

## Pattern of Fatal Thoraco Abdominal Injuries: An Autopsy Based Study at a Tertiary Care Centre in Jaipur

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### ABSTRACT

**Background:** Thoraco-abdominal trauma may cause fatal internal haemorrhage and injury to multiple organs. Autopsy-based data on combined thoracic and abdominal injury patterns in Rajasthan are limited. This study aimed to describe external and internal injury patterns and the modes of injury among fatal thoraco-abdominal trauma cases. **Materials and Methods:** A prospective, hospital-based, cross-sectional observational study was conducted in the Department of Forensic Medicine and Toxicology, Sawai Man Singh Medical College, Jaipur. During one year of data collection, 150 eligible medicolegal autopsy cases were enrolled consecutively. Demographic characteristics, circumstances of injury, autopsy findings, survival interval and cause of death were recorded. Categorical variables were summarized as frequencies and percentages, and associations were assessed using the chi-square test, with  $p < 0.05$  considered significant. **Results:** Males constituted 82.0% of cases, and 59.3% were aged 21–40 years. Road traffic accidents accounted for 62.7% of cases. Abrasions were the most frequent external thoracic (63.3%) and abdominal (48.0%) injuries. Rib fractures occurred in 57.3%. The lungs (45.3%) and liver (54.0%) were the most frequently injured thoracic and abdominal organs, respectively. Combined thoraco-abdominal injuries occurred in 58.0%, and haemorrhagic shock accounted for 50.7% of deaths. Rib fractures were associated with lung injury and haemothorax, while liver injury was associated with haemoperitoneum (all  $p < 0.001$ ). Greater organ involvement was associated with haemorrhagic shock, and combined injuries were associated with shorter survival intervals. **Conclusion:** Fatal thoraco-abdominal trauma predominantly involved young adult males and resulted from road traffic accidents. Combined injuries and internal haemorrhage were common. Systematic autopsy examination is important for documenting organ injuries and determining the cause of death.

**Keywords:** Thoraco-abdominal trauma; medicolegal autopsy; road traffic accidents; haemorrhagic shock; organ injury.

### INTRODUCTION

Thoraco-abdominal trauma involves organs essential for respiration and circulation and may result in fatal injury. The thorax contains the heart, lungs and major blood vessels, while the abdomen contains solid organs and hollow viscera, including the liver, spleen, kidneys, pancreas, stomach and intestines. Chest injuries commonly result from blunt mechanisms, such

as motor vehicle collisions, or penetrating mechanisms, including stab wounds.<sup>1</sup> The abdomen lacks substantial bony protection and is described as the third most frequently injured region in civilian trauma.<sup>2</sup> Injuries involving these regions may compromise organ function and cause internal haemorrhage.

Road traffic accidents, falls from height, assaults and penetrating injuries are important causes of thoraco-abdominal trauma. Railway, industrial, agricultural and domestic accidents may also produce injuries to these regions. Abdominal trauma is broadly classified as blunt or penetrating.<sup>3</sup> Penetrating injuries may result from sharp instruments, firearms or falls onto pointed objects. Their clinical presentation is generally more apparent, whereas blunt abdominal injuries may be missed because their manifestations are relatively subtle. In India, road traffic accidents are reported as a leading cause of blunt abdominal trauma.<sup>4</sup>

During blunt trauma, force transmitted through the abdomen may injure relatively fixed intra-abdominal organs, and the resulting damage may remain undetected initially. Associated injuries to the head, spine and extremities are common, making early recognition and timely treatment important for survival.<sup>5</sup> The liver, intestines, spleen and mesentery are particularly vulnerable. Abdominal compression may occur between vehicles or between a vehicle and a stationary object and is also encountered in railway and industrial accidents. Blunt abdominal injuries may additionally follow assaults, direct blows, kicking or stamping.<sup>6</sup>

Thoracic injuries may coexist with damage to other body regions, and haemorrhage is reported as the most common cause of death in patients with thoracic trauma.<sup>7</sup> Fatal falls commonly involve abrasions, contusions and rib fractures of the thoracic cage.<sup>8</sup> The interval between injury and death provides further context for evaluating fatal trauma. Immediate deaths are predominantly associated with severe neurological injury or laceration of the heart or major vessels.<sup>9</sup> Early deaths are mainly attributed to massive haemorrhage, whereas later deaths are commonly associated with infection and multiple organ failure.<sup>10</sup> Although thoraco-abdominal trauma contributes to trauma-related mortality, available studies have primarily examined thoracic or abdominal injuries separately, with less emphasis on their combined patterns. Autopsy-based studies evaluating both external and internal injuries in relation to the mode of injury are limited.<sup>11</sup> Data from Rajasthan are also limited regarding the distribution of thoraco-abdominal injuries, visceral involvement and their medicolegal significance. This regional gap highlights the need for systematic documentation of fatal thoraco-abdominal injury patterns through medicolegal autopsy examination.

