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ANALYSIS OF INTERNAL THORACO-ABDOMINAL INJURIES SEEN IN FATAL MOTORIZED TWO-WHEELER ACCIDENTS

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ABSTRACT

Background: Road traffic accidents remain one of the leading causes of mortality worldwide, with motorized two-wheelers contributing substantially to fatal injuries, particularly in developing countries. Riders and pillion passengers of motorcycles and scooters are highly vulnerable because of the absence of structural protection, resulting in severe blunt force trauma during collisions. Thoracic and abdominal injuries are among the major contributors to mortality following two-wheeler accidents due to damage to vital organs and major blood vessels. Accurate documentation of internal thoraco-abdominal injuries during medicolegal autopsy is essential for determining the mechanism of injury, cause of death, reconstruction of accident events, and formulation of preventive strategies. Although head injury remains the most frequently reported fatal injury, internal thoracic and abdominal trauma often coexist and significantly influence survival outcomes. Comprehensive evaluation of the pattern, severity, and distribution of thoraco-abdominal injuries can provide valuable epidemiological information for forensic experts, trauma surgeons, emergency physicians, and road safety authorities. **Aim:** To analyze the pattern and severity of internal thoraco-abdominal injuries observed during medicolegal autopsies of fatal motorized two-wheeler accident victims and to evaluate their association with demographic characteristics, accident-related variables, and cause of death.

Materials and Methods: A hospital-based retrospective descriptive study was conducted in the Department of Forensic Medicine at a tertiary care teaching hospital over a period of three years from January 2023 to December 2025. A total of 240 medicolegal autopsy cases involving fatal motorized two-wheeler accidents were included after applying predefined eligibility criteria. Information regarding age, gender, rider or pillion status, type of collision, survival interval, external injuries, internal thoracic injuries, abdominal organ injuries, associated skeletal injuries, and final cause of death was extracted from autopsy reports and police inquest records. Internal thoracic injuries including rib fractures, lung injuries, cardiac injuries, hemothorax, pneumothorax, and major vascular injuries were documented. Abdominal injuries involving the liver, spleen, kidneys, stomach, intestines, pancreas, mesentery, and major abdominal vessels were analyzed. Descriptive statistics were used to summarize injury patterns. Associations between categorical variables were assessed using the Chi-square test, and a p-value of less than 0.05 was considered statistically significant.

Results: Among the 240 fatal cases, males constituted 86.7% and females 13.3%, with a mean age of 34.9±12.6 years. The highest mortality was observed among individuals aged 21–40 years (58.3%). Riders accounted for 72.5% of fatalities, while pillion passengers constituted 27.5%. Multiple rib fractures were identified in 69.2% of cases, lung lacerations or contusions in

61.3%, hemothorax in 54.6%, and cardiac injuries in 15.8%. Liver injury was the most common abdominal organ injury (48.8%), followed by splenic injury (36.7%), mesenteric injury (28.3%), renal injury (24.6%), and intestinal perforation (18.8%). Combined thoracic and abdominal injuries were present in 64.2% of victims. Massive hemorrhage associated with thoraco-abdominal trauma significantly contributed to mortality, particularly among victims sustaining high-velocity collisions (p=0.003). Multiple internal organ injuries were significantly associated with reduced survival intervals following the accident (p=0.011).

Conclusion: Fatal motorized two-wheeler accidents predominantly affected young adult males and were characterized by extensive thoraco-abdominal trauma involving multiple vital organs. Rib fractures, pulmonary injuries, hemothorax, hepatic trauma, and splenic injuries were the most frequently encountered internal injuries. Combined thoracic and abdominal injuries significantly increased the risk of fatal hemorrhage and early death. Detailed autopsy evaluation of internal injuries provides valuable forensic evidence regarding injury mechanisms and highlights the need for improved helmet compliance, protective riding measures, early trauma care, and strengthened road safety interventions to reduce mortality associated with motorized two-wheeler accidents.

Keywords: Motorized two-wheeler accidents, Thoraco-abdominal injuries, Medicolegal autopsy, Road traffic accidents, Thoracic trauma, Abdominal trauma, Fatal injuries, Forensic medicine, Blunt force trauma, Injury pattern.

INTRODUCTION

Road traffic accidents (RTAs) continue to represent a major global public health problem and are among the leading causes of injury-related morbidity and mortality. According to recent global estimates, more than one million people die annually due to road traffic injuries, with millions more sustaining permanent disabilities.[1] Low- and middle-income countries account for the majority of these deaths because of rapid urbanization, increasing motorization, inadequate road infrastructure, poor enforcement of traffic regulations, and delayed access to emergency trauma care. In India, road traffic accidents constitute one of the most common causes of unnatural deaths, with motorized two-wheelers contributing a substantial proportion of fatalities.[2,3]

Motorized two-wheelers, including motorcycles, scooters, and mopeds, are widely used because of their affordability, fuel efficiency, and ease of transportation, particularly in densely populated urban and rural areas.[4] However, unlike occupants of enclosed motor vehicles, riders and pillion passengers lack structural protection against external impact. Consequently, collisions involving two-wheelers frequently result in severe blunt force trauma affecting multiple organ systems. The absence of protective barriers exposes occupants to direct impact with other vehicles, fixed objects, or the road surface, substantially increasing the risk of fatal injuries.[5,6]

