

Blunt versus penetrating trauma: differences in early physiology, coagulopathy, and outcomes in a Scandinavian trauma centre

Erik von Oelreich

Karolinska Institutet

Jesper Eriksson

Karolinska Institutet

Bjarni Arnason

Karolinska Institutet

Daniel Ohlén

Karolinska Institutet

Axel Hedin

Karolinska University Hospital

Anders Gille

Karolinska University Hospital

Malin Jonsson Fagerlund

Karolinska Institutet

Magnus Hedberg

`magnus.hedberg@ki.se`

Karolinska Institutet

Research Article

Keywords: Trauma, penetrating trauma, blunt trauma, resuscitation, transfusion, coagulation, outcome

Posted Date: June 17th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-9969793/v1>

License:   This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Version of Record: A version of this preprint was published at Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine on August 29th, 2026. See the published version at <https://doi.org/10.1186/s13049-026-01683-5>.

Abstract

Background

Blunt and penetrating trauma differ in injury patterns, management, and outcomes, but data comparing early physiological and haemostatic responses within Scandinavian trauma systems remain limited. We aimed to investigate differences in clinical characteristics, early physiology, and outcomes between blunt and penetrating trauma patients at a major Swedish trauma centre.

Methods

This observational cohort study included adult trauma patients admitted to the Karolinska University Hospital, Stockholm, between November 2022 and December 2024. Detailed prospective data were collected for patients receiving blood transfusion within two hours of arrival. Patients were categorised by injury type (blunt vs penetrating). The primary outcome was 30-day mortality. Secondary analyses compared physiological, metabolic, and coagulation parameters. Multivariable logistic regression was used to compare 30-day mortality between groups, adjusted for age, sex, Injury Severity Score, and preinjury comorbidity.

Results

A total of 2,193 patients were included, of whom 353 (16%) sustained penetrating trauma. Patients with penetrating trauma were younger (median 34 vs 49 years, $p < 0.001$), more often male (78% vs 66%, $p < 0.001$), and more frequently presented in shock (5.9% vs 2.2%, $p < 0.001$), with a greater need for emergency surgery (53% vs 30%, $p < 0.001$) and early blood transfusion (20% vs 4.5%, $p < 0.001$). Blunt trauma patients had higher injury severity (ISS > 15 : 34% vs 18%, $p < 0.001$), longer hospital stays (> 7 days: 26% vs 18%, $p = 0.001$), and worse functional outcomes at discharge (Glasgow Outcome Scale 2 or 3: 40% vs 12%, $p < 0.001$).

In the early transfusion subgroup ($n=152$), blunt trauma patients exhibited lower fibrinogen levels (median 2.1 vs 2.5 g/L, $p=0.027$), lower platelet counts (median 239 vs 271 $10^9/L$, $p=0.011$), and prolonged activated partial thromboplastin time (median 26 vs 23 seconds, $p<0.001$) compared with penetrating trauma patients, despite similar rates of trauma-induced coagulopathy defined by INR >1.2 (23% vs 16%, $p=0.32$).

After exclusion of non-trauma-related deaths, 30-day mortality did not differ significantly between groups in unadjusted or adjusted analyses.

Conclusions

Blunt and penetrating trauma represent distinct clinical phenotypes with differing injury patterns, physiological responses, and management needs. Despite these differences, adjusted mortality was

comparable. These findings support mechanism-specific approaches to trauma resuscitation and management.

Trial registration

The study was registered at ClinicalTrials.gov prior to initiation (NCT05573841).

Background

Trauma is a major contributor to mortality and morbidity across all age groups, with a particularly high burden among young adults [1]. Globally, the majority of trauma patients sustain injuries from blunt mechanisms; however, the proportion of blunt versus penetrating trauma varies considerably between geographical regions [2]. In recent years, the management of penetrating trauma has received increased attention, partly driven by ongoing armed conflicts worldwide. In Sweden, there has been a marked rise in penetrating trauma over the past decade, largely attributable to gang-related gun violence [3–5]. The Swedish national trauma registry has in recent years reported that penetrating injuries account for more than 8% of all trauma cases, with the exception of a downward trend observed in 2024 [6]. Despite the increase in gun-related violence, stab wounds remain the predominant mechanism of penetrating trauma in Sweden [3, 4, 6].