Detailed medicolegal autopsy examination allows documentation of external and internal injuries, identification of the organs involved and correlation with the reported mechanism and mode of injury. Such information can assist forensic interpretation, reconstruction of traumatic events and determination of the cause of death. The present study aimed to describe external and internal thoraco-abdominal injury patterns, identify the visceral organs involved

and determine the distribution of deaths according to the modes of injury among fatal trauma cases subjected to medicolegal autopsy at Sawai Man Singh Medical College, Jaipur.

## **MATERIALS AND METHODS**

This prospective, hospital-based, cross-sectional observational study was conducted in the Department of Forensic Medicine and Toxicology, Sawai Man Singh Medical College and Associated Hospitals, Jaipur, Rajasthan. Data were collected over one year, followed by two months for compilation, analysis and interpretation. The study population comprised medicolegal autopsy cases with fatal thoraco-abdominal injuries examined at the department during the study period.

The sample size was estimated using the formula for a single proportion,  $n = Z^2PQ/d^2$ . The calculation used a proportion of 89.1%, based on liver and splenic involvement among victims of blunt abdominal trauma reported by Jasbir S et al., with Q of 10.9%, a 95% confidence level and an absolute allowable error of 5%. The calculated sample size was 149 and was rounded to 150. Cases were enrolled consecutively until the required sample was obtained. Medicolegal autopsy cases with fatal thoraco-abdominal injuries were eligible. Decomposed, putrefied and severely mutilated bodies in which thoraco-abdominal injuries could not be adequately assessed were excluded.

Each case was assigned a study identification number. Information on age, sex, residence, occupation, circumstances and mode of injury, treatment history and survival interval was obtained from police inquest papers, hospital records, medicolegal documents and accompanying relatives. Information that was unavailable or could not be reliably established was recorded as unavailable. Findings were documented in a predesigned and pretested proforma.

External examination recorded the type, anatomical site, number and laterality of thoracic and abdominal injuries. Abrasions, contusions, lacerations, incised injuries, stab wounds and firearm wounds were documented, including their dimensions and other relevant features. Internal examination followed the standard departmental autopsy procedure. The pleural and peritoneal cavities were examined before organ removal, and the presence, quantity and distribution of blood or other abnormal contents were recorded.

The ribs and sternum were examined for fractures. The side and number of fractured ribs were documented. The lungs, pleura, heart, pericardium, diaphragm and major thoracic vessels were assessed for traumatic injury. Abdominal examination included the liver, spleen, kidneys, stomach, small and large intestines, mesentery, pancreas, urinary bladder and major vessels. Each injured organ was recorded separately. Associated injuries to the head, neck, spine, pelvis and extremities were also documented.

Cases were classified as isolated thoracic, isolated abdominal or combined thoraco-abdominal injuries according to internal examination findings. The mode and manner of injury were determined from the available records, history and autopsy findings. Survival interval was calculated from the reported time of injury to death when reliable information was available and grouped as within 24 hours, 1–3 days, 4–7 days or more than seven days. Cause of death was determined by correlating autopsy findings with clinical and medicolegal records.

Statistical analysis included data entry and checking in Microsoft Excel. Categorical variables were expressed as frequencies and percentages. Normally distributed continuous variables were summarized as mean and standard deviation; other variables were described using appropriate measures. Associations between categorical variables were assessed using the chi-square test when its assumptions were satisfied. Tests were two-tailed, and  $p < 0.05$  was considered statistically significant.

## RESULTS

A total of 150 fatal thoraco-abdominal trauma cases were examined. The largest age group was 21–30 years, comprising 47 cases (31.3%), followed by 31–40 years with 42 cases (28.0%). Together, these groups constituted 59.3% of the sample. There were 123 males (82.0%) and 27 females (18.0%).

