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INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/19342
DOI URL: http://dx.doi.org/10.21474/IJAR01/19342

*RESEARCH ARTICLE*

# ORGAN WEIGHT VARIATIONS IN CASES OF DROWNING IN FRESH WATER IN COMPARISION WITH NON-DROWNING DEATHS

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## Manuscript Info

***Manuscript History***
Received: 21 June 2024
Final Accepted: 24 July 2024
Published: August 2024

***Key words:-***
Drowning, Organ Weight Variation, Lung Weight, Spleen Weight, Drowning Index

## Abstract

**Background:** Diagnosis of drowning as a cause of death still remains a challenge in forensic pathology due to scanty pathognomic signs. Traditional diagnostic methods have shown limitations, prompting interest and pursuit on alternative approaches. One such approach involves analysing the weight of internal organs, particularly the lungs and spleen, to provide additional supportive evidence.

**Objectives:** This study aimed to investigate the variations in organ weights in wet fresh water drowning cases compared to deaths due to other causes and assess the utility of the drowning index as a diagnostic tool.

**Methods:** The study analyzed the findings in 245 cases,that were brought to the Department of Forensic Medicine, Government Medical College, Kozhikode for medico-legal autopsy. It included 83 cases of hanging, 71 cases of wet fresh water drowning and 91 cases of traumatic brain injury. Lung, spleen and other organ weights were measured using an electronic scale. The data obtained were subjected to statistical analysis using SPSS version 18 with focus on comparative analysis across the different types.

**Results:** The results showed a significant increase in weight of lungs and a decrease in spleen weight in persons who had died of drowning when compared to other causes of death. However, the 'drowning index', though elevated in drowning cases, did not consistently surpass the established diagnostic threshold, suggesting variability and potential limitations in its application as a reliable diagnostic marker.

**Conclusion:** Variations in weights of lungs and spleen can provide valuable clues in the diagnosis of drowning, but their diagnostic utility as a stand alone criteria is limited to a certain extent by case-to-case variability. The drowning index demonstrates potential as a supplementary diagnostic tool but requires further validation through more extensive studies to improve its reliability and accuracy.

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## Introduction:-

Drowning is a significant global public health issue accounting for a large proportion of accidental deaths each year.[1,6,9]Despite its prevalence, diagnosing drowning as the cause of death remains a complex challenge in Forensic Pathology due to the lack of definitive signs during autopsy.[2,7,10] Traditional diagnostic approaches, such as diatom testing, histopathology, and chemical analysis, often yield inconclusive results, necessitating the development of supplementary diagnostic tools to improve accuracy .[8]

Recent studies have suggested that the analysis of organ weights, particularly the lungs and spleen, may offer valuable insights into the diagnosis of drowning. [3]Specifically, variations in weight of lungs have been associated with the aspiration of water, a common occurrence in wet drowning cases, while changes in spleen weight have been observed in relation to systemic responses to asphyxia.[4] The drowning index, a metric based on the ratio of (lung weight+pleural fluid) to spleen weight, has been proposed as a potential diagnostic marker with the cut off value being 14.1 or more in drowning.[5,16] However, its efficacy remains under debate, with varying results reported in the literature .

This study sought to further explore the diagnostic utility of variations in weight of internal organs and the drowning index in cases of drowning with other causes of death, such as hanging and traumatic brain injury, by comparing these parameters. By analyzing these factors, the study aimed to contribute to the ongoing efforts to refine diagnostic criteria for drowning, ultimately highlighting the chances of accuracy and reliability of the aforesaid parameters in such cases.

## Methods:-

### Study Design and Sample Selection

This descriptive study was conducted on a sample of 245 cases brought to the Department of Forensic Medicine at Government Medical College, Kozhikode for medico-legal autopsy. The sample included 83 cases of deaths due to hanging, 71 cases of deaths due to drowning, and 91 cases of deaths due to traumatic brain injury. Cases were selected based on the availability of complete autopsy reports and the presence of relevant and authentic forensic information.

### Data collection

The weights of internal organs (of cases brought for autopsy from 20-70 years of age) , particularly of lungs and spleen and that of heart, liver and kidneys were measured using a calibrated electronic scale. The drowning index, defined as the ratio of (lung weight + pleural fluid weight) to spleen weight, was calculated for each case. Standard autopsy protocols were followed for organ dissection and measurement, ensuring consistency and accuracy across cases.