Patients sustaining penetrating trauma are typically young males with injuries confined to one or two anatomical regions, where uncontrolled haemorrhage constitutes the primary immediate threat to life [3, 7, 8]. In contrast, blunt trauma patients exhibit a broader age distribution and frequently sustain multisystem injuries, often including traumatic brain injury (TBI) [9].

Although differences in injury severity, management, and outcomes between blunt and penetrating trauma have been reported, data comparing early physiological, metabolic, and coagulation disturbances at hospital admission remain limited, particularly within Scandinavian trauma systems.

Improved understanding of how injury mechanism influences the early physiological response to trauma may inform clinical decision-making and resuscitation strategies. We therefore hypothesised that patients with penetrating trauma present with more pronounced physiological and metabolic derangement on arrival to hospital but, due to more isolated injury patterns and greater physiological reserve, have more favourable outcomes than patients sustaining blunt trauma.

The aim of this study was to investigate differences between blunt and penetrating trauma patients admitted to a major Swedish trauma centre, with 30-day mortality as the primary outcome. Secondary analyses included comparisons of physiological, metabolic, and coagulation parameters on admission with a focused analysis of patients requiring blood transfusion in the prehospital phase or within the first two hours of hospital care.

Methods

Ethics

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was granted by the Swedish Ethical Review Authority (Dnr 2021–04394), with a waiver of informed consent. The study is reported in accordance with the STROBE statement for observational studies (checklist provided as Additional Material).

Study design and setting

This prospective observational cohort study was conducted at Karolinska University Hospital in Solna, Stockholm, Sweden, between November 1, 2022, and December 31, 2024. The study was registered at ClinicalTrials.gov prior to initiation (ClinicalTrials.gov identifier: NCT05573841).

Karolinska University Hospital is the primary and only regional trauma centre in the Stockholm region, serving a predominantly urban catchment area of approximately 2.5 million inhabitants. The centre provides neurosurgical and cardiothoracic surgical services and receives trauma patients from across the region. Trauma patients bypass the emergency department and are admitted directly to the trauma unit, which has immediate access to computed tomography imaging, operating theatres, and interventional radiology.

Prehospital care

The regional prehospital emergency medical services consist primarily of ground ambulance units, supplemented by helicopter emergency medical services for patients located in the Stockholm archipelago or when transport times can be reduced. Physician-staffed rapid response units support the prehospital system and may be dispatched to life-threatening emergencies, including major trauma. These units are equipped to provide advanced treatment interventions and may carry whole blood or blood components depending on unit configuration.

Healthcare context and trauma registry

Sweden operates a tax-funded universal healthcare system. Each resident is assigned a unique personal identity number, enabling linkage across national healthcare registers with high completeness and accuracy [10]. Trauma data were obtained from the Swedish Trauma Registry, a national quality registry that prospectively records information on trauma patients admitted following trauma team activation.

The registry includes data on injury mechanism, physiological parameters, injury severity scoring, prehospital and in-hospital time intervals, and acute interventions. Patients with isolated limb injuries, drowning, hanging without traumatic injury, accidental hypothermia without concomitant trauma, chronic subdural hematoma, or burns involving less than 18% total body surface area without inhalation injury

are not included in the registry. At the Karolinska University Hospital, registry nurses perform continuous data entry and regular manual reviews of admission records from relevant departments to identify eligible patients.

Study population

All adult patients aged 15 years or older admitted via the trauma unit during the study period and recorded in the Karolinska Trauma Registry were eligible for inclusion. Patients declared dead on arrival without subsequent in-hospital interventions were not included in the study populations. Three study populations were defined: I) the overall trauma cohort, comprising all eligible patients registered during the study period; II) an early blood transfusion subgroup, defined as patients who received at least one unit of blood product (whole blood, packed red blood cells, plasma, or platelets) either in the prehospital phase or within 2 hours of hospital arrival; and III) a mortality analysis cohort, comprising the overall cohort after exclusion of patients with a non-trauma-related cause of death within 30 days.

Patients in the early transfusion group were initially identified by anaesthetic nurses or physicians who were members of the trauma team, and a study-specific research form was completed at admission. All trauma admissions were subsequently reviewed by a study investigator to ensure completeness of inclusion.