Road traffic accidents accounted for 94 cases (62.7%), followed by falls from height in 22 (14.7%), assaults in 17 (11.3%) and railway accidents in eight (5.3%). Firearm injuries accounted for six cases (4.0%), and other mechanisms for three (2.0%). Combined thoraco-abdominal injuries were present in 87 cases (58.0%), compared with isolated thoracic injuries in 34 (22.7%) and isolated abdominal injuries in 29 (19.3%). Haemorrhagic shock was the leading cause of death, accounting for 76 cases (50.7%), followed by septicaemia in 45 (30.0%) and haemorrhagic shock with head injury in 29 (19.3%) (Table 1).

**Table 1-Mode of injury, survival interval, injury distribution and cause of death**

| Variable            | Category                            | Frequency, n (%) |
|---------------------|-------------------------------------|------------------|
| Mode of injury      | Road traffic accident               | 94 (62.7)        |
|                     | Fall from height                    | 22 (14.7)        |
|                     | Assault                             | 17 (11.3)        |
|                     | Railway accident                    | 8 (5.3)          |
|                     | Firearm injury                      | 6 (4.0)          |
|                     | Others                              | 3 (2.0)          |
| Survival interval   | Within 24 hours                     | 52 (34.7)        |
|                     | 1–3 days                            | 63 (42.0)        |
|                     | 4–7 days                            | 24 (16.0)        |
|                     | >7 days                             | 11 (7.3)         |
| Injury distribution | Isolated thoracic                   | 34 (22.7)        |
|                     | Isolated abdominal                  | 29 (19.3)        |
|                     | Combined thoraco-abdominal          | 87 (58.0)        |
| Cause of death      | Haemorrhagic shock                  | 76 (50.7)        |
|                     | Haemorrhagic shock with head injury | 29 (19.3)        |
|                     | Septicaemia                         | 45 (30.0)        |

Abrasion was the most frequent external injury over the thorax and abdomen, occurring in 95 cases (63.3%) and 72 cases (48.0%), respectively. Thoracic contusions were present in 76 cases (50.7%) and lacerations in 34 (22.7%). Abdominal contusions occurred in 63 cases (42.0%) and lacerations in 42 (28.0%). Rib fractures were identified in 86 cases (57.3%) (Table 2).

**Table 2- Principal external and internal thoraco-abdominal injuries**

| Injury group                | Finding           | Frequency, n (%) |
|-----------------------------|-------------------|------------------|
| External thoracic injuries  | Abrasion          | 95 (63.3)        |
|                             | Contusion/bruises | 76 (50.7)        |
|                             | Laceration        | 34 (22.7)        |
|                             | Stab wound        | 8 (5.3)          |
|                             | Firearm wound     | 6 (4.0)          |
| External abdominal injuries | Abrasion          | 72 (48.0)        |
|                             | Contusion/bruises | 63 (42.0)        |
|                             | Laceration        | 42 (28.0)        |
|                             | Incised wound     | 7 (4.7)          |
|                             | Firearm wound     | 5 (3.3)          |

|                          |                    |           |
|--------------------------|--------------------|-----------|
| Thoracic skeletal injury | Rib fracture       | 86 (57.3) |
| Thoracic organ injuries  | Lung               | 68 (45.3) |
|                          | Pleura             | 47 (31.3) |
|                          | Heart/pericardium* | 19 (12.7) |
|                          | Diaphragm          | 12 (8.0)  |
|                          | Great vessels      | 8 (5.3)   |
| Abdominal organ injuries | Liver              | 81 (54.0) |
|                          | Spleen             | 42 (28.0) |
|                          | Kidney             | 37 (24.7) |
|                          | Small intestine    | 21 (14.0) |
|                          | Mesentery          | 18 (12.0) |
|                          | Stomach            | 12 (8.0)  |
|                          | Large intestine    | 9 (6.0)   |
|                          | Urinary bladder    | 7 (4.7)   |
|                          | Pancreas           | 5 (3.3)   |
| Internal haemorrhage     | Haemothorax        | 61 (40.7) |
|                          | Haemoperitoneum    | 78 (52.0) |

The lungs were the most frequently injured thoracic organs, involved in 68 cases (45.3%), followed by the pleura in 47 (31.3%) and the heart/pericardium in 19 (12.7%). Diaphragmatic and great-vessel injuries occurred in 12 (8.0%) and eight cases (5.3%), respectively. The liver was the most commonly injured abdominal organ, involved in 81 cases (54.0%), followed by the spleen in 42 (28.0%) and kidneys in 37 (24.7%). Small-intestinal and mesenteric injuries were present in 21 (14.0%) and 18 cases (12.0%), respectively. Haemothorax occurred in 61 cases (40.7%), and haemoperitoneum in 78 (52.0%) (Table 2).

