, are essential for accurate diagnosis and reliable medico-legal interpretation.

Keywords: Drowning, Autopsy, Diatom Test, Medico-Legal, PMCH Patna, Forensic Medicine, Asphyxia.

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Introduction

Drowning continues to be a serious public health issue and a frequent cause of unnatural death in India. Every year, a large number of individuals lose their lives to accidental immersion in water bodies such as rivers, ponds, wells, and canals. The problem is more acute in states like Bihar, where the Ganga River and its numerous tributaries flow across densely populated and flood-prone regions. Seasonal flooding, poor safety awareness, and unrestricted access to open water contribute to the high incidence of drowning deaths. In rural and peri-urban areas, daily activities such as bathing, fishing, irrigation, and transportation frequently involve close contact with natural water sources, increasing the risk of accidental submersion. Despite being a common occurrence, drowning remains one of the most difficult forms of asphyxial death to diagnose with certainty during postmortem examination.

Many bodies are recovered after varying intervals in water, often in advanced stages of decomposition, which obscure the classical features of drowning and complicate medico-legal interpretation.

From a forensic point of view, establishing drowning as the cause of death requires a cautious and comprehensive approach. The classical autopsy findings—fine froth at the mouth and nostrils, voluminous and water-logged lungs, Paltauf's hemorrhagic spots, and water or foreign material in the stomach—are useful indicators but not definitive on their own. These findings may be absent in decomposed or partially recovered bodies and can occasionally appear in other asphyxial deaths, leading to diagnostic confusion. Therefore, each case demands correlation between autopsy findings, circumstantial evidence, and ancillary test results.

The diatom test plays an important supportive role in confirming drowning, as the presence of diatoms in internal organs, especially when matching the species in the recovery water, suggests inhalation during life. Toxicological analysis is equally significant since alcohol or poison ingestion may precipitate drowning or modify its medico-legal interpretation. Determining whether immersion occurred before or after death, and differentiating between accidental, suicidal, and homicidal drowning, are essential steps in forensic certification. Scene investigation, injury analysis, and laboratory findings together form the foundation for a scientifically sound medico-legal opinion.

Although the phenomenon of drowning is frequently encountered in the Patna region, systematic studies addressing its patterns and medico-legal aspects remain limited. Environmental and social factors in Bihar—such as flooding during monsoon, agricultural dependence on river systems, and the use of open water bodies for domestic purposes—make the local population particularly vulnerable. The present study was therefore undertaken in the Department of Forensic Medicine and Toxicology at Patna Medical College and Hospital (PMCH) to examine 170 medico-legal autopsies of suspected drowning deaths over a two-year period. The aim was to document the demographic characteristics, autopsy findings, and ancillary test results, and to analyze the medico-legal implications of these cases with emphasis on diagnostic challenges. By identifying the limitations and strengths of current diagnostic methods, this work seeks to contribute to a more standardized and evidence-based approach to the investigation of drowning deaths. The findings are expected to improve the accuracy of postmortem diagnosis, assist in proper classification of the manner of death, and provide data that may ultimately support preventive public health strategies in this region.

Materials and Methods

The present study was conducted in the Department of Forensic Medicine and Toxicology, PMCH, Patna, over a period of 24 months. A total of 170 medico-legal autopsies of alleged drowning cases were included.

Inclusion Criteria: All cases where the body was recovered from water or where drowning was alleged as the cause of death.

Exclusion Criteria: Cases where an alternate clear cause of death was found at autopsy (e.g., firearm injury, hanging, poisoning prior to immersion) were excluded.

Methodology: Each case was thoroughly examined, and data were collected on:

- **Demographics:** age, sex, and residence.
- **Scene details:** type of water body, season, manner of recovery.
- **External findings:** presence of froth, washerwoman changes, cutis anserina, injuries.
- **Internal findings:** condition of lungs, Paltauf's spots, fluid in stomach and sinuses, lung weights.
- **Ancillary tests:** diatom test (bone marrow and recovery water comparison), toxicological analysis for alcohol and poisons, histopathology of lungs when indicated.
- **Medico-legal opinion:** cause of death, manner of death, and level of diagnostic certainty (certain, probable, or indeterminate).

All data were tabulated and statistically analyzed to identify significant correlations between autopsy findings and diagnostic certainty.

