Original Research Article

Comparative Analysis of Drowning Index: Relevance in Drowning Deaths versus Non-Drowning Asphyxial Deaths

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Abstract

Drowning remains a significant cause of mortality worldwide, necessitating accurate diagnostic tools for forensic investigation. This paper conducts a comparative analysis of the Drowning Index (DI) to ascertain its relevance in distinguishing drowning deaths from non-drowning asphyxial deaths. Drowning deaths present a challenge for forensic pathologists, because the autopsy findings may occur in many non-drowning scenarios. Previous studies have attempted to identify patterns in organ weights that may be specific for drowning. The drowning index has been defined as the weight ratio of the lungs and pleural effusion fluid to the spleen. We compared the lung and pleural effusion weight, spleen weight, and DI from 124 autopsies of asphyxia deaths including both drowning deaths and non-drowning asphyxia deaths such as hanging, strangulation, suffocation and mechanical asphyxia at the department of Forensic Medicine and Toxicology at the Gandhi Medical College, Bhopal from September 2021 to August 2022. Findings highlight the potential utility of the DI as a valuable adjunctive tool in forensic investigations, providing insights into its comparative efficacy in differentiating drowning from other modes of asphyxial deaths. Such insights are critical for enhancing accuracy in forensic diagnoses and contributing to advancements in medicolegal death investigations.

Keyword: Drowning, drowning index, data, autopsy.

Introduction

Drowning is defined as a form of death by suffocation, in which atmosphericair is prevented from entering the lungs by submerging the body in water or another liquid medium.[1] Drowning is considered the leading cause of death in water and the third leading cause of accidental death worldwide. Drowning rates are highest indeveloping countries.[2] The World Health Organization (WHO)

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defines it as: "The process of experiencing respiratory distress as a result of immersion/immersion in a liquid".[3] Drowning is one of the 10 leading causes of death among people under the age of 25 and is most common in low- and middle-income countries.[4] Drowning is an important but often neglected public health problem. Drowning affects all age groups, but certain groups are particularly vulnerable. Most drowning deaths (almost 97%) occur in developing countries like ours.[5]

In forensic pathology, the diagnosis of drowning as a cause of death follows the exclusion of other causes and requires the completion of a full autopsy, in which body fluids are examined and all results interpreted along with all known examination data. In the absence of signs of drowning, it is acceptable to consider another cause of death other than natural. External findings in drowning deaths are variable and are both nonspecific and nondiagnostic.

Nishitani et al. reported a new concept in the diagnosis of drowning based on autopsy findings. They recommended the drowning index (DI), which isthe ratio of lung and pleural effusion to spleen mass, and the drowning indexis higher.[6] A lighter spleen weight with pulmonary findings is also useful to diagnose drowning. In this study, we investigated the significance of the DI for diagnosis, especially the diagnosis standard and its application limits.

Materials and Methods

The study has been carried out in the year 2021-22 after approval from ethical committee of Gandhi medical college, Bhopal. 62 cases were taken to study the drowning deaths, excluding bodies in advanced state of decomposition and head injury. Same number of non-drowning asphyxia related death of the sample size. The study was carried out over the period of September 2021 to August 2022. Amount of pleural fluid measured and all organs were weighed prior to dissection, and drowning index was calculated. Drowning index was calculated by weight ratio of the lungs and pleural effusion to the spleen. The study did not involve any removal of organs or mutilation of bodies, which is prohibited by the ICMR guidelines. The clearance for the study was obtained from the college ethical committee. (D. I = both lung Wt. + pleural effusion/ Wt. of spleen)

Observations and Results

A total number of 4590 autopsies were carried out at Gandhi Medical College Bhopal, over a period of 12 months and of which there were 83 cases of deaths due to drowning out of which 62 cases are included and rest excluded due to decomposition and head injuries, constituting 1.35% of all the unnatural deaths at the Gandhi Medical College Bhopal. The cases taken were 62 and the study includes, only the non-decomposed, unmutilated dead bodies which were retrieved from water sources and having history of drowning, brought for post mortem examination.

Observations were tabled and compared with equal number of representatives control groups and the mean organ weights observed in the drowning group are given in table.1 and fig. 1. The weight of all organs of the drowning group was larger than the control group, except for the liver and spleen, where the liver remained almost unchanged and the spleen lost weight.

