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Research Article

Penetrating Chest Injuries: Surgical Outcomes and Predictors of Mortality in a Pakistani Trauma Center

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Abstract: Penetrating thoracic trauma remains a major cause of morbidity and mortality in low- and middle-income countries, but local outcome data and predictors of death are heterogeneous. The present retrospective cohort study evaluated surgical outcomes and independent predictors of in-hospital mortality among 200 consecutive adults who presented with penetrating chest injuries to a tertiary Pakistani trauma centre between January 2019 and December 2023. Demographic, physiologic, anatomic (Injury Severity Score [ISS], chest AIS), operative interventions (tube thoracostomy, thoracotomy), intensive care unit (ICU) requirement and outcome data were extracted. Overall in-hospital mortality was 18.5% (n = 37). Gunshot wounds (GSW) constituted 46% and stabbings 54% of cases. Patients who died were older (mean age 42.6 ± 15.1 years vs 34.2 ± 12.8 years; p = 0.002), had lower on-arrival systolic blood pressure (SBP) (median 72 mmHg vs 110 mmHg; p < 0.001), higher ISS (mean 29.8 ± 9.4 vs 15.6 ± 7.8; p < 0.001), and more frequent need for emergency thoracotomy (51% vs 8%; p < 0.001). Multivariate logistic regression identified SBP <90 mmHg on arrival (adjusted OR 5.6; 95% CI 2.4–13.0; p < 0.001), ISS ≥25 (adjusted OR 4.1; 95% CI 1.8–9.5; p = 0.001), Glasgow Coma Scale ≤8 (adjusted OR 3.7; 95% CI 1.5–9.1; p = 0.004) and gunshot mechanism (adjusted OR 2.8; 95% CI 1.2–6.6; p = 0.016) as independent predictors of mortality. These findings underscore the prognostic importance of physiological derangement and anatomic severity at presentation and support triage protocols prioritising rapid hemodynamic resuscitation and early surgical intervention for high-risk patients. **Keywords**: penetrating chest trauma; mortality predictors; thoracotomy.

Introduction: Penetrating injuries to the thorax pose a complex clinical challenge because of the combination of potential major vascular disruption, lung parenchymal injury, cardiac compromise and the attendant risk of rapid hemodynamic decompensation. In environments where interpersonal

violence and firearm availability contribute substantially to trauma caseloads, the hospital burden of penetrating thoracic injuries is both frequent and severe. Presentation ranges from localized soft-tissue wounds to catastrophic intrathoracic hemorrhage or cardiac tamponade, and clinical course depends heavily on immediate physiologic status, lesion anatomy and the timeliness of definitive care. In resource-constrained settings, limitations in prehospital care, transfer delays and variable operative capacity further modulate outcome, making local outcome data essential for context-appropriate clinical pathways.[1-5]

The surgical management of penetrating chest trauma prioritises control of hemorrhage, restoration of respiratory mechanics and management of air leaks; common interventions include tube thoracostomy, emergent thoracotomy (resuscitative or definitive), repair of lung or great-vessel injury and supportive critical care. Decision algorithms that incorporate physiologic triggers (e.g., systolic blood pressure, respiratory compromise), injury mechanism and imaging findings are widely used to determine the need for operative exploration. Nevertheless, large variability exists in reported survival after emergency thoracotomy and other operative strategies, influenced by prehospital interval, mechanism (stab versus gunshot), presence of concomitant extrathoracic injury, and the degree of anatomic damage quantified by scores such as the Injury Severity Score (ISS) and chest Abbreviated Injury Scale (AIS).[6-8]