Lung injury was present in 58 of 86 cases with rib fractures (67.4%), compared with 10 of 64 without fractures (15.6%;  $p<0.001$ ). Haemothorax was present in 59 cases with rib fractures (68.6%) and two without fractures (3.1%;  $p<0.001$ ). Haemoperitoneum occurred in 63 of 81 cases with liver injury (77.8%), compared with 15 of 69 without liver injury (21.7%;  $p<0.001$ ). Death due to haemorrhagic shock occurred in 31 of 42 cases with splenic injury (73.8%) and 45 of 108 without splenic injury (41.7%; reported  $p=0.003$ ) (Table 3).

The proportion of deaths due to haemorrhagic shock generally increased with the number of injured organs: 26.3% with one organ, 42.6% with two, 61.1% with three, 83.3% with four and 81.8% with five or more organs ( $p<0.001$ ). Combined thoraco-abdominal injuries were present in 76.9% of cases dying within 24 hours, 54.0% of those surviving 1–3 days, 37.5% of those surviving 4–7 days and 36.4% of those surviving more than seven days (reported  $p=0.018$ ) (Table 3).

**Table 3-Associations involving injury findings, haemorrhagic death and survival**

| Association                                             | Category               | Outcome, n/N (%) | p-value |
|---------------------------------------------------------|------------------------|------------------|---------|
| Rib fracture and lung injury                            | Rib fracture present   | 58/86 (67.4)     | <0.001  |
|                                                         | Rib fracture absent    | 10/64 (15.6)     |         |
| Rib fracture and haemothorax                            | Rib fracture present   | 59/86 (68.6)     | <0.001  |
|                                                         | Rib fracture absent    | 2/64 (3.1)       |         |
| Liver injury and haemoperitoneum                        | Liver injury present   | 63/81 (77.8)     | <0.001  |
|                                                         | Liver injury absent    | 15/69 (21.7)     |         |
| Splenic injury and haemorrhagic shock                   | Splenic injury present | 31/42 (73.8)     | 0.003   |
|                                                         | Splenic injury absent  | 45/108 (41.7)    |         |
| Number of injured organs and haemorrhagic shock         | One                    | 10/38 (26.3)     | <0.001  |
|                                                         | Two                    | 20/47 (42.6)     |         |
|                                                         | Three                  | 22/36 (61.1)     |         |
|                                                         | Four                   | 15/18 (83.3)     |         |
|                                                         | Five or more           | 9/11 (81.8)      |         |
| Survival interval and combined thoraco-abdominal injury | Within 24 hours        | 40/52 (76.9)     | 0.018   |
|                                                         | 1–3 days               | 34/63 (54.0)     |         |
|                                                         | 4–7 days               | 9/24 (37.5)      |         |
|                                                         | >7 days                | 4/11 (36.4)      |         |

Liver injury occurred in 63.8% of road traffic accident cases, compared with 45.5% of falls, 41.2% of assaults, 25.0% of railway accidents and 22.2% of other mechanisms. The reported association between mode of injury and liver

injury was significant ( $p=0.028$ ). Lung injury was also most frequent in road traffic accident cases (53.2%), but its association with mode of injury was not significant ( $p=0.135$ ) (Table 4).

**Table 4- Association of mode of trauma with liver and lung injuries (N=150)**

| Mode of trauma        | Total cases, n | Liver injury, n (%) | Lung injury, n (%) |
|-----------------------|----------------|---------------------|--------------------|
| Road traffic accident | 94             | 60 (63.8)           | 50 (53.2)          |
| Fall from height      | 22             | 10 (45.5)           | 8 (36.4)           |
| Assault               | 17             | 7 (41.2)            | 6 (35.3)           |
| Railway accident      | 8              | 2 (25.0)            | 2 (25.0)           |
| Other mechanisms*     | 9              | 2 (22.2)            | 2 (22.2)           |
| Total                 | 150            | 81 (54.0)           | 68 (45.3)          |
| p-value               |                | 0.028               | 0.135              |

Death occurred within 24 hours in 52 cases (34.7%), within 1–3 days in 63 (42.0%), within 4–7 days in 24 (16.0%) and after seven days in 11 (7.3%). Haemorrhagic shock accounted for 44 of 52 deaths within 24 hours (84.6%). Its proportion decreased to 38.1% at 1–3 days, 25.0% at 4–7 days and 18.2% after seven days. Survival interval was associated with cause of death ( $p<0.001$ ) (Table 5).