Table 1: The Mean Organ Weights among Cases And Controls

Organ weights	Cases (±SD) n=62	Controls (±SD) n=62
Brain	1023.61 ± 188	1083.01 ± 99.22
Right Lung	502.52 ± 122.80	333.25 ± 73.32
Left Lung	479.03 ± 121.80	323.84 ± 73.66
Combined lung	981.55 ± 244.60	657.09 ± 146.98
Pleural effusion	233.06 ± 77.23	16.45 ± 8.48
Liver	1042.40±198.12	1145.73±157.82
Spleen	123.15 ± 11.92	131.21 ± 17.58
Right Kidney	155.24 ± 29.08	129.90 ± 14.66
Left Kidney	147.23 ± 28.92	126.74 ± 12.90
Combined kidney	302.23 ± 58	256.64 ± 27.56

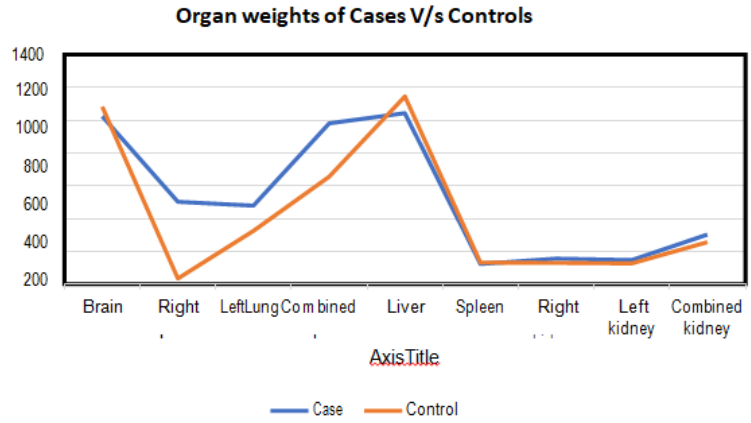

Fig 1: The mean organ weights among Cases and Controls

Comparative analysis of organ weights between cases (drowning deaths) and controls (non-drowning deaths) revealed significant differences. In cases, the mean brain weight was 1023.61 grams (±188), whereas controls exhibited a higher mean brain weight of 1083.01 grams (±99.22). Notably, both the right and left lung weights were markedly higher in cases compared to controls: right lung (502.52 grams ±122.80 vs. 333.25 grams ±73.32) and left lung (479.03 grams ±121.80 vs. 323.84 grams ±73.66). The combined lung weight was also substantially elevated in cases (981.55 grams ±244.60) compared to controls (657.09 grams ±146.98). Pleural effusion volume was significantly greater in cases (233.06 ml ±77.23) than in controls (16.45 ml ±8.48). Although the liver weight was slightly lower in cases (1042.40 grams ±198.12) compared to controls (1145.73 grams ±157.82), differences were not statistically significant. However, spleen weight showed a slight decrease in cases (123.15 grams ±11.92) compared to controls (131.21 grams ±17.58). Both right and left kidney weights were notably higher in cases than controls: right kidney (155.24 grams ±29.08 vs. 129.90 grams ±14.66) and left kidney (147.23 grams ±28.92 vs. 126.74 grams ±12.90). The combined kidney weight was significantly elevated in cases (302.23 grams ±58) compared to controls (256.64 grams ±27.56). These findings suggest distinct organ weight patterns between drowning and non-drowning asphyxial deaths, underscoring their potential diagnostic utility in forensic investigations.

The average organ weights observed in the drowning group were 1023.61 ± 188, 981.55 ± 244.60, 1042 ± 98.12, 123.15 ± 11.92, 302.23 ± 58, brain, combined lung, liver, spleen and combined kidney respectively and all organs of the drowning group were larger than the control group, except for liver and spleen, where the liver remained almost unchanged and the percentage increase was 49.32% for the mean combined lung weight, 17.97% for the combined kidney weight, and the spleen decreased of 6.14%, findings were in accordance with J.A. Hadley 82 study, lung and kidney weights increased by 47.8% and 14.7% respectively.[7]

In drowning cases, it has often been noted that the weight of the spleen falls and the weight of the lungs and pleural effusion increases; similarly, our study's results showed that the drowning index of cases is nearly twice that of the controls group, having p value of $p<0.00001$ which was found significant at $p <0.05$.