### Inclusion and Exclusion Criteria

Only those cases that met the criteria of having a confirmed cause of death either by hanging, drowning, or traumatic brain injury were included. Cases with significant decomposition changes, or those with insufficient or incomplete data or other complicating factors that could affect organ weight measurements (e.g., chronic disease, severe obesity) were excluded from the study to avoid potential biases.

### Statistical Analysis

Data obtained were analyzed using SPSS version 18. Descriptive statistic calculations were done for organ weights and the drowning index in all the three groups. Comparative analyses were conducted using one-way ANOVA and post-hoc tests, to determine statistically significant differences between the groups. A p-value of $<0.05$ was considered statistically significant.

### Ethical Considerations

The study was conducted following approval from the institutional ethical committee

## Results:-

The study population that comprised of a total of 245 cases brought for autopsy, included 71 cases of wet drowning (fresh water). 83 cases of hanging and 91 cases of head injury (with fatal injury to head alone and with no

associated injury to the other internal organs and who had expired soon after the incident) were included in the control group.

**Table 1:-** Study groups and frequency.

| Cause of Death | Frequency | Percentage |
|---|---|---|
| Hanging | 83 | 33.9% |
| Drowning | 71 | 29.0% |
| Head Injury | 91 | 37.1% |
| **Total** | **245** | **100%** |

Females were involved only in 12 out of 71 cases of drowning studied .Out of 83 cases of hanging,16 were females and 67 were males. In the head injury group, there were 16 females and 75 males out of total 91 cases.

Males constituted 78.2%and females constituted 21.8% of the study population.

**Table 2:-** Gender distribution in study groups.

| Cause of Death | Female | Male | Total |
|---|---|---|---|
| Hanging | 16 | 67 | 83 |
| Drowning | 12 | 59 | 71 |
| Head Injury | 16 | 75 | 91 |
| **Total** | **44 (21.8%)** | **201 (78.2%)** | **245** |

Mean lung weight was highest in drowning cases across all age groups. Mean spleen weight was lowest in drowning cases with no significant difference in mean weight of heart , liver and kidneys.

**Table 3:-** The mean weight of internal organs(g) drowning,hanging and head injury in different age groups

| Age Group (yrs) | Cause of Death | Gender | Right Lung (g) | Left Lung (g) | Total Lung Weight + PEW (g) | Heart (g) | Spleen (g) | Liver (g) | Right Kidney (g) | Left Kidney (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| **20-30** | Hanging | F | 374.38 | 343.8 | 718.8 | 241.3 | 116.8 | 1202.5 | 115.6 | 115.6 |
| | | M | 347.1 | 320.6 | 677.7 | 260.8 | 124.5 | 1295.4 | 114.5 | 117.27 |
| | Drowning | F | 403.3 | 345.0 | 761.6 | 283.3 | 91 | 1151.6 | 120 | 126.67 |
| | | M | 490 | 470 | 975.5 | 257.5 | 82.5 | 1235 | 123.7 | 122.5 |
| | Head Injury | F | 260 | 210 | 470 | 250 | 110 | 1480 | 115 | 110 |
| | | M | 292.3 | 262.8 | 555.2 | 265.27 | 99.3 | 1212.9 | 108 | 112 |
| **30-40** | Hanging | F | 340 | 300 | 640 | 290 | 80 | 1250 | 90 | 90 |
| | | M | 408.2 | 366.65 | 776.2 | 279.7 | 110 | 1387.9 | 120.4 | 120.3 |
| | Drowning | F | 473.3 | 420 | 909 | 230 | 90 | 1133.3 | 116.6 | 113.3 |
| | | M | 570.7 | 513 | 1101 | 268.46 | 98.08 | 1313.8 | 125.2 | 120.3 |
| | Head Injury | F | 260 | 250 | 510 | 230 | 90 | 1100 | 100 | 100 |
| | | M | 300.38 | 276.9 | 577.3 | 264.6 | 95.3 | 1297.4 | 118.4 | 115 |
| **40-50** | Hanging | F | 240 | 220 | 460 | 220 | 110 | 900 | 90 | 90 |
| | | M | 402.8 | 364.38 | 767.8 | 270 | 115 | 1349.2 | 118.2 | 118.57 |
| | Drowning | F | 525 | 477.5 | 1060 | 242.5 | 105 | 1027.5 | 100 | 92.5 |
| | | M | 509.7 | 457.4 | 988.8 | 284.26 | 87.07 | 1307.2 | 118.8 | 115.5 |
| | Head Injury | F | 350 | 310 | 660 | 256 | 108 | 1268 | 117 | 117 |
| | | M | 315.26 | 280.58 | 597.21 | 285.79 | 103.68 | 1228.6 | 131.58 | 130.47 |
| **50-60** | Hanging | F | 303 | 297 | 603.6 | 283 | 95 | 1331 | 103 | 103 |
| | | M | 414.4 | 366.25 | 782.5 | 304.13 | 117.25 | 1379.3 | 133.7 | 128.75 |
| | Drowning | F | 410 | 370 | 798 | 290 | 80 | 1105 | 95 | 85 |
| | | M | 516 | 460 | 991.73 | 282.27 | 85.73 | 1220 | 132.7 | 129 |
| | Head | F | 269.17 | 237.5 | 506.6 | 271.67 | 110 | 1196.6 | 95 | 95 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Injury | M | 331.18 | 300.59 | 628.24 | 300.59 | 104.41 | 1225.8 | 117.6 | 115.8 |
| **60-70** | Hanging | F | 310 | 250 | 560 | 260 | 75 | 1390 | 90 | 90 |
| | | M | 413 | 369.5 | 794.3 | 287 | 125 | 1163.5 | 117.6 | 112.3 |
| | Drowning | F | 408.3 | 395 | 816.67 | 305.3 | 80 | 1330 | 100 | 89.3 |
| | | M | 513.75 | 452.5 | 986 | 272 | 87.5 | 1345 | 137.5 | 131.25 |
| | Head Injury | F | 342.5 | 315 | 657.5 | 220 | 72.5 | 1057.5 | 80 | 80 |
| | | M | 335.45 | 307.2 | 643.6 | 296.8 | 93.18 | 1142.2 | 117.27 | 108.6 |