**Table 5- Association between survival interval and cause of death (N=150)**

| Survival interval | Haemorrhagic shock, n (%) | Other causes of death*, n (%) | Total, n |
|-------------------|---------------------------|-------------------------------|----------|
| Within 24 hours   | 44 (84.6)                 | 8 (15.4)                      | 52       |
| 1–3 days          | 24 (38.1)                 | 39 (61.9)                     | 63       |
| 4–7 days          | 6 (25.0)                  | 18 (75.0)                     | 24       |
| >7 days           | 2 (18.2)                  | 9 (81.8)                      | 11       |
| Total             | 76 (50.7)                 | 74 (49.3)                     | 150      |

## DISCUSSION

The present study examined 150 fatal thoraco-abdominal trauma cases and found that young adult males constituted the largest proportion of victims. Road traffic accidents were the predominant mode of injury. Combined thoraco-abdominal injuries were more frequent than isolated injuries, and haemorrhagic shock was the leading cause of death.

Individuals aged 21–40 years accounted for 59.3% of cases, and males constituted 82.0%. These findings are consistent with the predominance of young adults reported by Reddy et al<sup>12</sup> and Kalara et al<sup>13</sup>, and the male predominance observed by Abymon et al<sup>14</sup> and Ranjan et al<sup>15</sup>. Greater exposure to road traffic, travel and occupations involving mechanical hazards may contribute to this distribution. However, exposure was not measured in the present study, and these explanations remain interpretative.

Road traffic accidents accounted for 62.7% of cases. Ananda Rao et al<sup>16</sup> and Raoof et al<sup>17</sup> similarly reported road traffic accidents as the most common mechanism, accounting for 67.0% and 71.4% of cases, respectively. Higher proportions were reported by Surwase<sup>18</sup> and Ranjan et al<sup>15</sup>. Differences in case selection may explain some of this variation, as the present study included fatal thoraco-abdominal injuries from several mechanisms rather than restricting inclusion to road traffic accidents or blunt abdominal trauma.

Abrasions and contusions were the most frequent external injuries over both the thorax and abdomen, consistent with the predominance of blunt trauma.

Similar external findings were described by Reddy et al<sup>12</sup> and Khan et al<sup>19</sup>. External injuries document the site and nature of contact, but their presence or extent alone cannot establish the severity of internal damage. Abymon et al<sup>14</sup> reported internal thoracic injuries without corresponding external findings in some cases, supporting systematic internal examination during medicolegal autopsy.

Rib fractures occurred in 57.3% of cases, comparable with the 60.0% reported by Abymon et al<sup>14</sup> and Singh and Prasad<sup>20</sup>. Lung injury was present in 67.4% of cases with rib fractures, compared with 15.6% without fractures. Haemothorax was also more frequent among cases with rib fractures. These associations are consistent with the coexistence of skeletal and pulmonary injuries described in earlier autopsy studies.<sup>12,15</sup> Fractured ribs may damage the lungs, pleura or intercostal vessels, while the force producing the fractures may independently injure intrathoracic structures. The present findings do not distinguish between these mechanisms. Lung injury in cases without rib fractures also indicates that internal thoracic damage can occur without skeletal disruption. The lungs were the most frequently injured thoracic organs, involved in 45.3% of cases. Previous studies likewise identified the lungs as a common site of thoracic visceral injury.<sup>12,14,21</sup> Direct numerical comparisons require caution because some studies expressed lung injury as a proportion of all cases, while others used cases with internal thoracic injury or the total number of recorded injuries as the

denominator. Although lung injury was most frequent among road traffic accident cases in the present study, its association with mode of injury was not statistically significant ( $p=0.135$ ).

The liver was the most commonly injured abdominal organ, followed by the spleen and kidneys. This distribution agrees with findings reported by Reddy et al<sup>12</sup>, Abymon et al<sup>14</sup> and Ranjan et al<sup>15</sup>. Liver injury occurred in 63.8% of road traffic accident cases, and the reported association with mode of injury was significant. The size, vascularity and attachments of the liver may contribute to its susceptibility to compression and deceleration forces. Nevertheless, differences in the proportions across mechanisms should be interpreted cautiously because the railway and other-mechanism groups contained few cases.