Data sources and variables

Data were collected from multiple sources, including the study-specific research form completed in the trauma unit, the Swedish Trauma Registry, electronic medical records, anaesthesia charts, and the blood bank laboratory database. Collected variables included patient demographics, injury characteristics, physiological parameters, blood gas and coagulation analyses, administration of procoagulant agents and calcium, transfusion type and volume, and outcome measures. Traumatic coagulopathy was defined as International Normalised Ratio (INR) > 1.2 . Shock was defined as a systolic blood pressure < 90 mmHg.

Statistical analysis

Logistic regression analyses were conducted to estimate the odds of death associated with penetrating versus blunt trauma. An unadjusted model was first fitted, followed by a model adjusted for age and sex, and a fully adjusted model including age, sex, Injury Severity Score (ISS), and preinjury American Society of Anesthesiologists (ASA) classification. No formal missing data analysis was performed. All analyses were conducted on patients with available data for each variable (complete case analysis). Data completeness was high throughout the study period, owing to the prospective design, continuous data entry by registry nurses, and retrospective review of all trauma admissions by a study investigator. Survival over time was assessed using Kaplan–Meier analysis.

Categorical variables were reported as counts and percentages, and continuous variables as medians with interquartile ranges or means with standard deviations, as appropriate. Group comparisons were performed using Student's t-test for normally distributed continuous variables, Mann–Whitney U test for non-normally distributed continuous variables, chi-square test for categorical variables, and Kruskal–Wallis test for comparisons involving ≥ 3 groups. A two-sided p-value < 0.05 was considered statistically significant. Statistical analyses were performed using Stata version 19 (StataCorp, College Station, TX, USA).

Artificial Intelligence

The authors used ChatGPT (OpenAI) for language editing. The authors reviewed and verified all generated content and take full responsibility for the manuscript.

Results

Study population

The overall cohort comprised 2,193 patients, of whom 353 (16%) sustained penetrating trauma and 1,840 (84%) blunt trauma (Fig. 1, population I). After exclusion of 29 patients with a non-trauma-related cause of death, 2,164 patients remained in the mortality analysis cohort (population III), which formed the basis for the logistic regression analyses. The early blood transfusion subgroup consisted of 152 patients (population II), including 70 (46%) with penetrating trauma and 82 (54%) with blunt trauma. This subgroup had higher ISS and New Injury Severity Scores than the overall cohort. It was also more physiologically deranged with lower GCS scores, a higher proportion requiring intubation and more patients presenting in shock (Tables 1 and 2).

Table 1
Prehospital and baseline characteristics stratified by penetrating versus blunt trauma.

Factor	All patients		p-value	Early blood transfusion subgroup		
	Penetrating	Blunt		Penetrating	Blunt	p-value
N	353	1840		70	82	
Age, median (IQR)	34 (24, 46)	49 (31, 66)	< 0.001	33.5 (26, 47)	45.5 (31, 64)	0.003
Male sex, n (%)	276 (78.2%)	1208 (65.7%)	< 0.001	62 (89%)	53 (65%)	< 0.001
ASA preinjury, n (%)			0.019			0.55
1	157 (44.5%)	715 (38.9%)		37 (53%)	35 (43%)	
2	129 (36.5%)	643 (34.9%)		20 (29%)	25 (30%)	
3	65 (18.4%)	448 (24.3%)		12 (17%)	21 (26%)	
4	2 (0.6%)	34 (1.8%)		1 (1%)	1 (1%)	
Injury mechanism, n (%)			< 0.001			< 0.001
Traffic	1 (0.3%)	713 (38.8%)		0 (0%)	34 (41%)	
Shot by gun	75 (21.2%)	0 (0.0%)		23 (33%)	0 (0%)	
Stabbed by knife	275 (77.9%)	0 (0.0%)		47 (67%)	0 (0%)	
Struck by blunt object	0 (0.0%)	178 (9.7%)		0 (0%)	13 (16%)	
Fall	0 (0.0%)	862 (46.9%)		0 (0%)	33 (40%)	
Other	2 (0.6%)	85 (4.6%)		0 (0%)	2 (2%)	
First recorded GCS, n (%)			< 0.001			< 0.001
13–15	295 (92.2%)	1124 (77.5%)		51 (75%)	31 (39%)	
9–12	7 (2.2%)	112 (7.7%)		6 (9%)	11 (14%)	