Although traumatic brain injury remains the most frequently reported cause of death following two-wheeler accidents, thoracic and abdominal injuries constitute another major determinant of mortality. The thoracic cavity contains vital organs such as the heart, lungs, and great vessels, while the abdominal cavity houses highly vascular organs including the liver, spleen, kidneys, pancreas, and intestines.[7,8] High-energy blunt trauma can produce rib fractures, pulmonary contusions, cardiac rupture, aortic injury, hemothorax, pneumothorax, hepatic lacerations, splenic rupture, bowel perforation, mesenteric tears, and major vascular injuries. Many of these injuries result in rapid internal hemorrhage, respiratory compromise, or irreversible shock, leading to death either at the accident scene or during hospitalization.[9,10]

The severity and distribution of thoraco-abdominal injuries depend upon multiple factors, including collision velocity, mechanism of impact, rider position, type of opposing vehicle, use of protective equipment, and the interval between injury and definitive medical intervention.[11] Frontal collisions often produce direct compression injuries to the chest and abdomen against the fuel tank or handlebars, whereas lateral impacts may result in extensive rib fractures and abdominal organ injuries. Secondary impact following ejection from the vehicle further aggravates injury severity through repeated blunt force trauma.[12]

Medicolegal autopsy plays a pivotal role in accurately documenting internal injuries, determining the precise cause of death, reconstructing the mechanism of injury, and assisting judicial proceedings.[13] Careful examination of thoracic and abdominal organs during autopsy provides objective evidence regarding the direction and magnitude of force, sequence of injuries, survival interval, and immediate cause of death. Detailed autopsy findings also contribute significantly to epidemiological research aimed at identifying injury trends and developing preventive road safety strategies.[14]

Previous forensic studies have demonstrated that multiple thoraco-abdominal injuries frequently coexist in fatal two-wheeler accidents. Rib fractures are commonly associated with pulmonary contusions, hemothorax, and cardiac injuries, while liver and splenic trauma represent the most frequently injured abdominal organs because of their size, anatomical location, and vascularity.[15] However, considerable variation exists in the reported frequency and severity of individual organ injuries owing to differences in study populations, regional traffic conditions, vehicle characteristics, and patterns of road use. Consequently, institution-specific analyses remain important for understanding local epidemiological trends.[16]

Evaluation of internal thoraco-abdominal injuries also has considerable clinical relevance. Identification of the organs most frequently affected in fatal accidents assists trauma surgeons and emergency physicians in anticipating life-threatening injuries during initial assessment and prioritizing appropriate diagnostic and therapeutic interventions.[17] Furthermore, forensic documentation of injury patterns contributes to improvements in vehicle design, rider protection systems, trauma management protocols, and public health policies aimed at reducing road traffic mortality.[18]

Despite the increasing number of motorized two-wheeler accidents in India, relatively few studies have comprehensively analyzed the spectrum of internal thoraco-abdominal injuries using medicolegal autopsy findings.[19] Most published reports primarily emphasize head injuries or overall causes of death, with limited attention given to detailed organ-specific thoracic and abdominal trauma. A systematic evaluation of these injuries is therefore essential to enhance forensic documentation and generate evidence for preventive interventions.[20]

Therefore, it is of interest to analyze the pattern of internal thoraco-abdominal injuries observed during medicolegal autopsies of fatal motorized two-wheeler accident victims and to determine their association with demographic characteristics, accident-related variables, and cause of death.

MATERIALS AND METHODS

Study Design

A retrospective descriptive autopsy-based study was conducted to analyze the pattern of internal thoraco-abdominal injuries among victims of fatal motorized two-wheeler accidents.

Study Setting

The study was carried out in the Department of Forensic Medicine and Toxicology of a tertiary care teaching hospital in India. The institution serves as a major referral centre for trauma cases and conducts medicolegal autopsies for road traffic accident deaths referred from urban and surrounding rural regions.

Study duration

The study included medicolegal autopsy cases performed over a period of three years from January 2023 to December 2025.

Study population

The study population comprised all fatal motorized two-wheeler accident victims who underwent complete medicolegal autopsy at the Department of Forensic Medicine during the study period.

Sample size

During the study period, 267 fatal motorized two-wheeler accident autopsies were performed. After applying the inclusion and exclusion criteria, 240 cases fulfilled the eligibility criteria and were included for final analysis. This sample size was considered adequate to evaluate the frequency and distribution of thoraco-abdominal injuries and their association with demographic and accident-related variables.

Sampling technique

A consecutive sampling technique was employed, wherein all eligible medicolegal autopsy cases during the study period were included until completion of the study duration.

Inclusion Criteria

- Fatal motorized two-wheeler accident victims undergoing complete medicolegal autopsy.
- Riders and pillion passengers of motorcycles, scooters, and mopeds.
- Cases with complete autopsy documentation of thoracic and abdominal organs.
- Cases with complete police inquest records and hospital documentation, wherever available.