Results

1. Demographic Profile

A total of 170 medico-legal autopsies of suspected drowning were examined during the study period of 24 months at Patna Medical College and Hospital. Out of these, 123 cases (72.4%) were males and 47 (27.6%) were females, giving a male-to-female ratio of approximately 2.6: 1. The age of the victims ranged from 4 to 78 years, with the majority belonging to the 21–40 year age group (46.5%), followed by 41–60 years (23.5%). Children below 18 years constituted 14.1% of the cases, while elderly individuals above 60 years accounted for 6.5%.

The seasonal trend revealed a sharp increase in drowning cases during the monsoon months (June–September), accounting for 45.3% of all cases. A gradual decline was noted in the post-monsoon and winter months.

Figure 1: Monthly Distribution of Drowning Cases (n=170)

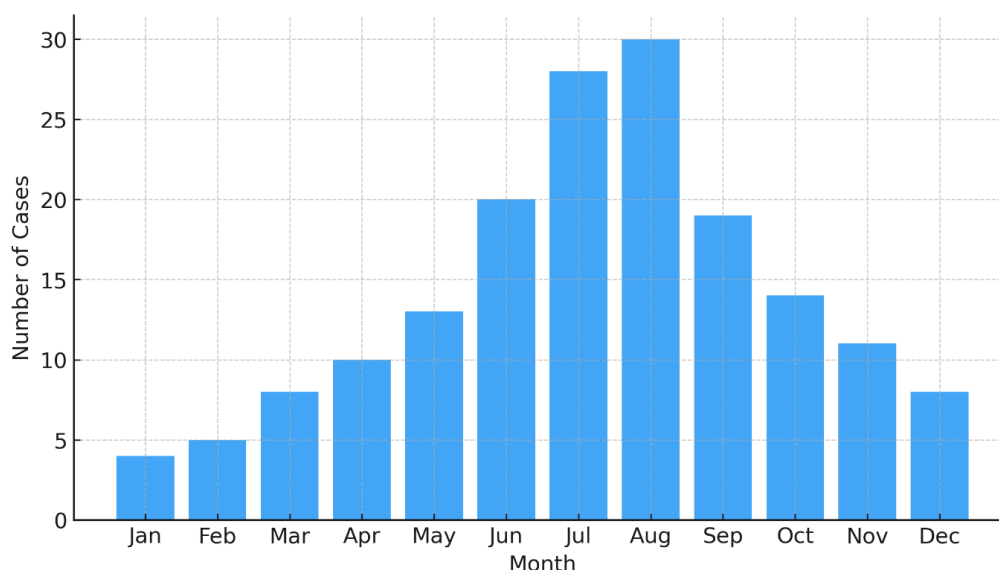


Figure 1: Distribution of Drowning Cases by Month (n = 170)

2. Site and Circumstances of Recovery

Most bodies were recovered from natural water bodies. Rivers were the most common site (48.2%), followed by ponds (28.8%), canals (16.5%), and

wells/tanks (6.5%). In 82.4% of cases, the manner of death was determined as accidental, 11.8% were suicidal, 1.2% homicidal, and 4.7% remained undetermined due to insufficient evidence or decomposition.

Table 1: Distribution of Cases by Water Body and Manner of Death (n = 170)

Type of Water Body	No. of Cases	Percentage (%)	Common Manner of Death
River	82	48.2	Accidental (mainly bathing/flood)
Pond	49	28.8	Accidental (bathing/fishing)
Canal	28	16.5	Accidental (slip while working)
Well/Tank	11	6.5	Suicidal/Accidental
Total	170	100	—

3. External Examination Findings

Typical external signs of drowning were variably present. Froth at the mouth and nostrils was seen in 113 cases (66.5%), while washer-woman changes were noted in 100 cases (58.8%). Cutis anserina was observed in 75 cases (44.1%). Postmortem injuries due to aquatic animals or contact with hard surfaces were recorded in 28 cases (16.5%), and definite

antemortem injuries unrelated to drowning were noted in 7 cases (4.1%).

In well-preserved bodies, froth was fine, white, and persistent, whereas in decomposed bodies it was either absent or mixed with debris. The presence of these external features showed a statistically significant correlation with shorter postmortem interval and lower decomposition grade.