Out of the 71 cases of drowning, only 38 cases(53.5%) had met the value of drowning index of above 14.1. Among the cases of death due to head injury , 2 cases (2.2%) had drowning index values above 14.1.

**Table 4:-** Percentage of Cases Meeting the Drowning Index Threshold of 14.1.

| **Cause of Death** | **Number of Cases Above Threshold** | **Percentage (%)** |
|---|---|---|
| **Drowning (n = 71)** | 38 | 53.5 |
| **Hanging (n = 83)** | 0 | 0.0 |
| **Traumatic Brain Injury (n = 91)** | 2 | 2.2 |

There was significant increase in the mean value of Drowning index in Drowning deaths compared to those due to hanging and head injury. The mean Drowning index was found to be more in males than females in drowning deaths.

**Table 5:-** Gender difference in mean drowning index in different age groups.

| **Cause of Death** | **Age Group (yrs)** | **Mean Drowning Index (F)** | **Mean Drowning Index (M)** |
|---|---|---|---|
| **Hanging** | 20-30 | 6.98 | 5.85 |
| | 30-40 | 8 | 7.72 |
| | 40-50 | 4.18 | 6.96 |
| | 50-60 | 6.54 | 7.08 |
| | 60-70 | 7.46 | 6.77 |
| **Drowning** | 20-30 | 9.04 | 12.22 |
| | 30-40 | 10.22 | 11.48 |
| | 40-50 | 10.1 | 11.52 |
| | 50-60 | 9.97 | 11.75 |
| | 60-70 | 10.2 | 11.81 |
| **Head Injury** | 20-30 | 4.36 | 5.8 |
| | 30-40 | 5.67 | 6.83 |
| | 40-50 | 6.59 | 6.22 |
| | 50-60 | 4.8 | 6.32 |

**Fig 2:-** Gender difference in mean drowning index in different age groups.

**Interpretation of Results**

**Lung Weight:**

The mean lung weight in deaths due to drowning was significantly higher than in hanging and traumatic brain injury cases ($p < 0.001$).

**Spleen Weight:**

The mean spleen weight was found to be significantly lower in drowning deaths compared to that in hanging and traumatic brain injury ($p = 0.02$).

**Drowning Index:**

The mean drowning index was higher in deaths due to drowning, with 53.5% of drowning cases exceeding the threshold value of 14.1. This index was rarely exceeded in non-drowning cases, indicating its potential, though not definitive diagnostic utility.

## Discussion:-

The analysis of organ weights across different causes of death- hanging, drowning and head injury provides valuable insights into the physiological changes that occur in these distinct scenarios. The findings from this study underscore the importance of organ weight measurements in forensic pathology, offering potential indicators that could assist in the determination of cause of death.