Factor	All patients		p-value	Early blood transfusion subgroup		
	Penetrating	Blunt		Penetrating	Blunt	p-value
3–8	18 (5.6%)	214 (14.8%)		11 (16%)	38 (48%)	
Highest level of prehospital care, n (%)			< 0.001			0.052
No Field Care	14 (4.2%)	51 (3.4%)		2 (3%)	1 (1%)	
ALS - no physician	166 (49.6%)	1142 (75.7%)		12 (17%)	28 (34%)	
ALS - physician	155 (46.3%)	316 (20.9%)		56 (80%)	53 (65%)	
Prehospital intubated, n (%)	15 (4.6%)	99 (6.8%)	0.15	10 (14%)	38 (46%)	< 0.001
Prehospital cardiac arrest, n (%)	11 (3.4%)	29 (2.0%)	0.12	8 (12%)	9 (11%)	0.90
Mode of transportation, n (%)			< 0.001			0.12
Ground ambulance	281 (83.9%)	1079 (71.5%)		49 (70%)	46 (56%)	
Helicopter ambulance	40 (11.9%)	379 (25.1%)		19 (27%)	35 (43%)	
Other	14 (4.2%)	51 (3.4%)		2 (3%)	1 (1%)	
Time on scene (min), median (IQR)	15 (10, 21)	22 (15, 29)	< 0.001	15 (9.5, 20.5)	18 (11, 25)	0.058
Transport time (min), median (IQR)	16 (11, 21)	15 (11, 21)	0.61	13 (9, 17)	13 (9, 17)	0.59

Categorical parameters are presented as n (%), continuous parameters as median with interquartile range (IQR). ALS, advanced life support; GCS, Glasgow Coma Scale; IQR, interquartile range. Early blood transfusion was defined as prehospital or within 2 hours of hospital arrival.

Table 2
Trauma room characteristics and outcomes stratified by penetrating versus blunt trauma.

Factor	All patients			Early blood transfusion subgroup		
	Penetrating	Blunt	p-value	Penetrating	Blunt	p-value
N	353	1840		70	82	
Shock on arrival, n (%)	21 (5.9%)	41 (2.2%)	< 0.001	14 (20%)	18 (22%)	0.77
Respiratory rate, n (%)			0.020			< 0.001
Slow (≤ 9)	2 (0.6%)	8 (0.4%)		0 (0%)	0 (0%)	
Normal (10–29)	295 (88.9%)	1598 (87.7%)		38 (76%)	26 (40%)	
Fast (≥ 30)	18 (5.4%)	55 (3.0%)		5 (10%)	2 (3%)	
Intubated	17 (5.1%)	162 (8.9%)		7 (14%)	37 (57%)	
First Base Excess, median (IQR)	0 (-3, 1.9)	0.6 (-2, 2)	0.030	-3.2 (-8.5, -0.5)	-4.7 (-12, -2)	0.18
ISS, n (%)			< 0.001			< 0.001
ISS 0–15	290 (82.4%)	1212 (65.9%)		32 (46%)	9 (11%)	
ISS 16–25	31 (8.8%)	370 (20.1%)		16 (23%)	17 (21%)	
ISS 26–35	19 (5.4%)	183 (9.9%)		13 (19%)	25 (30%)	
ISS 36–75	12 (3.4%)	75 (4.1%)		9 (13%)	31 (38%)	
NISS, n (%)			< 0.001			< 0.001
NISS 0–15	263 (74.7%)	989 (53.8%)		24 (34%)	5 (6%)	
NISS 16–25	36 (10.2%)	375 (20.4%)		11 (16%)	7 (9%)	
NISS 26–35	33 (9.4%)	293 (15.9%)		22 (31%)	29 (35%)	
NISS 36–75	20 (5.7%)	183 (9.9%)		13 (19%)	41 (50%)	

