International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Fatal Thoracic Trauma in Southern Assam: A Retrospective Autopsy-Based Investigation 2024-2025

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Abstract

Thoracic trauma is a major contributor to trauma-related mortality, often presenting catastrophic internal injuries with minimal external markers. This retrospective autopsy-based investigation analyzes the socio-demographic profile, pathophysiological mechanisms, and lethal outcomes of fatal thoracic trauma in southern Assam between 2024 and 2025. Conducted at Silchar Medical College and Hospital, the study evaluated 70 fatalities using detailed medicolegal autopsies, police inquests, and clinical records. The cohort demonstrated a marked vulnerability among young adult males (78.6%), with a mean age of 34.66 years. The predominant mechanism of injury was road traffic accidents (74.3%), driven overwhelmingly by blunt force (88.6%). Alcohol consumption was a prevalent behavioral risk factor (45.7%). Survival dynamics revealed extreme immediate lethality, with 48.6% of victims dying instantaneously at the scene and a median survival time of just one hour. Distinct biomechanical injury patterns emerged: blunt trauma was overwhelmingly associated with lung contusions (71.0%, $p < 0.001$), while penetrating trauma significantly correlated with lung lacerations (62.5%, $p = 0.023$). Massive hemothorax was identified in 48.6% of cases, culminating directly in hemorrhagic shock, which formed the leading cause of death (57.1%), followed by traumatic coma (28.6%). The findings underscore that thoracic trauma fatalities in this region are fundamentally driven by high-velocity blunt forces from vehicular collisions. The profound pre-hospital mortality rate highlights the immediate lethality of intrathoracic hemorrhage, necessitating urgent improvements in early trauma resuscitation, advanced pre-hospital care, and road safety infrastructure.

Keywords: Thoracic trauma; medicolegal autopsy; hemorrhagic shock; blunt force biomechanics; forensic pathology.

Introduction

Thoracic trauma represents one of the most complex and lethal domains within forensic pathology and emergency trauma surgery. The thoracic cavity houses a dense concentration of vital cardiovascular, respiratory, and vascular structures, all enclosed within a semi-rigid biomechanical framework comprising the ribs, sternum, costal cartilages, and thoracic vertebrae[1]. Under normal physiologic conditions, the

viscoelastic properties of the thoracic cage successfully dissipate minor mechanical impacts while accommodating respiratory excursion[1]. However, in scenarios of high-energy trauma, the limits of elastic deformation are rapidly exceeded, transforming the protective bony enclosure into a mechanism for profound kinetic energy transfer and structural failure[1].

The mechanistic pathways dictating the lethality of thoracic trauma are heavily influenced by the nature of the applied external force. In blunt trauma, which is frequently encountered in high-speed vehicular collisions and falls from height, the sudden compression of the thorax causes intrathoracic pressure to spike, forcefully squeezing the viscera against the spinal column[1]. Simultaneously, rapid deceleration triggers the phenomenon of differential inertia. Mobile organs, such as the lungs and the ascending aorta, shift violently against fixed anatomical tethers like the aortic isthmus and pulmonary hila, resulting in catastrophic shearing injuries[1]. Conversely, penetrating trauma operates by overcoming tissue-piercing resistance, directly breaching anatomical barriers to generate localized tracts of destruction that rapidly precipitate exsanguination, cardiac tamponade, or tension pneumothorax[1].

Despite the substantial global burden of injury-related mortality, region-specific epidemiological data regarding thoracic trauma fatalities in northeast India remains critically limited. Southern Assam features a rapidly evolving landscape of expanding highway networks intermixed with rural transit routes, creating a high-risk environment for vehicular and occupational trauma. The purpose of this study is to systematically evaluate thoracic trauma fatalities brought for medicolegal autopsy to define the specific demographic vulnerabilities, structural injury patterns, and immediate pathophysiological pathways leading to death. The rationale underlying this investigation is to generate foundational medicolegal and clinical evidence that highlights systemic gaps in pre-hospital trauma care, thereby informing targeted road safety protocols, emergency response system upgrades, and public health interventions aimed at mitigating preventable mortality.

Material and Methods

The investigation was designed as a retrospective autopsy-based descriptive study. The research was conducted exclusively within the Department of Forensic Medicine and Toxicology at Silchar Medical College and Hospital (SMCH), Silchar, Assam. As a tertiary care referral center, this institution serves as the primary medicolegal autopsy facility for a vast catchment area in southern Assam, encompassing the districts of Cachar, Hailakandi, and Karimganj[1]. The study period spanned twelve months, capturing all eligible cases presenting between November 2024 and October 2025[1].