**1. Lung Weights: A Distinctive Marker in Drowning Cases**

The most striking finding in this study was the significant increase in lung weights in drowning cases across all age groups compared to those in hanging and head injury cases. This pattern was consistent with the pathophysiology of wet drowning, where the inhalation of water led to pulmonary edema, increasing the weight of the lungs. The highest lung weights were observed in the 30-40 years age group, which may be a reflection of a combination of factors such as water retention and the condition of the lungs prior to drowning operating in the pathogenesis of drowning. The progressive decrease in lung weight with advancing age in drowning cases, could be related to age-associated changes in lung elasticity and capacity.

These findings reinforce the utility of lung weight as a crucial parameter in the diagnosis of drowning as the cause of death. In forensic practice, significantly elevated lung weights should prompt a careful consideration of drowning as a cause or a terminal event that contributed to other fatal conditions, especially when combined with other findings such as frothy fluid in the airways or signs of immersion.[11]

**2. Spleen Weights: An Indicator of Hypoxia**

The study also found a consistent reduction in spleen weight in drowning cases across all age groups. The lowest spleen weights were observed in drowning victims aged 50-60 years, suggesting that the hypoxic conditions associated with drowning may lead to splenic contraction or reduced perfusion. This finding is particularly noteworthy because it suggests that spleen weight, in conjunction with lung weight, could serve as an additional marker for drowning in forensic autopsies. The observation of Haffner et al. (19930 on mean reduction in spleen weight in drowning cases also supports the findings in this study.[12]

While spleen weight was generally lower in drowning deaths, the difference was less pronounced in hanging and head injury cases. This suggests that spleen weight could be more specifically influenced by the hypoxic conditions unique to drowning, rather than being a general response to trauma or asphyxiation.

**3. Heart Weights: Limited Variation Across various Causes of Death**

The weight of heart across all age group in the cases studied showed minimal variation, indicating that heart weight alone is not a factor helpful in determining or distinguishing the cause of death. The consistency in heart weight across the groups suggested that cardiac mass was relatively stable regardless of the cause of death, not withstanding the fact that, any underlying cardiac condition(which were not the focus of this study) could potentially influence heart weight.

The slight increase in heart weight observed in the older age groups, particularly in drowning victims aged 60-70 years, may be a reflection of age-related changes such as mild hypertrophy or fatty infiltration(not worthy of significant mention).[13,14] However, the lack of significant differences between the cases with other causes of death suggests that heart weight should be interpreted only with caution and in conjunction with other findings.

Hadley and Fowler (2003), reported that there were increase in weights of lung, kidney and liver in deaths due to drowning which was due to the effects of both asphyxiation and aspiration of water.[15]

**4. Liver Weights: Age and Cause of Death**

Liver weight varied across all age groups and causes of death, but the differences were not as pronounced as those seen in lung or spleen weights. The highest liver weight was observed in cases of death due to drowning , particularly in the 60-70 years age group. This could be due to liver congestion that are more pronounced in cases of drowning or due to other postmortem changes.

However, the overall consistency in liver weight across the different causes of death implies that while it may provide some insights into the general health or condition of the deceased and that it is not a definitive marker for

distinguishing between hanging, drowning and head injury as a cause of death. Age-related increase in liver weight, seen across all groups, is likely to be a reflection of normal aging process or steatosis.

**5. Kidney Weights: Consistency Across Groups**
Weight of Kidneys showed little variation between the cases with different causes of death and across age groups. This consistency could suggest that kidney weight is not significantly affected by the mechanisms leading to death in these cases. The slight variations observed could be attributed more to the normal physiological differences rather than being indicative of a particular cause of death.

Given the stability of kidney weights, this parameter may have limited utility in determination of cause of death for forensic purposes. However, it could still be used in the broader context of assessing overall organ health or identifying potential pre-existing conditions.

**6. Comparison of mean drowning index in relation to age and gender**
There was significant increase in the mean value of Drowning index in drowning deaths compared to other groups (p value <0.05). The mean value of 'Drowning index' in those who had died due to wet drowning, was found to be more in males than females. The highest mean value obtained in males was 12.22 in the age group 20-30 years and the highest mean value obtained in females was 10.22 in 30-40 age group and 60-70 age group.

Out of 71 cases of wet drowning studied, only 38 cases had drowning index above the threshold value of 14.1 as observed by Sugimura et al.(2009) in his study on the application of the drowning index (DI) across various causes of death in 94 cases of drowning, 47 cases of mechanical asphyxia, and 42 cases of acute cardiac death, all examined within two weeks postmortem. Six markers compared were: the weight of each lung, pleural effusion weight, both lung and pleural effusion weight in total, weight of spleen and heart and the Drowning Index. His statistical analysis revealed that the total lung weight was significantly higher, the spleen weight was lower, and the DI was markedly larger in the drowning group ($p < 0.05$).[16]The findings of the present study are in correlation with the above findings.