Factor	All patients			Early blood transfusion subgroup		
	Penetrating	Blunt	p-value	Penetrating	Blunt	p-value
Intubated at ED, n (%)			0.33			< 0.001
Intubated at trauma bay	32 (9.9%)	150 (10.2%)		26 (37%)	28 (34%)	
Not intubated	278 (85.8%)	1227 (83.4%)		35 (50%)	17 (21%)	
Intubated prehospital	14 (4.3%)	95 (6.5%)		9 (13%)	37 (45%)	
Time to CT, n (%)			< 0.001			0.010
Time to CT ≤ 30 min	202 (69.4%)	898 (55.3%)		23 (33%)	35 (43%)	
Time to CT 31–60 min	42 (14.4%)	377 (23.2%)		12 (17%)	25 (30%)	
Time to CT > 60 min	47 (16.2%)	350 (21.5%)		35 (50%)	22 (27%)	
Time to first emergency procedure, n (%)			< 0.001			0.12
≤30 min	42 (22.1%)	56 (9.9%)		26 (37%)	28 (34%)	
31–60 min	45 (23.7%)	62 (11.0%)		20 (29%)	14 (17%)	
>60 min	103 (54.2%)	447 (79.1%)		24 (34%)	40 (49%)	
First emergency procedure, n (%)			< 0.001			0.087
DC thoracotomy	10 (2.8%)	8 (0.4%)		8 (11%)	8 (10%)	
DC laparotomy	41 (11.6%)	33 (1.8%)		21 (30%)	16 (20%)	
Limb revascularisation	7 (2.0%)	4 (0.2%)		2 (3%)	1 (1%)	
Interventional radiology	5 (1.4%)	22 (1.2%)		2 (3%)	2 (2%)	
Craniotomy	1 (0.3%)	84 (4.6%)		1 (1%)	8 (10%)	
ICP device insertion	3 (0.8%)	30 (1.6%)		0 (0%)	0 (0%)	

Factor	All patients		p-value	Early blood transfusion subgroup		
	Penetrating	Blunt		Penetrating	Blunt	p-value
Other	121 (34.3%)	374 (20.3%)		34 (49%)	37 (45%)	
No emergency intervention	165 (46.7%)	1282 (69.7%)		2 (3%)	10 (12%)	
Highest level of care, n (%)			< 0.001			< 0.001
Emergency Department	48 (13.6%)	228 (12.4%)		0 (0%)	0 (0%)	
General Ward	118 (33.4%)	706 (38.4%)		5 (7%)	3 (4%)	
Operation Theatre	124 (35.1%)	349 (19.0%)		33 (47%)	14 (17%)	
HDU	13 (3.7%)	145 (7.9%)		4 (6%)	3 (4%)	
Intensive Care Unit	50 (14.2%)	412 (22.4%)		28 (40%)	62 (76%)	
Hospital LOS, n (%)			< 0.001			0.018
≤2 days	202 (57.2%)	712 (38.7%)		17 (24%)	19 (23%)	
3–7 days	88 (24.9%)	649 (35.3%)		25 (36%)	14 (17%)	
>7 days	63 (17.8%)	479 (26.0%)		28 (40%)	49 (60%)	
GOS at discharge, n (%)			< 0.001			< 0.001
Death	13 (3.7%)	99 (5.4%)		9 (13%)	28 (34%)	
Persistent vegetative state	0 (0.0%)	5 (0.3%)		0 (0%)	0 (0%)	
Severe disability	43 (12.2%)	728 (39.6%)		19 (27%)	47 (57%)	
Moderate disability	105 (29.7%)	475 (25.8%)		29 (41%)	5 (6%)	
Good recovery	192 (54.4%)	533 (29.0%)		13 (19%)	2 (2%)	

Factor	All patients			Early blood transfusion subgroup		
	Penetrating	Blunt	p-value	Penetrating	Blunt	p-value
30-day mortality, n (%)	14 (4.0%)	134 (7.3%)	0.022	10 (14%)	26 (33%)	0.008
Trauma-related death, n (%)			0.027			0.53
Not trauma-related	0 (0.0%)	29 (21.6%)		0 (0%)	1 (4%)	
Trauma-related	13 (92.9%)	104 (77.6%)		10 (100%)	25 (96%)	
Unknown	1 (7.1%)	1 (0.7%)		0 (0%)	0 (0%)	
Cause of death, n (%)			< 0.001			0.022
TBI	3 (21.4%)	65 (48.5%)		2 (20%)	13 (50%)	
Haemorrhagic shock	8 (57.1%)	3 (2.2%)		6 (60%)	3 (12%)	
MOF	0 (0.0%)	7 (5.2%)		0 (0%)	3 (12%)	
Other	3 (21.4%)	59 (44.0%)		2 (20%)	7 (27%)	

Categorical parameters are presented as n (%), continuous parameters as median with interquartile range (IQR). ISS, Injury Severity Score; NISS, New Injury Severity Score; CT, computed tomography; DC, damage control; ED, emergency department; GOS, Glasgow Outcome Scale; HDU, High Dependency Unit; ICP, intracranial pressure; LOS, length of stay; MOF, multiple organ failure; NISS, New Injury Severity Score; TBI, traumatic brain injury. Early blood transfusion was defined as prehospital or within 2 hours of hospital arrival.