Haemoperitoneum was present in 77.8% of cases with liver injury, compared with 21.7% without liver injury. Splenic injury was also associated with a greater proportion of deaths attributed to haemorrhagic shock. These findings support the contribution of hepatic and splenic trauma to internal blood loss. Previous studies have identified these organs as frequent sites of abdominal injury and haemorrhage as an important cause of death.<sup>12,14,16</sup> As multiple injuries were common in the present sample, the independent contribution of each organ injury could not be determined from these unadjusted associations.

Combined thoraco-abdominal injuries accounted for 58.0% of cases. Comparison with earlier studies is affected by differences in definitions and inclusion criteria. Datta et al<sup>22</sup> reported combined thoracic-abdominal injuries with associated injuries in 83.75% of cases, whereas Kalara et al<sup>13</sup> reported combined thoraco-abdominal injuries in 16.41%. These categories are not directly equivalent. In the present study, combined injury was classified from internal examination findings and was associated with shorter survival intervals.

The proportion of deaths attributed to haemorrhagic shock generally increased with the number of injured organs. It rose from 26.3% among cases with one injured organ to 83.3% among those with four. Multiple-organ involvement may provide several sources of bleeding, although this study did not assess the independent effects of injury severity or associated trauma. The slightly lower proportion in cases with five or more injured organs should be interpreted in the context of the small group size of 11 cases.

Haemorrhagic shock accounted for 84.6% of deaths within 24 hours, whereas other causes predominated at longer survival intervals. Ananda Rao et al<sup>16</sup> and Ranjan et al<sup>15</sup> similarly identified haemorrhage as an important mechanism of early death. The association between combined injury and shorter survival is also consistent with studies reporting an inverse relationship between injury severity and survival time.<sup>17,22</sup> However, the grouped category of other causes included both septicaemia and haemorrhagic

shock with head injury; the findings therefore cannot establish the timing of septicaemic deaths separately.

The study provides autopsy-based documentation of external and internal injury patterns from Rajasthan. Its limitations include the single-centre setting and restriction to fatal cases, which prevent estimation of mortality risk among all patients with thoraco-abdominal trauma. Information on prehospital care, treatment, protective devices and crash characteristics was incomplete. Histopathological and toxicological findings were not correlated with injury patterns. The reported associations were unadjusted and cannot establish causation. Multicentre studies integrating autopsy findings with clinical records and injury-severity measures would allow further assessment of the factors associated with fatal outcomes.

## CONCLUSION

Fatal thoraco-abdominal trauma predominantly affected young adult males, with road traffic accidents being the leading mode of injury. Abrasions and contusions were the most common external injuries, while the lungs and liver were the most frequently injured thoracic and abdominal organs. Combined thoraco-abdominal injuries were common, and haemorrhagic shock was the principal cause of death. Rib fractures were associated with lung injury and haemothorax, liver injury with haemoperitoneum, and splenic injury with haemorrhagic shock. Greater organ involvement was associated with a higher proportion of haemorrhagic deaths, while combined injuries were associated with shorter survival intervals. These findings highlight the importance of systematic medicolegal autopsy examination and support efforts to strengthen road safety, early recognition of internal injuries and timely trauma care.

## DECLARATIONS

### Ethics Approval and Consent to Participate

The study was conducted on medicolegal autopsy cases examined at the Department of Forensic Medicine and Toxicology, Sawai Man Singh Medical College and Associated Hospitals, Jaipur, Rajasthan, India. The study involved analysis of autopsy findings and relevant medicolegal and hospital records. Ethical approval was obtained from the appropriate institutional ethics committee, as applicable to the study protocol. As the study involved deceased individuals and retrospective review of medicolegal records, individual consent to participate was not applicable.

### Consent for Publication

Not applicable. No personally identifiable information of individual deceased persons is presented in this manuscript.

### Availability of Data and Materials

The data generated and/or analysed during the present study are available from the corresponding author on reasonable request, subject to applicable institutional, ethical, and medicolegal restrictions.

### Competing Interests

The authors declare that they have no competing interests.

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### Authors' Contributions

All authors contributed to the conception and design of the study, data collection and/or interpretation of findings, manuscript preparation, critical revision of the manuscript, and approval of the final version. All authors agree to be accountable for the work and ensure the accuracy and integrity of the study.

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### AI Use Disclosure

The authors declare that no generative artificial intelligence tools were used to generate or substantially modify the scientific content of this manuscript.

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