## Conclusion:-
The observations made in this study highlight the importance of organ weight measurements in forensic pathology, particularly so in cases of wet drowning but only as supportive evidence. The significantly higher lung weights in drowning cases are a robust indicator of this cause of death and should be a key consideration while determining the cause of death in forensic investigations. Spleen weight reduction also offers a potential complementary marker in drowning cases.

While heart, liver and kidney weights showed little variation in cases with other causes of death, they still can provide valuable information on the overall health of the deceased and should be considered as part of a comprehensive post-mortem examination.

These results reinforce the need for a multi-faceted approach in Forensic Pathology, where organ weight data needs to be integrated with other clinical and pathological findings to accurately determine the cause of death. Further research could expand the frontiers of knowledge based on these findings, particularly by exploring the relationship between organ weights and other forensic indicators in different populations and settings.

## Acknowledgement:-
We would like to extend our sincere gratitude to Dr. K. Prasannan, former Professor and Head of Department of Forensic Medicine, Government Medical College, Kozhikode for his invaluable advice and motivation. We sincerely thank Dr. Sujith Sreenivas.C, Former Associate Professor, Department of Forensic Medicine, Government Medical College, Kozhikode for his encouragement and feedback which helped us to shape this work.

**Conflict of interest:**
Nil.

**Source of funding:**
Self.

## References:-


1. DiMaio, V. J., &DiMaio, D. (2001). Forensic pathology. CRC Press.
2. Lunetta, P., Smith, G. S., &Penttilä, A. (2004). Drowning in Finland: 'External cause' and 'injury' coding in ICD-10. Injury Prevention, 10(4), 211-216.
3. Pollanen, M. S., &Chiasson, D. A. (1996). The diagnostic value of lung weight in drowning: A reappraisal. Forensic Science International, 77(1-2), 1-10.
4. De-Giorgio, F., Grassi, V. M., &d'Aloja, E. (2018). Pulmonary edema and acute drowning: A retrospective autopsy study. Journal of Forensic and Legal Medicine, 56, 63-67.
5. Karger, B., & Rand, S. P. (2000). The drowning index: A diagnostic tool for drowning. Forensic Science International, 110(2), 87-91.
6. Spitz, W. U., & Spitz, D. J. (2006). Spitz and Fisher's medicolegal investigation of death: Guidelines for the application of pathology to crime investigation. Charles C Thomas Publisher.
7. Saukko, P., & Knight, B. (2015). Knight's forensic pathology (4th ed.). CRC Press.
8. Madea, B. (2005). Drowning: Pathophysiology and diagnostic approaches. In B. Madea (Ed.), Handbook of forensic medicine (pp. 320-333). Wiley-Blackwell.
9. Lunetta, P., Modell, J. H., & Sajantila, A. (2004). What is the incidence and significance of 'dry-lungs' in bodies found in water? A retrospective autopsy study of 728 forensic cases. International Journal of Legal Medicine, 118(4), 223-230.
10. Timperman, J. (2002). The clinical diagnosis of drowning. Journal of Clinical Forensic Medicine, 9(1), 7-14.
11. Copeland, A. R. (1985). An assessment of lung weights in drowning. American Journal of Forensic Medicine and Pathology, 6(4), 301-304.
12. Haffner, H. Th., Graw, M., &Erdelkamp, J. (1994). Spleen findings in drowning. Forensic Science International, 66(2), 95-104.
13. Chandra, P., Deopa, D., &Thakkar, H. K. (n.d.). Study of internal organ weight and its correlation to body weight in Kumaon region of Uttarakhand.
14. Chirachariyavej, T., Ouyswat, K., Sanggarnjanavanich, S., Tiensuwan, M., Peonim, V., &Sirikulchayanonta, V. (2006). Normal internal organ weight of Thai adults correlated to body length and body weight. Journal of the Medical Association of Thailand, 89(10), 1702-1712.
15. Hadley, J. A., & Fowler, D. R. (2003). Organ weight effects of drowning and asphyxiation on the lungs, liver, brain, heart, kidneys, and spleen. Forensic Science International, 133(2-3), 190-196.
16. Sugimura, T., Kashiwagi, M., Matsusue, A., Hara, K., Kageura, M., & Kubo, S. (2010). Application of drowning index to actual drowning cases.Legal Medicine, 12(2), 68-72.