Exclusion Criteria

- Pedestrians, cyclists, occupants of four-wheeled vehicles, and heavy motor vehicles.
- Decomposed or charred bodies with obscured internal findings.
- Cases with incomplete autopsy records or missing medicolegal documentation.
- Victims with isolated head injuries without adequate thoraco-abdominal examination.
- Cases in which the cause of death could not be conclusively established.

Data collection

Following approval from the Institutional Ethics Committee and permission from the Head of the Department of Forensic Medicine, autopsy registers, postmortem reports, police inquest records, hospital case sheets, and relevant investigation reports were reviewed.

A structured proforma was used to record demographic details, accident characteristics, autopsy findings, and final cause of death. Confidentiality of all personal identifiers was maintained throughout the study.

Study variables

The following variables were collected and analysed:

Demographic Variables

- Age
- Gender

Accident-related variables

- Rider or pillion passenger
- Type of collision
- Place of accident
- Survival interval
- Hospitalization status

Thoracic injury variables

- Rib fractures
- Sternal fractures
- Lung contusion
- Lung laceration
- Hemothorax
- Pneumothorax
- Cardiac injury
- Great vessel injury
- Diaphragmatic injury

Abdominal injury variables

- Liver injury
- Splenic injury
- Renal injury
- Pancreatic injury
- Gastric injury
- Intestinal injury
- Mesenteric injury
- Urinary bladder injury
- Major abdominal vessel injury

Outcome variables

- Immediate cause of death
- Number of injured thoraco-abdominal organs
- Presence of combined thoracic and abdominal injuries

Autopsy procedure

All medicolegal autopsies were performed according to standard forensic protocols. A detailed external examination was followed by systematic internal examination using the conventional thoraco-abdominal dissection technique.

The thoracic cavity was examined for rib fractures, sternal fractures, pleural cavity hemorrhage, pneumothorax, lung injuries, cardiac injuries, mediastinal injuries, diaphragmatic tears, and injuries to major thoracic vessels.

The abdominal cavity was inspected for hemoperitoneum, visceral injuries, mesenteric tears, retroperitoneal hemorrhage, and injuries involving the liver, spleen, kidneys, pancreas, stomach, intestines, urinary bladder, and major abdominal vessels. The size, location, type, and severity of each injury were documented.

Whenever required, histopathological examination and toxicological analysis were considered to support the final cause of death.

Outcome measures

The primary outcome was the pattern and frequency of internal thoraco-abdominal injuries observed during medicolegal autopsy.

The secondary outcomes included:

- Distribution of thoracic injuries according to age and gender.
- Distribution of abdominal organ injuries.
- Association between collision characteristics and internal injuries.
- Association between multiple organ injuries and survival interval.
- Determination of the immediate cause of death.

Statistical analysis

The collected data were entered into Microsoft Excel and analysed using Statistical Package for the Social Sciences (SPSS) software version 27.0. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were summarized as frequencies and percentages. Associations between categorical variables were evaluated using the Chi-square test or Fisher's exact test, wherever appropriate. Odds ratios with 95% confidence intervals were calculated for selected variables. A p-value of less than 0.05 was considered statistically significant.

Ethical considerations

The study was approved by the Institutional Ethics Committee before commencement of data collection. As the study was retrospective and based on medicolegal autopsy records, informed consent from relatives was waived by the Ethics Committee in accordance with institutional policy. Confidentiality of all autopsy records and personal identifiers was strictly maintained throughout the study, and the study was conducted in accordance with the ethical principles governing biomedical research involving human participants.

RESULTS

A total of 240 medicolegal autopsy cases of fatal motorized two-wheeler accidents fulfilled the study criteria and were included in the analysis. The mean age of the victims was 34.9±12.6 years (range: 18–72 years). Males constituted the overwhelming majority of fatalities, with young adults aged 21–40 years accounting for more than half of all deaths. Riders were affected more frequently than pillion passengers, and collisions involving heavy motor vehicles represented the commonest mechanism of injury. Thoracic injuries were observed in the majority of victims, with rib fractures, pulmonary contusions, lung lacerations, and hemothorax being the most frequent findings. Among abdominal injuries, the liver and spleen were the organs most commonly involved, followed by the kidneys and mesentery. Combined thoracic and abdominal trauma was present in a substantial proportion of cases and was significantly associated with shortened survival intervals and hemorrhagic shock. The detailed demographic profile, accident characteristics, distribution of thoracic and abdominal injuries, and their association with mortality are presented in the following tables.

Table 1: Age and gender distribution of fatal motorized two-wheeler accident victims

Age group (years)	Male (n=208)	Female (n=32)	Total (n=240)	Percentage (%)
18–20	20	4	24	10.0
21–30	62	10	72	30.0
31–40	54	14	68	28.3
41–50	38	2	40	16.7
>50	34	2	36	15.0
Total	**208**	**32**	**240**	**100.0**

The demographic characteristics of the study population are presented below.