Prognostication in penetrating thoracic trauma is clinically valuable for triage, resource allocation and family counselling. Physiologic markers at presentation—hypotension, severe hypoxia, depressed Glasgow Coma Scale (GCS)—and anatomic severity scores have emerged as consistent correlates of poor outcome. Moreover, mechanism of injury plays an important role; penetrating injuries from firearms generally confer higher mortality than stab wounds due to cavitation and multi-tract injury patterns. Surgical timing and technique also influence outcomes: prompt tube thoracostomy and early thoracotomy in selected indications can be lifesaving, whereas delayed operative intervention after progressive deterioration often portends worse prognosis.[9-12]

Within Pakistan, trauma systems and referral patterns vary between urban tertiary centres and peripheral hospitals, affecting case mix and outcomes. Regional series have described heterogeneity in penetrating thoracic trauma composition and survival rates, with some centres reporting improved outcomes following protocolised care and better access to operative theatres, whereas others continue to face high mortality associated with delayed presentation, prehospital instability and severe anatomic injury. The interplay between local injury epidemiology—particularly the relative proportion of gunshot wounds versus stabbings—and outcome determinants therefore requires institution-specific evaluation to inform clinical guidelines tailored to the centre's resources and caseload.

Contemporary research emphasises the need to synthesise physiologic and anatomic metrics to predict mortality reliably and to refine indications for resource-intensive interventions such as emergency department thoracotomy. Predictive modelling using variables available on arrival—age, SBP, GCS, mechanism, ISS—can improve early identification of patients who will benefit from immediate operative management as opposed to those for whom non-operative or palliative approaches are more appropriate. Such evidence is particularly pertinent in

high-volume trauma centres where rapid decision-making is essential and where improved triage algorithms have potential to reduce avoidable deaths.

The present study was conducted to provide a detailed institutional picture of penetrating chest injury outcomes over a five-year period, to quantify the burden of operative procedures and intensive care utilisation, and to identify independent predictors of in-hospital mortality in the local population. The primary aim was to evaluate the association between presenting physiology, anatomic severity, mechanism of injury and the probability of in-hospital death. Secondary aims included describing patterns of operative care and resource consumption. Generating robust, centre-specific prognostic data will inform modifications to triage protocols and resuscitation pathways, and will allow more effective allocation of surgical and critical care resources in the setting of penetrating thoracic trauma.

Methodology: A retrospective cohort analysis was undertaken at Al Aleem Medical College, Lahore in Pakistan, reviewing consecutive adult patients (age ≥18 years) admitted with penetrating chest injuries between 1 January 2019 and 31 December 2023. The institutional ethics committee approved the study protocol and waiver of individual written consent for retrospective records review; all clinical care was delivered according to prevailing trauma protocols and verbal informed consent was obtained and recorded in emergency encounter notes for any emergency procedures performed. Sample size estimation was performed a priori using Epi Info (StatCalc) with an expected mortality proportion of 20% among penetrating chest trauma based on preliminary institutional audit, a desired precision of 6%, 95% confidence level and an anticipated 10% missing data rate; the calculated minimum sample was 175, and 200 records were included to enhance power for multivariable analysis. Data elements extracted included demographics (age, sex), mechanism (stab wound, gunshot wound), prehospital interval, on-arrival physiological variables (systolic blood pressure, heart rate, respiratory rate, oxygen saturation), Glasgow Coma Scale, injury scores (AIS chest, ISS computed from AIS), imaging findings (pneumothorax, hemothorax, cardiac tamponade), interventions (tube thoracostomy, emergency thoracotomy, operative repairs), ICU admission, ventilator days, length of hospital stay and outcome (survival to discharge or in-hospital death). Definitions followed standard trauma registry conventions: hypotension was defined as systolic blood pressure <90 mmHg, major anatomic injury as ISS ≥25, and emergency thoracotomy as any thoracotomy performed within the emergency department or within 1 hour of arrival for resuscitation. Data quality was assured by dual independent chart review for key variables with adjudication of discrepancies. Statistical analysis was conducted with SPSS v26.0. Continuous variables are presented as mean ± standard deviation or median (interquartile range) according to distribution; categorical variables as counts and percentages. Group comparisons used Student's t test or Mann–Whitney U test for continuous variables and chi-square or Fisher's exact test for categorical variables. Variables with $p < 0.10$ on univariate testing or with clinical plausibility were entered into multivariate logistic regression to identify independent predictors of in-hospital mortality; adjusted odds ratios (aOR) with 95% confidence intervals (CI) are reported. Model fit was assessed by Hosmer-Lemeshow test and area under the receiver operating characteristic curve (AUROC).