The study population consisted of deceased individuals subjected to medicolegal autopsy. A non-probability, purposive sampling method was utilized to enroll participants based on strict selection criteria. The primary inclusion criterion required that thoracic trauma be identified as either the direct cause of death or a significant contributing factor, irrespective of the victim's age or gender[1]. Exclusion criteria were rigorously applied to eliminate bodies exhibiting significant putrefaction or decomposition, as such postmortem changes obscure the accurate assessment of structural injuries[1]. Furthermore, cases where the cause of death was unequivocally unrelated to thoracic trauma, such as isolated craniocerebral injury or poisoning, and cases involving unidentified bodies lacking essential socio-demographic history, were excluded from the analysis[1]. The application of these criteria yielded a final cohort of 70 cases.

Data collection was facilitated utilizing a pre-tested, semi-structured proforma specifically developed for this research[1]. The tool was divided into distinct sections designed to capture socio-demographic variables, incident circumstances, clinical course, and comprehensive external and internal postmortem findings.

Validation of the tool was achieved through departmental peer review, ensuring alignment with standardized forensic pathology reporting protocols. Information regarding the incident and baseline demographics was obtained through structured interviews with the accompanying relatives or legal guardians of the deceased, cross-referenced with police inquest reports and available clinical records[1].

The technical execution of the autopsies adhered to rigorous anatomical principles. The thoracic cavity was accessed using standardized Y-shaped or I-shaped incisions to afford full exposure of the ribs and sternum while minimizing artefactual distortion[1]. The removal of the anterior chest wall was controlled via costochondral separation to prevent the artefactual generation of fractures or pleural tears[1]. An in-situ evaluation of the mediastinal relationships and pleural cavities was prioritized before visceral extraction to accurately quantify fluid accumulations, such as hemothorax or hemopericardium, and to identify natural pathophysiological accumulations that serve as theoretical markers of injury severity and timing[1]. Subsequent layered dissection along established anatomical planes allowed the preservation of spatial relationships and the tracing of force transmission pathways[1].

The study protocol received formal clearance from the Institutional Ethics Committee (IEC) of Silchar Medical College and Hospital prior to commencement[1]. Strict adherence to ethical principles was maintained throughout the study. Written informed consent was obtained from the legal representatives of the deceased before conducting interviews and abstracting data[1]. Absolute confidentiality was preserved by assigning unique study identification numbers to all case records, ensuring that the identity of the deceased remained protected.

Statistical methods for analyzing the collected data involved both descriptive and inferential techniques. Raw data were digitized and managed within spreadsheet software before being imported into dedicated statistical software packages for advanced computation. Continuous variables, such as age and survival period, were summarized using means, standard deviations, medians, and interquartile ranges, while categorical variables were expressed as frequencies and percentages[1]. To explore associations between variables—such as the relationship between the mechanism of trauma and specific internal injuries—the Pearson Chi-square test was employed[1]. In instances where expected cell frequencies were insufficient, Fisher's exact test was utilized to maintain the robustness of the statistical inference[1]. Effect sizes were calculated using Cramer's V and Phi coefficients to determine the strength of the observed associations[1]. A p-value of less than or equal to 0.05 was considered statistically significant across all analyses.

Results

The socio-demographic analysis of the 70 autopsy-confirmed thoracic trauma fatalities revealed a pronounced susceptibility among specific population segments. The mean age of the victims was 34.66 ± 15.04 years, with a median age of 33 years, indicating a predominantly young adult demographic[1]. The age distribution demonstrated that over half of the fatalities (54.3%) were concentrated between 21 and 40 years of age. A stark gender disparity was evident, with males constituting 78.6% of the cohort[1]. Analysis of residential and socio-economic backgrounds indicated that nearly half of the victims (48.6%) originated from rural localities. Furthermore, the majority of the deceased belonged to the middle (48.6%) or lower (40.0%) economic strata. Occupational data correlated with these findings, showing that manual laborers (28.6%) and agricultural cultivators (17.1%) were disproportionately represented[1]. Notably, an assessment of behavioral risk markers identified a documented history of alcohol use in 45.7% of the victims, and tobacco use in 40.0%, highlighting substance consumption as a prevalent associative factor in these fatal incidents[1].