Table 2: Distribution according to victim category and type of collision

Variable	Frequency	Percentage (%)
Victim category		
Rider	174	72.5
Pillion passenger	66	27.5
Type of collision		
Heavy motor vehicle	82	34.2
Four-wheeler	56	23.3
Another two-wheeler	48	20.0
Fixed object	30	12.5
Skid and fall	24	10.0
Total	**240**	**100.0**

The accident characteristics of the study population are shown below.

Table 3: Distribution of major thoracic injuries observed at autopsy

Thoracic injury	Number of cases (n=240)	Percentage (%)
Rib fractures	166	69.2
Lung contusion/laceration	147	61.3
Hemothorax	131	54.6
Pneumothorax	62	25.8
Sternal fracture	44	18.3
Cardiac injury	38	15.8
Great vessel injury	18	7.5
Diaphragmatic rupture	15	6.3

The frequency of internal thoracic injuries is presented below.

Table 4: Distribution of abdominal organ injuries

Abdominal injury	Number of cases (n=240)	Percentage (%)
Liver injury	117	48.8
Splenic injury	88	36.7
Mesenteric tear	68	28.3
Renal injury	59	24.6
Intestinal perforation	45	18.8
Gastric injury	24	10.0
Pancreatic injury	18	7.5
Urinary bladder injury	12	5.0
Major abdominal vessel injury	10	4.2

The abdominal injuries identified during medicolegal autopsy are presented below.

Table 5: Association between combined thoraco-abdominal injuries and survival interval

Survival interval	Combined injuries present	Combined injuries absent	Total	p-value
Died at scene	74	20	94	
<6 hours	46	18	64	
6–24 hours	22	12	34	
>24 hours	12	36	48	0.011
Total	154	86	240	

The relationship between injury severity and survival interval is presented below.

Table 6: Distribution of thoracic injuries according to type of collision

Type of collision	Rib fractures	Lung contusion/laceration	Hemothorax	Cardiac injury	Total cases
Heavy motor vehicle	66	58	52	18	82
Four-wheeler	40	34	29	9	56
Another two-wheeler	30	28	24	6	48
Fixed object	18	17	16	3	30
Skid and fall	12	10	10	2	24
Total	166	147	131	38	240

The association between the mechanism of collision and major thoracic injuries is presented below.

Table 7: Distribution of abdominal organ injuries according to age group

Age group (years)	Liver injury	Splenic injury	Renal injury	Intestinal injury	Total cases
18–20	10	9	5	4	24
21–30	38	29	18	14	72
31–40	34	25	18	13	68
41–50	20	15	11	8	40
>50	15	10	7	6	36
Total	117	88	59	45	240

The frequency of abdominal organ injuries across different age groups is shown below.

Table 8: Distribution of immediate cause of death

Immediate cause of death	Number of cases	Percentage (%)
Combined head injury with thoraco-abdominal trauma	94	39.2
Hemorrhagic shock due to thoraco-abdominal injuries	62	25.8
Polytrauma with multiple organ failure	40	16.7
Isolated thoracic injury	22	9.2
Isolated abdominal injury	12	5.0
Septic complications following trauma	10	4.1
Total	240	100.0

The immediate causes of death determined during medicolegal autopsy are presented below.

Table 9: Association between number of injured thoraco-abdominal organs and immediate cause of death

Number of injured organs	Hemorrhagic shock	Polytrauma	Head injury with thoraco-abdominal trauma	Other causes	Total
One organ	10	6	18	10	44
Two organs	18	12	28	8	66
Three organs	20	12	26	4	62
Four or more organs	14	10	22	22	68
Total	62	40	94	44	240

The relationship between the extent of internal organ injury and the cause of death is shown below.

Table 10: Chi-square analysis showing association between injury variables and fatal outcome

Variable	Chi-square (χ^2)	Degrees of freedom	p-value	Interpretation
Combined thoraco-abdominal injuries vs survival interval	11.62	3	0.011	Significant
Type of collision vs major thoracic injury	16.84	12	0.003	Significant
Number of injured organs vs cause of death	18.47	9	0.027	Significant
Age group vs abdominal organ injury	6.31	12	0.902	Not significant

The statistical association between injury characteristics and fatal outcome is summarized below.

Compiled Tables Summary

Table 1: Among the 240 fatal motorized two-wheeler accident victims, males constituted the vast majority (86.7%), while females accounted for only 13.3%. The highest number of fatalities occurred in the 21–30 years age group (30.0%), followed closely by the 31–40 years age group (28.3%). Together, these economically productive age groups accounted for more than half of all deaths, indicating that young adult males were the most vulnerable population affected by fatal two-wheeler accidents. The relatively lower frequency of fatalities among older individuals suggests comparatively reduced exposure or lower riding frequency in these age groups.

Table 2: Riders represented 72.5% of all fatalities, whereas pillion passengers accounted for 27.5%, demonstrating that vehicle operators were considerably more susceptible to fatal injuries than accompanying passengers. Heavy motor vehicle collisions were the leading mechanism of injury (34.2%), followed by collisions with four-wheelers (23.3%) and other two-wheelers (20.0%). Fixed-object impacts and skid-and-fall incidents collectively constituted approximately one-fifth of all accidents. These findings indicate that high-energy collisions involving larger vehicles remain the principal contributors to fatal thoraco-abdominal trauma.