Figure 2: External Findings in Drowning Victims (n=170)

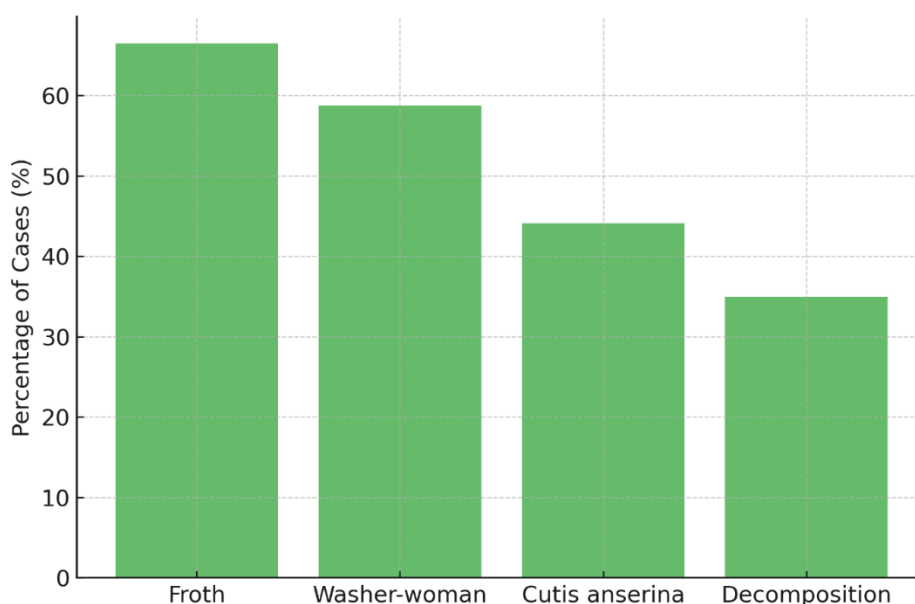


Figure 2: External Findings in Drowning Victims (n = 170)

4. Internal Examination Findings

The lungs were voluminous, water-logged, and covered the heart in 71.2% of cases. Emphysema aquosum and frothy fluid in the bronchi were frequently observed. Paltauf's hemorrhagic spots were present in 41.2% of cases. The mean combined

lung weight was $1,380 \pm 280$ grams, ranging from 1,000 to 2,000 grams depending on body size and degree of decomposition. Water and fine debris were found in the stomach and upper small intestine in 65.3% of cases, suggesting antemortem aspiration. Fluid was detected in the sphenoid sinus in 58.2% of cases.

Table 2: Major Internal Findings in Drowning Cases

Finding	No. of Cases	Percentage (%)
Over-inflated water-logged lungs	121	71.2
Paltauf's hemorrhagic spots	70	41.2
Water/debris in stomach	111	65.3
Fluid in sphenoid sinus	99	58.2
Cerebral edema	86	50.6
Middle ear congestion/hemorrhage	45	26.5

5. Ancillary Investigations

The diatom test was performed in all cases. Diatoms were detected in 105 cases (61.8%), and in 54 of these (51.4%), the species matched those obtained from the recovery water. This correlation was most

consistent in river and pond cases. Alcohol was detected in 37.6% of adult victims (53/141), while pesticides and sedatives were found in 10 cases (7.1%). Histopathological examination of lungs revealed emphysema aquosum and pulmonary edema in the majority of positive cases.

Figure 3: Diatom Test Results (n=170)

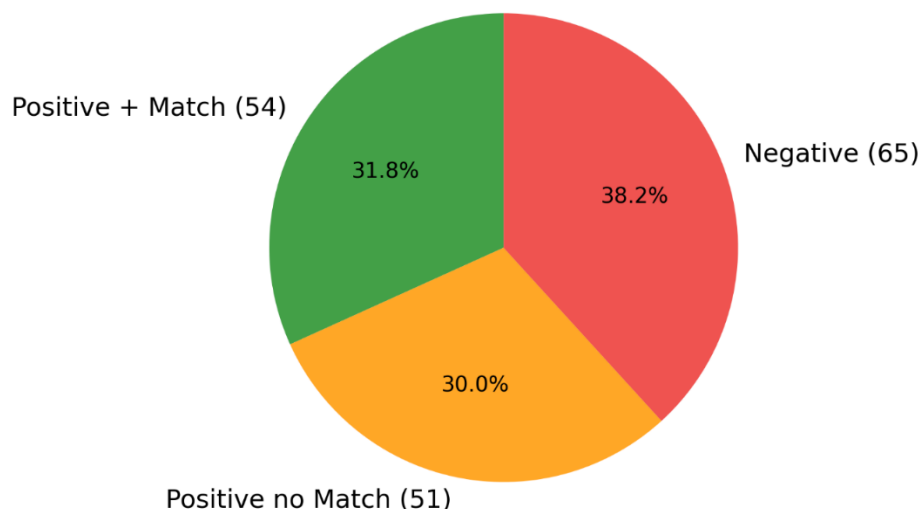


Figure 3: Proportion of Diatom Positivity and Species Matching

6. Diagnostic Certainty and Medico-Legal Opinion

Out of 170 cases, drowning was certified as the definite cause of death in 96 cases (56.5%), probable

drowning in 47 (27.6%), and indeterminate in 27 (15.9%). Factors associated with diagnostic certainty included the presence of fine froth, water-logged lungs, positive diatom test with species correlation, and lower decomposition grade.