Table 1: Baseline Socio-Demographic and Behavioral Profile of Thoracic Trauma Fatalities (N = 70)

	Category	Frequency (n)	Percentage (%)
Age Group (years)	0–20	10	14.3
	21–40	38	54.3
	41–60	18	25.7
	>60	4	5.7
Sex	Male	55	78.6
	Female	15	21.4
Locality	Rural	34	48.6
	Semi-urban	20	28.6
	Urban	16	22.9
Occupation	Labourer / Cultivator	32	45.7
	Student / Service / Business	23	32.9
	Homemaker / Unemployed / Other	15	21.4
Economic Status	Lower	28	40.0
	Middle	34	48.6
	Upper	8	11.4
Alcohol Use	Present	32	45.7
	Absent	38	54.3

The incident profile demonstrated that road traffic accidents were the overwhelming cause of fatal thoracic trauma, accounting for 74.3% of the cases[1]. Falls from height and railway-related incidents contributed 11.4% and 7.1%, respectively[1]. Motor vehicles were identified as the primary offending object in nearly three-quarters of the fatalities. Consequently, the fundamental mechanism of thoracic injury was predominantly blunt force, which was responsible for 88.6% of the cases, whereas penetrating trauma

accounted for the remaining 11.4%[1]. The condition of the victims' garments provided circumstantial evidence of the trauma mechanics, with garments found torn in 28.6% and stained in 22.9% of the cases, supporting the presence of high-impact and abrasive forces[1].

Survival dynamics illustrated the extreme and immediate lethality of the injuries sustained. Nearly half of the victims (48.6%) were declared dead at the scene of the incident[1]. An additional 17.1% succumbed while en route to a medical facility, leaving only 34.3% who survived long enough to be admitted and subsequently die in the hospital[1]. The survival intervals were markedly right-skewed; while the mean survival time was calculated at 9.97 hours, the median survival time was a mere 1 hour, reflecting the rapid physiological collapse characteristic of severe thoracic disruption[1]. Medical treatment prior to death was administered in only 42.9% of the cases, indicating that a substantial majority died without accessing advanced trauma interventions[1].

Table 2: Incident Characteristics, Circumstances of Death, and Survival Dynamics (N = 70)

Variable	Category	Frequency (n)	Percentage (%)
Cause of Incident	Road Traffic Accident	52	74.3
	Fall from Height	8	11.4
	Railway / Penetrating / Other	10	14.3
Thoracic Mechanism	Blunt	62	88.6
	Penetrating	8	11.4
Place of Death	Spot	34	48.6
	On the way to hospital	12	17.1
	Hospital	24	34.3
Survival Interval	Spot death (0 hours)	34	48.6
	< 1 hour	10	14.3
	1 – 6 hours	9	12.9
	> 6 hours	17	24.3
Treatment Received	Yes	30	42.9
	No	40	57.1

The anatomical distribution of injuries confirmed that fatal thoracic trauma frequently occurs within the context of severe polytrauma. External examination revealed that 85.7% of the victims sustained injuries over the chest and abdomen, 65.7% exhibited limb trauma, and 54.3% suffered concomitant head and neck injuries[1]. Internal evaluations demonstrated widespread disruption of the bony thorax and pleuropulmonary structures. Rib fractures were the most ubiquitous skeletal injury, identified in 74.3% of

the total cohort, displaying comparable prevalence across both blunt and penetrating mechanisms[1]. However, structural damage to the costal cartilages was significantly associated with penetrating trauma, present in 75.0% of penetrating cases compared to only 11.3% of blunt force incidents ($p < 0.001$)[1].

The pulmonary parenchyma exhibited highly divergent failure patterns contingent upon the energy vector. Lung contusions were identified in 62.9% of the total cohort, but were exclusively associated with blunt trauma (present in 71.0% of blunt cases versus 0.0% of penetrating cases, $p < 0.001$)[1]. Conversely, direct lung lacerations were significantly overrepresented in penetrating trauma (62.5%) compared to blunt trauma (21.0%), yielding a statistically significant association ($p = 0.023$)[1]. Hemorrhage into the pleural cavity was a major finding, with massive hemothorax documented in 48.6% of all cases ($p = 0.001$)[1]. Cardiomediastinal disruptions, while less frequent overall, represented highly lethal focal injuries; cardiac injury was observed in 12.9% of the cohort, hemopericardium leading to tamponade in 7.1%, and catastrophic great vessel injury in 4.3%[1].