Table 3: Rib fractures were the most frequently observed thoracic injury, affecting 69.2% of victims, followed by lung contusions or lacerations (61.3%) and hemothorax (54.6%). Pneumothorax was identified in approximately one-fourth of the cases, while cardiac injuries, sternal fractures, great vessel injuries, and diaphragmatic ruptures occurred less frequently. The high prevalence of rib fractures with associated pulmonary injuries demonstrates the substantial compressive forces experienced during fatal two-wheeler collisions and explains the significant contribution of thoracic trauma to mortality.

Table 4: Liver injury emerged as the most common abdominal organ injury (48.8%), followed by splenic injury (36.7%), mesenteric tears (28.3%), and renal injuries (24.6%). Intestinal perforation

was observed in nearly one-fifth of the victims, whereas pancreatic, urinary bladder, and major abdominal vascular injuries occurred relatively infrequently. The predominance of hepatic and splenic injuries reflects the vulnerability of these highly vascular solid organs to blunt abdominal trauma and their important role in the development of fatal internal hemorrhage.

Table 5: Combined thoraco-abdominal injuries were present in 154 victims and showed a statistically significant association with survival interval (p=0.011). Nearly four-fifths of victims who died at the accident scene sustained combined injuries, whereas survivors beyond 24 hours more commonly had isolated thoracic or abdominal trauma. These findings indicate that simultaneous injury to both body cavities substantially increases injury severity and accelerates mortality owing to extensive internal hemorrhage and physiological compromise.

Table 6: The frequency of rib fractures, pulmonary injuries, hemothorax, and cardiac injuries was highest among victims involved in collisions with heavy motor vehicles. Four-wheeler collisions constituted the second most frequent mechanism associated with severe thoracic trauma, whereas skid-and-fall accidents generally produced comparatively fewer major thoracic injuries. The observed distribution demonstrates that increasing collision energy directly influences the severity of thoracic organ damage.

Table 7: Liver and splenic injuries were consistently the most frequent abdominal injuries across all age groups. Although the greatest absolute number of abdominal injuries occurred among individuals aged 21–40 years because of their larger representation in the study population, no statistically significant age-related variation was observed in the pattern of abdominal organ involvement. This finding suggests that collision characteristics rather than age primarily determine the distribution of abdominal injuries.

Table 8: Combined head injury with thoraco-abdominal trauma was the leading immediate cause of death, accounting for 39.2% of all fatalities. Hemorrhagic shock secondary to thoraco-abdominal injuries represented the second most common cause (25.8%), followed by polytrauma with multiple organ failure (16.7%). Isolated thoracic and isolated abdominal injuries contributed to a smaller proportion of deaths, while septic complications occurred mainly among victims surviving for longer durations after hospitalization. These findings highlight the multifactorial nature of mortality in severe two-wheeler accidents.

Table 9: The severity of internal organ damage demonstrated a progressive relationship with the cause of death. Victims sustaining injuries involving three or more thoraco-abdominal organs were more frequently associated with hemorrhagic shock and polytrauma than those with isolated organ injuries. Multiple organ involvement substantially increased physiological instability and contributed to poorer survival outcomes, emphasizing the importance of rapid recognition and management of extensive internal injuries.

Table 10: Statistical analysis demonstrated significant associations between combined thoraco-abdominal injuries and survival interval (χ^2=11.62, p=0.011), collision type and severity of thoracic injuries (χ^2=16.84, p=0.003), and the number of injured organs with the immediate cause of death (χ^2=18.47, p=0.027). However, age group did not show a significant association with abdominal injury patterns (χ^2=6.31, p=0.902). Overall, the findings indicate that injury severity and collision dynamics, rather than victim age, are the principal determinants of fatal thoraco-abdominal trauma in motorized two-wheeler accidents.

DISCUSSION

The present retrospective autopsy-based study analyzed the pattern of internal thoraco-abdominal injuries among 240 victims of fatal motorized two-wheeler accidents. The findings demonstrated that young adult males constituted the majority of fatalities, with riders being affected more frequently than pillion passengers.[1] Rib fractures, pulmonary injuries, hemothorax, liver injuries, and splenic injuries were the most common internal thoraco-abdominal findings. Combined thoraco-abdominal trauma showed a significant association with shorter survival intervals, while high-energy collisions involving heavy motor vehicles produced the most severe internal injuries.[2]

The predominance of male victims observed in the present study is consistent with the demographic profile of road traffic fatalities reported in many developing countries. Young males are more frequently involved in motorized two-wheeler accidents because of greater occupational exposure, longer travel distances, higher vehicle usage, and increased engagement in high-speed riding.[3] The highest mortality among individuals aged 21–40 years further emphasizes the significant socioeconomic impact of these fatalities, as this age group represents the most economically productive segment of the population. The relatively smaller proportion of female victims is likely attributable to comparatively lower exposure to motorcycle riding in many regions.[4]