Table 3: Correlation Between Findings and Diagnostic Certainty

Parameter	Present (%) in "Certain" Diagnosis	Absent (%) in "Certain" Diagnosis	p-Value
Persistent froth	77.1	22.9	<0.05
Positive diatom test	76.0	24.0	<0.01
Low decomposition	70.8	29.2	<0.05
Alternate cause of death absent	95.8	4.2	<0.05

Discussion

The study was undertaken to analyze the postmortem findings, investigative outcomes, and medico-legal implications of drowning deaths examined at Patna Medical College and Hospital over a two-year period. A total of 170 cases were studied in detail to understand not only the characteristic features of drowning but also the diagnostic difficulties that often arise in such cases. The findings of this work reflect both the environmental realities of the region and the practical challenges faced by forensic experts in establishing drowning as the cause of death beyond reasonable doubt.

The demographic profile observed in this study is similar to that reported from other parts of India. Most victims were young adult males in the second to fourth decades of life. This predominance can be explained by the social and occupational behavior typical of this age group, as they are more frequently involved in agricultural, fishing, or outdoor

activities near water. In contrast, females accounted for a smaller proportion of the cases and were more commonly associated with suicidal circumstances or accidental immersion during household chores near wells, tanks, or ponds. These findings are in harmony with previous regional reports and highlight the influence of local lifestyle and environmental exposure on the incidence of drowning. The presence of a few cases among children emphasizes the lack of supervision and public awareness regarding safety around open water sources, which remain easily accessible in both rural and suburban areas.

The temporal pattern of drowning deaths showed a distinct seasonal variation, with a marked rise during the monsoon and post-monsoon months. This observation is not surprising given the topography of Bihar, where flooding of rivers and overflow of ponds are common during this period. The increased use of water bodies for bathing, transportation, and daily activities during floods also contributes to

accidental submersion. Such seasonal clustering mirrors findings from other riverine states of India, suggesting that climatic and environmental factors play a major role in the frequency of drowning incidents. These findings underline the importance of preventive efforts such as community education, improved rescue facilities, and fencing of dangerous water bodies during high-risk seasons.

The study also brought out significant observations regarding the manner of death. Accidental drowning was by far the most common, followed by suicidal and a few homicidal cases. The predominance of accidental deaths reflects the socio-economic and environmental setup of the population, where open and unguarded water sources are part of everyday life. Suicidal drownings were mainly observed among young females and middle-aged males, usually with associated psychological or social stress factors. The two cases categorized as homicidal presented with suspicious injuries and inconsistent scene findings. Differentiating homicidal drowning from other forms remains one of the most challenging aspects in forensic practice, since deliberate submersion can easily be masked as an accident. In some cases, the cause and manner could not be conclusively established due to advanced decomposition or absence of corroborative evidence. This emphasizes that postmortem findings must always be interpreted in conjunction with circumstantial and investigative information before forming a medico-legal opinion.

External examination findings in the present series were largely consistent with classical descriptions, although their frequency varied according to the condition of the body. Fine froth at the mouth and nostrils was observed in approximately two-thirds of the cases. When fresh and persistent, this sign was considered strongly indicative of drowning, while in decomposed bodies, it was either absent or mixed with debris. Washer-woman changes and cutis anserina were also common, but these signs are indicative of immersion rather than of drowning as the cause of death. The practical value of such external features lies in their corroborative role, especially when they appear in combination. However, they cannot be solely relied upon in the absence of internal and laboratory evidence. Postmortem injuries caused by aquatic animals, boat propellers, or contact with hard surfaces were encountered in a fair number of cases. Differentiating these from antemortem injuries was sometimes difficult, but careful examination of wound margins and hemorrhagic infiltration helped to establish their nature. Decomposition, as expected, was one of the major obstacles to diagnosis and had a direct impact on the visibility of external signs.