Table 3: Comprehensive Anatomical Injury Distribution (N = 70)

Anatomical Region / Structure	Injury Type / Finding	Frequency (n)	Percentage (%)
External Regions	Chest & Abdomen	60	85.7
	Limbs	46	65.7
	Head & Neck	38	54.3
Bony Thorax	Rib Fracture	52	74.3
	Sternum Fracture	10	14.3
	Costal Cartilage Injury	13	18.6
Pleuropulmonary	Lung Contusion	44	62.9
	Lung Laceration	18	25.7
	Massive Hemothorax	34	48.6
Cardiovascular	Cardiac Injury	9	12.9
	Hemopericardium	5	7.1
	Great Vessel Injury	3	4.3

The synthesis of these extensive pathological disruptions culminated in distinct terminal physiological events. Hemorrhagic shock was established as the primary cause of death in 57.1% of the fatalities, directly reflecting the massive intrathoracic blood loss observed[1]. The high prevalence of associated head and neck

injuries translated into traumatic coma serving as the terminal mechanism in 28.6% of the cases[1]. Sepsis accounted for 12.9% of the deaths, strictly confined to the subgroup of victims who survived the acute post-traumatic phase only to succumb to delayed systemic complications during extended hospitalizations[1].

Table 4: Distribution of Primary Causes of Death Derived from Autopsy Pathology (N = 70)

	Frequency (n)	Percentage (%)
Hemorrhagic Shock	40	57.1
Coma (Secondary to Head Injury)	20	28.6
Sepsis (Delayed Complication)	9	12.9
Syncope / Obstructive Shock	1	1.4

Discussion

This comprehensive retrospective autopsy-based investigation provides vital epidemiological, biomechanical, and pathophysiological insights into thoracic trauma fatalities in southern Assam. The data illustrates a severe public health challenge driven predominantly by motorized transit, disproportionately extinguishing the lives of young, economically active males.

The demographic vulnerability isolated in this cohort—specifically the massive overrepresentation of males (78.6%) with a mean age of 34.66 years—aligns seamlessly with broader global and regional epidemiological trends in trauma literature. Previous autopsy-based analyses by Kanchan et al. and Reddy et al. similarly emphasized the substantial public health burden of road traffic accidents among economically productive males in their twenties and thirties[1]. The correlation between this age demographic and physically demanding occupations, such as manual labor and agricultural cultivation, suggests that necessity-driven mobility heavily dictates trauma exposure[1]. This population relies extensively on two-wheelers or open-cab transport traversing suboptimal rural road networks, inherently stripping away the physical safety barriers afforded by modern enclosed vehicles. Compounding this structural vulnerability is the high prevalence of alcohol use (45.7%), a behavioral risk factor that profoundly impairs psychomotor reaction times and spatial judgment. The intersection of intoxicated driving, inadequate infrastructure, and high occupational mobility creates an environment where severe vehicular impacts become increasingly probable and fatal[1].

A deeper mechanistic analysis reveals the biomechanical reasons behind the exceptional susceptibility of the thoracic cavity to vehicular trauma. The finding that blunt force was responsible for 88.6% of the fatalities is a direct corollary of the dominance of road traffic accidents[1]. The thoracic cage is anatomically engineered to flex and dissipate moderate energy; however, vehicular collisions apply kinetic energy at rates that vastly exceed local elastic limits[1]. When the anterior chest wall strikes a steering wheel or a roadway, the sternum and ribs bow inward. Once the failure threshold is crossed, multiple rib fractures

ensue. In this study, rib fractures were documented in nearly three-quarters of all cases, acting as reliable markers of massive energy transfer and frequently functioning as secondary internal projectiles that exacerbate parenchymal damage[1].

The differential transmission of kinetic energy to the viscera ultimately drives mortality. The observation that lung contusions were present in 71.0% of blunt trauma cases but entirely absent in penetrating injuries is biomechanically profound[1]. During a blunt impact, a transient high-pressure shockwave propagates through the fluid- and air-filled lung parenchyma, causing widespread alveolar disruption, microvascular tearing, and capillary hemorrhage[1]. This creates a functional "blast effect" within the closed thoracic cavity, severely impairing gas exchange even in the absence of macroscopic lacerations. In stark contrast, penetrating trauma localizes force. The energy required to pierce the chest wall is concentrated on the tip of the offending weapon or object. Once internal, the object directly incises tissue, explaining the highly significant statistical association ($p = 0.023$) between penetrating mechanisms and the presence of direct lung lacerations (62.5%)[1].