Table 3: Comparison of Drowning Parameters Among the Two Groups

Groups	Combined lugs weight	Pleural effusion	Spleen weight	Drowning Index
Cases	981.55 ± 244.60	233.06 ±77.23	123.15 ± 11.92	9.87 ± 2.30
Controls	657.09 ±146.98	16.45 ± 8.48	131.21 ± 17.58	5.13 ± 0.86

Comparison of drowning parameters between cases (drowning deaths) and controls (non-drowning deaths) revealed significant differences. In cases, the combined lung weight was substantially higher at 981.55 grams (±244.60) compared to controls at 657.09 grams (±146.98). Similarly, pleural effusion volume

was markedly elevated in cases (233.06 ml ±77.23) compared to controls (16.45 ml ±8.48). Conversely, spleen weight showed a slight decrease in cases (123.15 grams ±11.92) compared to controls (131.21 grams ±17.58). The Drowning Index was significantly higher in cases (9.87 ± 2.30) compared to controls (5.13 ± 0.86). These findings underscore the relevance of these parameters in distinguishing drowning deaths from non-drowning asphyxial deaths, emphasizing the potential diagnostic value of the Drowning Index in forensic investigations. Results clearly showed that the drowning index of cases is nearly twice that of the controls group and combined lugs weight, pleural effusion weight andspleen weight of cases are larger than the control group.(Table.3).

Table 4: Comparison of drowning index for significance Group Statistics

		N	Mean	Std. Deviation	Std. Error Mean
DI	Drowning cases	62	9.8706	1.16067	.14741
	Control cases	62	5.1305	.43522	.05527

Table 5. Independent Samples Test

DI	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variance assumed	28.120	.000	30.110	122	.000	4.74016	.15743	4.42852	5.05181
Equal variance not assumed			30.110	77.821	.000	4.74016	.15743	4.42674	5.05359

A comparison of the Drowning Index (DI) between drowning cases and control cases revealed significant differences. In drowning cases (n=62), the mean DI was 9.8706 (±1.16067), whereas in control cases (n=62), it was 5.1305 (±0.43522). Levene's test for equality of variances indicated unequal variances between the two groups (F=28.120, p<.001). Consequently, the t-test for equality of means, assuming unequal variances, showed a highly significant difference between the two groups (t=30.110, df=122, p<.001). The mean difference in DI between drowning cases and control cases was 4.74016, with a standard error difference of 0.15743. The 95% confidence interval for the difference in DI ranged from 4.42674 to 5.05359. These findings suggest a substantial and statistically significant variation in DI between drowning deaths and non-drowning asphyxial deaths, emphasizing its potential as a diagnostic tool in forensic investigations. Values are given as means ± standard deviation. Numbers show weight (g) except drowning index. Independent t test was applied in drowning index of case and control and observed that the drowning index mean of cases and control are 9.87 and 5.13 respectively, which shows a significant mean difference and highly statically significant. (P<0.00001) and 83.88% significant for differences between drowning and non-drowning cases. (Table.4 and 5).

Upon calculation of mean DI from 62 the cases in our study the mean was found 9.87. Of the 62 cases 50 cases were found to have DI higher than the mean value, which holds a percent of 83.88%, and we can assume that DI value 9.87 having the high significant for drowning deaths. This is compared to other studies such as Tomoko Sugimura[8] who reported to apply the drowning index (DI) for diagnosis, within 2 weeks post mortem, who propose DI "14.1" as the standard DI value (cut off value).

Conclusion

The results of our analysis provide compelling evidence of the significance of the Drowning Index (DI) in distinguishing between drowning deaths and non-drowning asphyxial deaths. Our findings indicate a substantial difference in DI values between the two groups, with drowning cases exhibiting significantly higher DI compared to control cases. This disparity underscores the utility of DI as a diagnostic tool in forensic investigations, particularly in cases where the cause of death may be ambiguous.

The observed variation in DI values highlights the importance of considering multiple factors, such as lung weight, pleural effusion volume, and spleen weight, in forensic examinations of drowning victims. The higher DI values in drowning cases likely reflect the physiological responses to submersion in water, including lung congestion and the accumulation of pleural effusion. In contrast, control cases, which represent non-drowning asphyxial deaths, exhibit lower DI values indicative of different underlying mechanisms of death.

These findings have significant implications for forensic pathology practice, providing forensic examiners with valuable insights into the diagnostic value of DI in distinguishing drowning from other modes of asphyxial deaths. By incorporating DI into routine forensic examinations, practitioners can enhance the accuracy and reliability of cause-of-death determinations in cases involving submersion incidents.

Overall, our study underscores the importance of incorporating DI as a complementary tool in forensic investigations of drowning deaths, contributing to improved forensic diagnostics and ultimately serving the interests of justice and public safety. Further research and validation studies are warranted to corroborate these findings and refine the utility of DI in forensic practice.

Ethical Clearance: The study has been carried out in the year 2021-22 after approval from ethical committee of Gandhi medical college, Bhopal. Vide letter no.: 26734/MC/IEC/2021, dated 24/08/2021.

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