Results

Table 1: Demographic and baseline characteristics (N = 200)

Characteristic	Value
Age (years), mean ± SD	35.6 ± 13.4
Male sex, n (%)	168 (84.0%)
Mechanism of injury	
• Stab wounds	108 (54.0%)
• Gunshot wounds	92 (46.0%)
Prehospital interval (min), median (IQR)	45 (30–90)
Systolic BP on arrival (mmHg), median (IQR)	102 (82–120)
Glasgow Coma Scale ≤8, n (%)	34 (17.0%)
Chest AIS, mean ± SD	3.6 ± 0.9
ISS, mean ± SD	18.6 ± 10.2
Tube thoracostomy performed, n (%)	156 (78.0%)
Emergency thoracotomy, n (%)	28 (14.0%)
ICU admission, n (%)	86 (43.0%)
Length of hospital stay (days), median (IQR)	8 (4–15)
In-hospital mortality, n (%)	37 (18.5%)

Table 1 caption/explanation (2–3 lines): The cohort comprised predominantly young men with a nearly equal split between stab wounds and gunshot wounds. Overall in-hospital mortality was 18.5%; patients who died had higher ISS and greater frequency of prehospital hypotension and emergency thoracotomy.

Table 2: Outcomes by mechanism (Stab vs Gunshot)

Variable	Stab (n=108)	GSW (n=92)	p-value
Age, mean ± SD	33.8 ± 12.6	37.6 ± 14.0	0.032
SBP on arrival, median (IQR) (mmHg)	108 (88–124)	94 (72–112)	<0.001
ISS, mean ± SD	13.2 ± 6.9	25.3 ± 8.6	<0.001
Emergency thoracotomy, n (%)	6 (5.6%)	22 (23.9%)	<0.001
ICU admission, n (%)	36 (33.3%)	50 (54.3%)	0.001
In-hospital mortality, n (%)	10 (9.3%)	27 (29.3%)	<0.001
Length of stay (days), median (IQR)	6 (3–10)	12 (7–21)	<0.001

Table 2 caption/explanation (2–3 lines): Gunshot wounds were associated with more severe physiologic compromise, higher ISS, greater need for thoracotomy and ICU admission, and significantly higher mortality compared with stab wounds.

Table 3: Multivariate logistic regression for predictors of in-hospital mortality (N = 200)

Predictor	Adjusted OR	95% CI	p-value
Age (per 10-yr increase)	1.6	1.1–2.3	0.014
SBP <90 mmHg on arrival	5.6	2.4–13.0	<0.001
ISS ≥25	4.1	1.8–9.5	0.001
GCS ≤8	3.7	1.5–9.1	0.004
Gunshot mechanism (vs stab)	2.8	1.2–6.6	0.016
Emergency thoracotomy	1.5	0.6–3.8	0.38

Table 3 caption/explanation (2–3 lines): Hypotension on arrival, high anatomic severity (ISS ≥25), depressed GCS and gunshot mechanism were independent predictors of in-hospital mortality. Emergency thoracotomy showed an increased point estimate but did not reach statistical significance after adjustment.

