



**Application of the Drowning Index to Opioid & Multidrug Intoxication Deaths: A Retrospective Analysis**



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The authors have no actual or potential conflicts of interest, financial or otherwise, to disclose in relation to the content of this presentation.

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**How common is drowning?**

- Accidental drowning accounts for an average of **3,868 deaths per year** (or approximately **10 deaths per day**) in the United States, including drownings associated with boating incidents [1-2].
- In Missouri alone, accidental drownings have accounted for between **21 and 68 deaths per year** since 2011; most of these have occurred in publicly-owned freshwater lakes and rivers during the summer months [3].
- The Office of Chief Medical Examiner of Boone & Callaway Counties names **asphyxia due to drowning** as the cause of death in an average of **11 cases each year (about 2% of our total cases)**.

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### Autopsy findings in drowning cases

- **Marked pulmonary edema**
  - Frothy or foamy fluid in airways
  - Increased lung weight
  - Dusky discoloration indicating vascular congestion
- Water in the stomach
- Hemorrhage of mastoid air cells in the middle ear
- Increased fluid volume in the maxillary sinus and sphenoid sinus ("Svechnikov's sign")
- Presence of diatoms in pulmonary vasculature
- Hemolytic staining of the aortic intima (particularly in freshwater drownings)
- Decreased spleen weight [4-8]

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### The Drowning Index (D.I.)

Nishitani et al. (2006):

$$\text{Drowning Index (DI)} = \frac{[\text{Lungs (g)} + \text{Pleural Effusion (g)}]}{\text{Spleen (g)}}$$

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### The Drowning Index (D.I.)

Sugimura et al. (2010):

$$\text{DI} = \frac{[\text{Lungs (g)} + \text{Pleural Effusion (g)}]}{\text{Spleen (g)}} \geq 14.1$$

Specific for **drowning** vs. **mechanical asphyxia** and **acute cardiac death**

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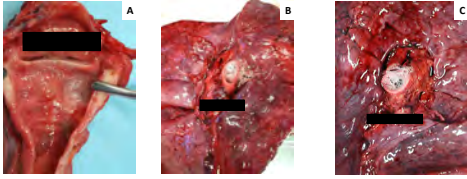
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**Figure 1. Photos from Drowning**



(A) shows foamy secretions in the trachea; (B) and (C) show foam in the bronchi (pulmonary edema) and dusky discoloration of the lung parenchyma indicating significant congestion.

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**Figure 2. Photo from Opioid Intoxication**



Foamy secretions in the trachea

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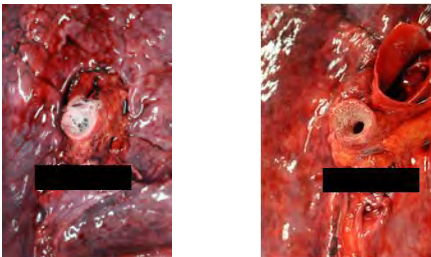
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**Can you tell the difference?**



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### Case Selection

- Causes of death from Boone-Callaway County Medical Examiner's Office in Columbia, Missouri cases between January 1, 2011 and December 31, 2016 were collected.
- Deaths due to drowning, opioid intoxication, multidrug intoxication, and asphyxia due to hanging were identified.
- Cases were excluded if:
  - They contained insufficient data for analysis.
  - The body showed signs of decomposition at time of autopsy.
  - The decedent was under the age of 18 years.
- Cases were not separated for analysis based on gender or age.

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### Data Collection

- 536 total cases were identified:
  - 45 drowning cases
  - 180 opioid intoxication cases
  - 261 multidrug intoxication cases
  - 50 hanging cases
- The body weight, spleen weight, bilateral pleural effusion volumes, and bilateral lung weights for each case were recorded.
  - Pleural effusion volume for each autopsy is estimated in milliliters.
  - If no pleural effusion volume was recorded, the minimum pleural fluid volume was estimated using 0.16 milliliters/kilogram body weight [14].
  - Pleural effusion volumes were converted to weight in grams using a density of 1 gram/milliliter.