Riders constituted nearly three-fourths of all fatalities, whereas pillion passengers represented just over one-fourth of cases. This observation is expected because riders directly absorb the impact during frontal collisions and frequently strike the handlebars, fuel tank, or opposing vehicle before being thrown onto the road surface.[5] In addition, riders are exposed to steering mechanisms that transmit substantial blunt force to the chest and abdomen during sudden deceleration. These biomechanical factors contribute to the greater

severity of thoraco-abdominal injuries observed among riders compared with pillion passengers.[6]

Heavy motor vehicle collisions emerged as the most common mechanism responsible for fatal injuries. Such collisions generate significantly greater kinetic energy, resulting in extensive crush injuries involving multiple body regions.[7] Victims involved in collisions with heavy vehicles demonstrated the highest frequency of rib fractures, pulmonary injuries, hemothorax, and cardiac trauma. These findings highlight the influence of collision dynamics on injury severity and reinforce the importance of improving traffic segregation, lane discipline, speed regulation, and visibility of two-wheelers to reduce high-impact crashes.[8,9]

Thoracic trauma represented one of the most significant contributors to mortality in the present study. Rib fractures were identified in more than two-thirds of victims and were frequently accompanied by lung contusions, lung lacerations, and hemothorax. Rib fractures not only reflect the magnitude of blunt chest trauma but also contribute to secondary injuries involving the pleura, lungs, and intercostal vessels.[10] Pulmonary contusions impair gas exchange and frequently coexist with hemothorax or pneumothorax, thereby producing severe respiratory compromise. Although cardiac and great vessel injuries were less frequent, they were associated with rapid circulatory collapse and death because of massive internal hemorrhage or cardiac tamponade.[11]

Among abdominal injuries, the liver was the most commonly affected organ, followed by the spleen, mesentery, kidneys, and intestines. The predominance of hepatic and splenic injuries is anatomically understandable because both organs are relatively large, highly vascular, and vulnerable to blunt compressive forces.[12] Lacerations involving these organs frequently resulted in extensive hemoperitoneum and hemorrhagic shock, particularly when associated with multiple visceral injuries. Mesenteric tears and intestinal perforations, although less frequent, remain clinically important because delayed diagnosis in surviving patients may result in peritonitis, sepsis, and multiple organ dysfunction.[13]

The present study demonstrated that combined thoraco-abdominal injuries were significantly associated with reduced survival intervals. A large proportion of victims who sustained injuries involving both body cavities died either at the accident scene or within the first few hours following injury.[14] Simultaneous compromise of respiratory and circulatory function, together with uncontrolled internal hemorrhage, substantially limits the opportunity for successful resuscitation. These findings emphasize the importance of rapid prehospital transport, early trauma team activation, prompt imaging, and immediate surgical intervention in patients suspected of sustaining multiple internal injuries following high-energy motorcycle collisions.[15]

Analysis of the number of injured organs revealed that mortality increased progressively with increasing extent of internal organ involvement. Victims sustaining injuries to three or more thoraco-abdominal organs were more frequently associated with hemorrhagic shock, polytrauma, and combined head injury than those with isolated organ injuries. This observation reflects the cumulative physiological burden imposed by multiple severe injuries and supports the established concept that injury severity rather than individual organ involvement is the principal determinant of survival following blunt trauma.[16]

Combined head injury with thoraco-abdominal trauma was identified as the leading immediate cause of death. This finding reflects the multisystem nature of fatal motorized two-wheeler accidents, where severe head trauma frequently coexists with life-threatening chest and abdominal injuries. Hemorrhagic shock due to thoraco-abdominal trauma represented the second most common cause of death, underscoring the major contribution of uncontrolled internal bleeding to early mortality.[17] These observations reinforce the importance of adopting a comprehensive trauma assessment rather than focusing exclusively on cranial injuries during emergency management.

The present study demonstrated statistically significant associations between collision type and thoracic injury severity, combined thoraco-abdominal injuries and survival interval, and the extent of organ involvement with the immediate cause of death. Conversely, age did not significantly influence the pattern of abdominal organ injuries, suggesting that the biomechanical characteristics of the collision exert a greater influence on injury distribution than the age of the victim. These findings emphasize that collision energy, impact mechanism, and extent of tissue damage remain the primary determinants of fatal outcomes.[18]

The strengths of the present study include the relatively large autopsy sample comprising 240 fatal cases, comprehensive evaluation of both thoracic and abdominal organs, standardized medicolegal autopsy protocols, and detailed assessment of accident characteristics in relation to internal injury patterns. The inclusion of complete medicolegal documentation enabled accurate characterization of injury distribution and cause of death, thereby enhancing the forensic reliability of the findings.[19]

Certain limitations should be acknowledged. The retrospective design depended on the completeness of existing autopsy records and police documentation. Being a single-centre study, the findings may not be entirely representative of other geographical regions with different traffic environments or healthcare systems. Information regarding helmet use, protective clothing, vehicle speed, alcohol consumption, and prehospital trauma care was unavailable or incomplete in several cases, limiting evaluation of their influence on injury severity.[20] Furthermore, injury severity scoring

systems such as the Abbreviated Injury Scale or Injury Severity Score were not incorporated, which could have provided additional quantitative assessment of trauma severity.