Primary outcome: Comparison of 30-day mortality between penetrating and blunt trauma patients

Kaplan–Meier survival curves comparing blunt and penetrating trauma are shown in Fig. 2. Mortality following penetrating trauma occurred predominantly during the first day after admission, with only one death occurring beyond day 3. In contrast, mortality after blunt trauma was distributed throughout the 30-day follow-up period.

Figure 2. Kaplan–Meier estimates of survival up to 30 days after trauma comparing patients with penetrating versus blunt injury. The x-axis shows days after trauma and the y-axis shows proportion alive.

Associations between injury type and 30-day mortality are presented in Table 3. No statistically significant association was observed between penetrating trauma and 30-day mortality compared with blunt trauma in unadjusted analysis, in analyses adjusted for age and sex, or in the fully adjusted model including age, sex, ISS, and ASA classification. Causes of death are presented in Table 2. In the blunt trauma group, the cause of death was TBI in 49% and haemorrhage in 2.2%. In the penetrating group, the proportion of deaths from haemorrhage was 57% and 21% from TBI.

Table 3 Association of penetrating trauma with 30-day mortality compared with blunt trauma (reference).		
Unadjusted	All patients	p-value
	0.63 (0.35–1.13)	0.12
Restricted model*	1.03 (0.56–1.90)	0.93
Full model**	1.46 (0.60–3.55)	0.40

Odds ratios and 95% confidence intervals. Analyses were performed in the mortality analysis cohort (n = 2,164), comprising the overall cohort after exclusion of patients with a non-trauma-related cause of death within 30 days.

* Restricted model: adjusted for age and sex.

** Full model: in addition to age and sex, adjusted for Injury Severity Score (ISS) and American Society of Anesthesiologists (ASA) classification.

Prehospital and baseline characteristics

Prehospital and baseline characteristics stratified by injury type are presented in Table 1. In the overall cohort, patients with penetrating trauma were younger and more often male compared with patients with blunt trauma. Patients with blunt trauma more frequently had higher preinjury ASA classifications than patients with penetrating trauma. Blunt mechanisms were dominated by falls and traffic-related injuries, while penetrating trauma was most commonly caused by stab wounds.

The distribution of first recorded Glasgow Coma Scale scores differed between groups, with higher scores (GCS 13–15) being more common among patients with penetrating trauma and lower scores (GCS 3–8) more frequent among patients with blunt trauma. Physician-staffed prehospital care was more frequently provided to patients with penetrating trauma, and prehospital scene times were shorter for patients with penetrating trauma. No differences were observed between groups regarding prehospital intubation in the overall cohort, although in the early blood transfusion subgroup prehospital intubation was substantially more frequent among patients with blunt trauma.

Trauma room characteristics and in-hospital outcomes

Trauma room characteristics and in-hospital outcomes stratified by injury type are presented in Table 2. In the overall cohort, patients with penetrating trauma more frequently presented with shock on arrival. Patients with blunt trauma more frequently had higher Injury Severity Score and New Injury Severity Score categories. Emergency procedures were more often performed in patients with penetrating trauma, particularly damage control laparotomy and thoracotomy. Time to first computed tomography scan after arrival differed between groups, with shorter times observed among patients with penetrating trauma.

Hospital length of stay was longer among patients with blunt trauma. Functional outcome at discharge differed between groups, with good recovery being more common among patients with penetrating trauma and severe disability more common among patients with blunt trauma.

In the early blood transfusion subgroup, blunt trauma patients more frequently had higher Injury Severity Score and New Injury Severity Score categories. In this subgroup, most patients underwent emergency interventions, 97% of penetrating patients and 88% of blunt patients. Time to computed tomography was longer among patients with penetrating trauma.