Internal examination provided valuable clues in most cases. Overinflated, waterlogged lungs—

described as emphysema aquosum—were observed in more than seventy percent of the victims. This feature, resulting from aspiration of water and air mixture during the struggle for breath, is regarded as one of the strongest morphological indicators of drowning. The mean combined lung weight observed in this series was 1,380 grams, a finding consistent with previous studies of freshwater drowning. Paltauf's subpleural hemorrhages were seen in about forty percent of the cases, adding further support to the diagnosis. The presence of water and debris in the stomach in a large number of victims also suggested antemortem aspiration and swallowing of water. However, the absence of these findings in some cases indicates that drowning may occur even without significant water inhalation, such as in "dry drowning," where reflex laryngeal spasm prevents water entry. This variability emphasizes that each case must be interpreted as a whole, taking into account all available findings.

Laboratory investigations were an important component of this study. The diatom test yielded positive results in around sixty-two percent of the cases, and in more than half of these, the species matched those found in the water at the recovery site. This correlation strongly supports the reliability of the test when performed with proper technique and control samples. Nevertheless, false negatives cannot be ruled out, particularly in decomposed bodies or in stagnant waters with low diatom content. The test, therefore, should be interpreted in conjunction with other evidence rather than in isolation. Toxicological examination revealed that alcohol was present in about one-third of the adult victims, indicating its role as a major contributory factor in accidental drowning. Pesticides and sedatives were detected in a smaller percentage, particularly in suicidal cases. These findings align with previous studies showing that intoxication impairs judgment and coordination, thereby increasing the risk of submersion. Histopathological examination of the lungs supported the gross findings, revealing pulmonary edema and emphysema aquosum in most positive cases. Such microscopic features, though not specific, strengthen the overall inference when correlated with autopsy and laboratory data.

In several instances, decomposition significantly limited diagnostic certainty. As the body decomposes, classical features of drowning, such as froth and inflated lungs, become less distinct, while artifacts like gas formation and bloating create confusion. In this study, the cause of death could be established with confidence in 56.5 percent of cases, was considered probable in 27.6 percent, and remained indeterminate in 15.9 percent. This proportion is comparable with findings reported from other large autopsy centers in India. Diagnostic certainty increased when multiple findings such as

fine froth, positive diatom test, and minimal decomposition were present together. The practical implication of this observation is that a combination of supportive features, rather than reliance on any single sign, provides the most reliable basis for opinion in drowning cases.

From a medico-legal standpoint, drowning cases pose unique challenges. The distinction between accidental, suicidal, and homicidal drowning has profound legal consequences. Proper scene investigation, timely recovery of the body, and careful documentation of injuries are indispensable to reach a fair conclusion. The forensic expert's role extends beyond conducting the autopsy to ensuring proper collection of samples, maintenance of chain of custody, and presentation of evidence in court. Inaccurate or incomplete documentation can easily weaken the evidentiary value of the findings. This study also highlights the regional vulnerabilities that contribute to the high incidence of drowning deaths in Bihar—namely unprotected water bodies, lack of safety measures, alcohol misuse, and seasonal flooding. Public health authorities, law enforcement agencies, and local communities should work together to address these preventable risk factors. Educational campaigns promoting water safety, restrictions on alcohol use near water, and the establishment of rescue services during flood seasons could help in reducing mortality.

While the present study provides valuable insight, certain limitations were encountered. Some cases lacked detailed scene investigation data, and advanced analytical techniques such as molecular diatom analysis were not available. Decomposition and delay in retrieval further affected the reliability of results in several instances. Future studies incorporating improved laboratory methods and multidisciplinary collaboration would help to refine diagnostic criteria and establish uniform standards for drowning investigations in India.

Conclusion

Drowning continues to be a significant cause of preventable mortality in the Patna region, predominantly affecting young adult males during the monsoon season. The findings of this study demonstrate that the diagnosis of drowning is best established through a combination of autopsy features, ancillary investigations, and circumstantial evidence rather than reliance on any single sign. The presence of fine froth, overinflated waterlogged lungs, and diatom positivity with species correlation strongly support a diagnosis of drowning, while decomposition and environmental factors remain major diagnostic challenges. Alcohol intoxication was a notable contributory factor in many accidental cases. Strengthening interdepartmental coordination, ensuring standardized postmortem protocols, and enhancing public awareness of water

safety can improve both forensic accuracy and prevention efforts. Continuous regional surveillance and adoption of uniform investigative guidelines are essential for reducing diagnostic uncertainty and improving medico-legal outcomes.

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