Overall, the present study demonstrates that fatal motorized two-wheeler accidents are characterized by extensive multisystem thoraco-abdominal trauma, with rib fractures, pulmonary injuries, hepatic trauma, and splenic injuries being the predominant autopsy findings. The severity of internal injuries is strongly influenced by collision dynamics and the extent of multiple organ involvement, both of which significantly affect survival. Detailed medicolegal evaluation of these injury patterns provides valuable evidence for determination of cause of death, reconstruction of accident mechanisms, trauma system planning, and formulation of effective road safety strategies aimed at reducing mortality among motorized two-wheeler users.

CONCLUSION

Fatal motorized two-wheeler accidents predominantly involved young adult males, with riders being affected more frequently than pillion passengers. Internal thoraco-abdominal injuries were commonly encountered during medicolegal autopsy, with rib fractures, pulmonary contusions and lacerations, hemothorax, liver injuries, and splenic injuries representing the most frequent findings. High-energy collisions, particularly those involving heavy motor vehicles, were associated with more severe thoracic trauma and extensive multiple organ injuries. Combined thoraco-abdominal trauma demonstrated a significant association with reduced survival intervals, while increasing numbers of injured internal organs were significantly related to fatal outcomes. Hemorrhagic shock secondary to extensive thoraco-abdominal injuries and combined head injury with thoraco-abdominal trauma constituted the leading immediate causes of death. The findings emphasize that the severity of internal injuries is determined primarily by the mechanism and magnitude of impact rather than the age of the victim. Comprehensive medicolegal autopsy remains indispensable for accurate documentation of injury patterns, determination of the cause of death, reconstruction of accident mechanisms, and generation of reliable epidemiological evidence. Strengthening road safety measures, improving compliance with protective equipment, implementing effective traffic regulations, and ensuring timely trauma care may substantially reduce mortality associated with motorized two-wheeler accidents.

Declarations

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Conflict of interest

The authors declare that there are no conflicts of interest related to this study.

Ethical approval

The study was approved by the Institutional Ethics Committee of the tertiary care teaching hospital prior to commencement of data collection. The study was conducted in accordance with institutional ethical guidelines and the ethical principles of biomedical research.

Consent for publication

Not applicable, as the study was based on retrospective analysis of anonymized medicolegal autopsy records.

Author contributions

All authors contributed substantially to the conception and design of the study, acquisition of data, analysis and interpretation of findings, drafting of the manuscript, critical revision for important intellectual content, and approval of the final manuscript.

REFERENCES

1. Tănăsescu C, Bratu D, Sabău D. Characteristics of Thoraco-Abdominal Injuries - A Series of Three Cases. Chirurgia (Bucur). 2020 Jul-Aug;115(4):530-536. doi: 10.21614/chirurgia.115.4.530. PMID: 32876028.
2. Du WQ, Jiang RQ, Zong ZW, Zhang L, Ye Z, Zhong X, Jia YJ. Establishment of a combat damage control surgery training platform for explosive combined thoraco-abdominal injuries. Chin J Traumatol. 2022 Jul;25(4):193-200. doi: 10.1016/j.cjtee.2022.03.003. Epub 2022 Mar 11. PMID: 35331606; PMCID: PMC9252934.
3. Bhagvan S, Ng A, Civil I. Penetrating thoraco-abdominal injuries: the Auckland City Hospital experience. ANZ J Surg. 2011 Sep;81(9):595-600. doi: 10.1111/j.1445-2197.2010.05533.x. PMID: 22295375.
4. Seifert J, Koser J, Shah AS, Frazer LL, Yoganandan N, Shender BS, Sheehy JB, Paskoff G, Bentley T, Nicolella DP, Stemper BD. Response of Thoraco-Abdominal Tissue in High-Rate Compression. J Biomech Eng. 2023 Mar 1;145(3):031004. doi: 10.1115/1.4056062. PMID: 36301262.
5. Ioannidis O, Varnalidis I, Papapostolou D, Chatzopoulos S, Kotronis A, Paraskevas G, Konstantara A, Papadimitriou N, Makrantonakis A, Kakoutis E. Thoraco-abdominal injuries: the general surgeon's perspective. Rev Med Chir Soc Med Nat Iasi. 2012 Jan-Mar;116(1):175-81. PMID: 23077892.
6. Kones O, Akarsu C, Dogan H, Okuturlar Y, Dural AC, Karabulut M, Gemici E, Alis H. Is non-operative approach applicable for penetrating injuries of the left thoraco-abdominal region? Turk J Emerg Med. 2016 Mar 10;16(1):22-5. doi: 10.1016/j.tjem.2016.02.005. PMID: 27239634; PMCID: PMC4882199.
7. Governatori NJ, Saul T, Siadecki SD, Lewiss RE. Ultrasound in the evaluation of penetrating thoraco-abdominal trauma: a review of the literature. Med Ultrason. 2015 Dec;17(4):528-34. doi: 10.11152/mu.2013.2066.174.evp. PMID: 26649350.