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### Calculations

- The DI was calculated for each case [9].
- The DI, combined effusion and lung weight, and spleen weight was compared among the cause of death groups.
  - The Mann-Whitney U-test was used to evaluate for statistical significance using a 95% confidence interval ( $p < 0.05$ ).

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**Table 1. Summary of Data from Each Cause of Death Group**

Cause of Death	Drowning	Opioid Intoxication	Multidrug Intoxication	Asphyxia due to Hanging
Sample Size	45	180	261	50
Effusion + Lungs (grams)	1463 (655-2790)	1562 (606-3530)	1409 (596-4050)	1268 (647-2118)
Spleen (grams)	180 (50-580)	255 (20-1800)	220 (60-750)	200 (75-500)
DI	7.9 (5.3-25.2)	5.6 (1.1-30.5)	6.2 (1.8-33.0)	6.4 (2.1-11.5)

\*Data are given as median (minimum-maximum)

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**Combined Lung & Effusion Weight**

- Opioid overdose resulted in the highest combined lung and effusion weight.
- Hanging resulted in the lowest combined lung and effusion weight.
- The difference in combined lung and effusion weight when comparing multidrug overdose to drowning was not statistically significant.

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**Spleen Weight**

- Opioid overdose resulted in the highest spleen weight.
- Drowning resulted in the lowest spleen weight.
- The difference in spleen weight between drowning and hanging was not significant.

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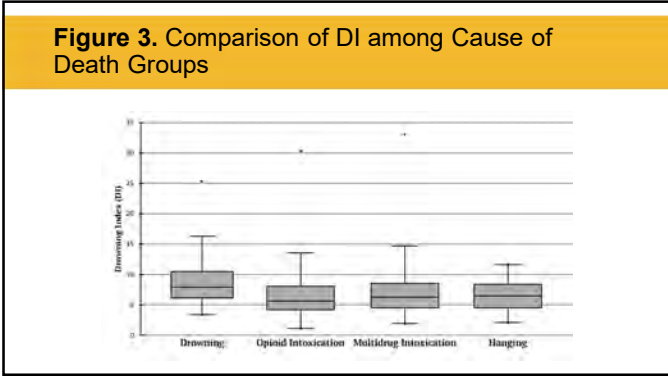
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**Table 2. Percentage of Cases with DI > 14.1**

Cause of Death	
Drowning	13.3% (6/45)
Opioid Intoxication	6.1% (11/180)
Multidrug Intoxication	3.5% (9/261)
Asphyxia due to Hanging	0.0% (0/50)

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**Drowning Index (D.I.)**

- The lowest DI (1.1) was associated with an opioid overdose and highest DI (33) was associated with a multidrug overdose.
- Drowning cases accounted for the highest mean DI of the causes of death studied.
- DI > 14.1:
  - 6 of 45 drowning cases (13.3%)
  - 11 of 180 opioid overdoses (6.11%)
  - 9 of 261 multidrug overdoses (3.45%)
  - 0 of the hangings (0%)
- The specificity of the DI for drowning is 95%.
- The sensitivity of the DI for drowning is 13%.

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### Discussion

- Combined lung and pleural effusion weight are meaningless when distinguishing between drowning, acute opioid intoxication, and acute multidrug intoxication deaths.
- The inclusion of spleen weight confers a higher specificity of the DI when compared to combined lung and effusion weight alone.
- A DI greater than or equal to 14.1 cannot be considered diagnostic of drowning.
- The drowning index has no applicability in distinguishing between asphyxia or "asphyxia-like" deaths, including those associated with acute drug intoxication.

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### Areas for Further Research

- Future research to investigate the possibility of decreased spleen weight in true asphyxial deaths, such as drowning and hanging, is warranted.

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