The lethal efficiency of these injury patterns is starkly illustrated by the cohort's survival dynamics. The median survival time of precisely one hour, coupled with a 48.6% spot-death rate, confirms that the traditional clinical concept of the "golden hour" is frequently compressed into a few fatal minutes[1]. Hemorrhagic shock was responsible for 57.1% of the deaths, directly corresponding to the massive hemothoraces found in nearly half the cohort[1]. The thoracic cavity is a vast potential space capable of accommodating several liters of blood. Consequently, a lacerated intercostal artery, a torn pulmonary hilum, or a sheared aortic isthmus can exsanguinate a patient internally before external signs of hemorrhagic shock become clinically actionable[1]. The finding that all fatalities occurring "on the way to the hospital" fell within the 1-to-6-hour survival window signals a catastrophic failure in pre-hospital trauma care and transport logistics[1]. In the absence of immediate scene interventions—such as needle decompression for tension pneumothorax or rapid volume resuscitation—these victims succumb to hypovolemic and obstructive cascades long before accessing definitive surgical intervention.

Furthermore, the autopsy data validates that fatal thoracic trauma is rarely an isolated event. Over 54% of victims exhibited concomitant head and neck trauma, which directly translated into traumatic coma becoming the second leading cause of death (28.6%)[1]. This polytrauma presentation demands that trauma resuscitation protocols move beyond localized assessments and adopt aggressive, holistic damage-control paradigms[1]. The findings generated by this research validate the irreplaceable role of the medicolegal autopsy in injury surveillance. Clinical imaging and rapid external examinations routinely fail to quantify the true extent of pulmonary parenchymal destruction, subtle myocardial contusions, or exact vascular tear points. By isolating the precise modes of tissue failure—whether through hydraulic burst mechanisms in the heart, differential deceleration in the aorta, or localized lacerations in the lungs—forensic pathology bridges the critical gap between mechanical force application and physiological death[1].

While this study offers robust insights, it is not without limitations. The sample size of 70 cases, though methodologically adequate for descriptive epidemiological profiling, may limit the generalizability of certain statistical associations, particularly within the smaller subset of penetrating trauma fatalities. Furthermore, as a single-center autopsy-based study, the data inherently captures only the fatal spectrum of thoracic trauma, restricting the ability to compare survival determinants against non-fatal presentations.

Conclusions

Fatal thoracic trauma in southern Assam is primarily an epidemic of high-velocity blunt force trauma,

inextricably linked to the rising incidence of road traffic accidents. The demographic burden falls heavily on the young, working-class male population, exacerbated significantly by behavioral risk factors such as alcohol intoxication. The extreme rate of pre-hospital mortality and the absolute predominance of hemorrhagic shock highlight severe inadequacies in current emergency medical services, transport infrastructure, and early trauma resuscitation protocols. To meaningfully reduce this preventable mortality, systemic public health and clinical interventions are urgently required. Immediate priorities must encompass the rigorous enforcement of road safety laws, the widespread implementation of anti-drunk-driving campaigns, and infrastructural upgrades to rural highway networks. Clinically, the rapid lethality of intrathoracic hemorrhage demands the deployment of advanced pre-hospital trauma life support (ATLS) capabilities, ensuring that paramedics can initiate life-saving stabilization directly at the scene. Finally, integrating precise autopsy-derived injury data into regional trauma registries will provide continuous, high-fidelity surveillance necessary to guide future public health policies and trauma system designs.

Acknowledgments

We express our profound gratitude to Prof. Dr. Bhaskar Gupta, Principal-cum-Chief Superintendent, Silchar Medical College & Hospital, for granting the institutional permissions necessary to conduct this research[1]. Exceptional acknowledgment is extended to Dr. Yengkhom Nungshiton Singha, Professor and Head of the Department of Forensic Medicine, for his invaluable supervision, mentorship, and methodological guidance throughout the study[1]. Additional thanks are owed to the medical officers, mortuary attendants, and support staff of the forensic medicine department for their indispensable operational assistance during the execution of the autopsy procedures[1].

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