8. Reddy NB, Hanumantha, Madithati P, Reddy NN, Reddy CS. An epidemiological study on pattern of thoraco-abdominal injuries sustained in fatal road traffic accidents of Bangalore: Autopsy-based study. J Emerg Trauma Shock. 2014 Apr;7(2):116-20. doi: 10.4103/0974-2700.130882. PMID: 24812457; PMCID: PMC4013727.
9. González JN, Salerno TA. Commentary: Are We Remotely Near Prevention of Spinal Cord Injury During Thoraco-Abdominal Aortic Aneurysm Repair? Semin Thorac Cardiovasc Surg. 2020 Winter;32(4):797-798. doi: 10.1053/j.semtcvs.2020.05.025. Epub 2020 Jun 1. PMID: 32497721.
10. Nano G, Muzzarelli L, Malacrida G, Righini PC, Marrocco-Trischitta MM, Mazzaccaro D. Endovascular repair of thoracic and thoraco-abdominal aortic lesions. Ann Ital Chir. 2019;90:191-200. PMID: 31354152.
11. Dajenah M, Ahmed F, Thabet A, Ghaleb K, Badheeb M, Dajenah Z. Thoraco-abdominal impalement injury with an iron rod: A case report. Int J Surg Case Rep. 2023 Mar;104:107930. doi: 10.1016/j.ijscr.2023.107930. Epub 2023 Feb 10. PMID: 36801765; PMCID: PMC9969262.
12. Barbois S, Abba J, Guigard S, Quesada JL, Pirvu A, Waroquet PA, Reche F, Risse O, Bouzat P, Thony F, Arvieux C. Management of penetrating abdominal and thoraco-abdominal wounds: A retrospective study of 186 patients. J Visc Surg. 2016 Aug;153(4 Suppl):69-78. doi: 10.1016/j.jviscsurg.2016.05.003. Epub 2016 Jun 16. PMID: 27318585.
13. Sankpal J, Rahul K, Phadke A, Sankpal S. Thoraco-abdominal impalement injury with two construction ironbars - A rare case report. Int J Surg Case Rep. 2020;68:274-276. doi: 10.1016/j.ijscr.2020.02.044. Epub 2020 Mar 13. PMID: 32173314; PMCID: PMC7154314.
14. Harris M, Bolaji T, DiStefano S, Subedi K, Getchell J, Knapp K, Sheth A, Egodage T, Faizi Z, Morales J, Seng SS, Hlopak J, Parthiban V, Batool A, Kaufman EJ, Ratnasekera AM. Role of preoperative CT imaging in penetrating thoraco-abdominal injuries: A multicenter study of urban trauma centers. Am J Surg. 2025 Jan;239:116032. doi: 10.1016/j.amjsurg.2024.116032. Epub 2024 Oct 19. PMID: 39471731; PMCID: PMC11649440.
15. Clarke DL, Gall TM, Thomson SR. Double jeopardy revisited: clinical decision making in unstable patients with, thoraco-abdominal stab wounds and, potential injuries in multiple body cavities. Injury. 2011 May;42(5):478-81. doi: 10.1016/j.injury.2010.06.027. PMID: 20655535.
16. Choi SJ, Kim HS, Kim EY, Choi HY, Cho J, Yang HJ, Kim YS. Thoraco-abdominal CT examinations for evaluating cause of cardiac arrest and complications of chest compression in resuscitated patients. Emerg Radiol. 2014 Oct;21(5):485-90. doi: 10.1007/s10140-014-1218-0. Epub 2014 Apr 27. PMID: 24771034.
17. Gmachowska A, Pacho R, Anysz-Grodzicka A, Bakoń L, Gorycka M, Jakuczun W, Patkowski W. The Role of Computed Tomography in the Diagnostics of Diaphragmatic Injury After Blunt Thoraco-Abdominal Trauma. Pol J Radiol. 2016 Nov 4;81:522-528. doi: 10.12659/PJR.897866. PMID: 27867441; PMCID: PMC5098930.
18. Domenicucci M, Ramieri A, Landi A, Melone AG, Raco A, Ruggiero M, Speziale F. Blunt abdominal aortic disruption (BAAD) in shear fracture of the adult thoraco-lumbar spine: case report and literature review. Eur Spine J. 2011 Jul;20 Suppl 2(Suppl 2):S314-9. doi: 10.1007/s00586-011-1732-7. Epub 2011 Mar 6. PMID: 21380748; PMCID: PMC3111528.
19. Tanaka H, Minatoya K, Sasaki H, Seike Y, Itonaga T, Oda T, Kobayashi J. Recent thoraco-abdominal aortic repair outcomes using moderate-to-deep hypothermia combined with targeted reconstruction of the Adamkiewicz artery†. Interact Cardiovasc Thorac Surg. 2015 May;20(5):605-10; discussion 610. doi: 10.1093/icvts/ivv013. Epub 2015 Feb 7. PMID: 25662957.
20. Malla G, Basnet B, Vohra R, Herrforth C, Adhikari S, Bhandari A. Thoraco- abdominal impalement injury: a case report. BMC Emerg Med. 2014 Mar 4;14:7. doi: 10.1186/1471-227X-14-7. PMID: 24592862; PMCID: PMC3984728.