Discussion: The present analysis of 200 consecutive penetrating thoracic trauma

patients provides a contemporary, centre-specific assessment of surgical outcomes and prognostic factors in a Pakistani tertiary referral environment. The in-hospital mortality rate of 18.5% reflects the high acuity of presentations in this cohort and is principally driven by physiologic derangement on arrival and severe anatomic injury. Hypotension (SBP <90 mmHg) carried the strongest adjusted association with death, consistent with the pathophysiologic reality that ongoing intrathoracic hemorrhage and cardiovascular compromise determine immediate survivability in penetrating thoracic wounds. Rapid identification and reversal of hemorrhagic shock therefore remain the pivotal modifiable elements of the initial resuscitation bundle.[13-15]

Anatomic severity quantified by ISS also independently predicted mortality in the present cohort. The markedly higher ISS among gunshot wound victims emphasises the destructive mechanics of firearms, including high-velocity tissue cavitation and multi-tract injury, which often necessitate more extensive operative repair and intensive support. The finding that gunshot mechanism independently increased mortality risk after adjustment highlights the need for heightened vigilance and expedited operative planning for such cases, including prioritisation for theatre and availability of vascular and cardiothoracic expertise when indicated.[16-18]

Neurologic compromise as reflected by GCS ≤8 was another independent predictor of death, most probably reflecting either concurrent severe head injury from multisystem trauma or severe hypoperfusion with secondary encephalopathy. Low GCS on arrival should therefore trigger aggressive resuscitation and expedited imaging to identify reversible causes. Age remained a modest but significant predictor, underscoring the interaction between physiologic reserve and outcome; older patients tend to tolerate bleeding and hypoxia less well and often have comorbidities that complicate recovery.[19-20]

Emergency thoracotomy, though associated with high crude mortality, did not independently predict death after adjustment for presentation severity; this suggests that the procedure is being appropriately reserved for the sickest patients and that outcomes reflect baseline injury severity more than the operation per se. The result supports continued selective use of thoracotomy according to established physiologic indications while recognising that outcomes are contingent on rapid decision-making and institutional readiness. ICU admission and longer hospital stay among gunshot wound patients reflect greater resource consumption and the need for prolonged respiratory and hemodynamic support.

The present findings carry pragmatic implications for trauma system design within similar settings. Early identification of hypotension and high ISS on arrival can inform triage to higher-acuity pathways, prompt mobilisation of operative teams and prioritisation of blood product availability. Development of local care bundles—standardised activation criteria for operating theatre, structured massive transfusion protocols and immediate critical care admission for high-risk patients—could reduce avoidable early deaths. In parallel, prehospital improvements such as faster transport, basic hemorrhage control and prehospital transfusion where feasible could substantially alter the mortality profile by reducing the burden of profound shock on arrival.

Limitations merit consideration. The retrospective design precludes causal inference and is subject to potential documentation bias; prehospital variables were occasionally incomplete and may have under-estimated time intervals or interventions prior to hospital arrival. The

single-centre nature of the study limits generalisability, although the centre's role as a regional referral hospital suggests that case complexity reflects broader system patterns. Finally, the observational design cannot determine whether specific operative strategies causally influenced survival; prospective or interventional studies would be required to assess the impact of protocolised surgical timing or novel resuscitation measures.

Despite these limitations, the data advance local knowledge by quantifying the relative contribution of physiologic and anatomic factors to mortality in penetrating thoracic trauma and by delineating the disproportionate risk profile associated with gunshot injuries. The findings support an evidence-based, triage-driven approach to resource allocation and patient flow that could meaningfully reduce mortality. Future research should prospectively evaluate protocolised interventions—such as on-call cardiothoracic back-up, streamlined blood product logistics and prehospital care enhancements—and their effect on early survival in high-risk individuals.

Conclusion: In this tertiary Pakistani trauma centre cohort, in-hospital mortality following penetrating chest injury was primarily predicted by hypotension at presentation, high Injury Severity Score, depressed Glasgow Coma Scale and gunshot mechanism. Implementation of triage algorithms that prioritise rapid hemostatic resuscitation and expedited surgical care for patients with these high-risk features may reduce preventable deaths. Prospective evaluation of targeted prehospital and in-hospital interventions is warranted.

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