High-resolution prehospital and in-hospital parameters

High-resolution prehospital and early in-hospital parameters for patients receiving early blood transfusion are presented in Table 4. Patients with penetrating trauma more frequently received prehospital blood transfusion, whereas those with blunt trauma received larger volumes of crystalloid fluids.

Table 4

High-resolution prehospital and in-hospital parameters in patients receiving early blood transfusion.

Factor	Penetrating	Blunt	p-value
N	70	82	
Prehospital administration and transfusion			
Tranexamic acid, n (%)	41 (59%)	44 (54%)	0.54
Crystalloid (mL), mean (SD)	99 (222)	205 (403)	0.053
Whole blood transfusion, n (%)	19 (27%)	17 (21%)	0.35
PRBC transfusion, n (%)	12 (17%)	6 (7%)	0.062
Plasma transfusion, n (%)	9 (13%)	4 (5%)	0.080
Blood transfusion of any product, n (%)	31 (44%)	24 (29%)	0.055
Laboratory testing at arrival to the trauma unit			
Lactate, median (IQR)	4.8 (3, 8.7)	4 (2.7, 8.4)	0.31
Base Excess, median (IQR)	-3.2 (-8.5, -0.5)	-4.7 (-12, -2)	0.18
pH, median (IQR)	7.29 (7.14, 7.36)	7.26 (7.12, 7.32)	0.22
Hb, median (IQR)	126 (115, 147)	128 (115, 142)	0.95
Ionized calcium (mmol/L), median (IQR)	1.15 (1.11, 1.20)	1.17 (1.13, 1.21)	0.31
Fibrinogen, median (IQR)	2.45 (2, 2.85)	2.1 (1.7, 2.6)	0.027
APTT, median (IQR)	23 (21, 26)	26 (23, 33)	< 0.001
Platelet count, median (IQR)	271 (208, 330)	239 (174, 286)	0.011
INR, median (IQR)	1.1 (1.0, 1.2)	1.1 (1.0, 1.2)	0.047
EXTEM CT, median (IQR)	65 (59, 75)	67 (60, 79.5)	0.37
FIBTEM A5, median (IQR)	11 (9, 14)	11 (7, 14)	0.46
EXTEM A5, median (IQR)	46 (39, 51)	43 (37.5, 49)	0.057
EXTEM ML, median (IQR)	6 (3, 10)	3.5 (2, 7.5)	0.005
Trauma-induced coagulopathy, n (%)	10 (16%)	17 (23%)	0.32
Massive transfusion, n (%)	37 (54%)	55 (67%)	0.092
Tranexamic acid total dose, first 3 h, n (%)			0.18
0 g	8 (12%)	14 (17%)	
1 g	21 (30%)	27 (33%)	

Factor	Penetrating	Blunt	p-value
2 g	38 (55%)	36 (44%)	
>2 g	2 (2%)	4 (5%)	
Transfusions during the first 24 h			
Whole blood (mL), median (IQR)	456 (0, 1346)	459 (0, 954)	0.88
PRBC (mL), median (IQR)	531 (250, 1286)	1028 (272, 1999)	0.083
Plasma (mL), median (IQR)	513 (245, 1774)	970 (252, 1802)	0.20
Platelets (mL), median (IQR)	0 (0, 207)	196 (0, 395)	0.021
Total transfusion (mL), median (IQR)	1702 (901, 4021)	2659 (1164, 5370)	0.12

Categorical parameters are presented as n (%), continuous parameters as median with interquartile range (IQR) or mean with standard deviation (SD). APTT, activated partial thromboplastin time; EXTEM/FIBTEM, rotational thromboelastometry parameters; Hb, haemoglobin; INR, International Normalized Ratio; PRBC, Packed Red Blood Cells. Early blood transfusion was defined as prehospital or within 2 hours of hospital arrival.

Prothrombin time (INR) and initial blood gas parameters, including lactate, base excess, pH, haemoglobin, and ionised calcium, were similar between groups. However, despite identical median INR values and no significant difference in the incidence of traumatic coagulopathy (INR > 1.2), the overall INR distributions showed a borderline significance ($p = 0.047$). Patients with blunt trauma also had lower fibrinogen levels, lower platelet counts, and prolonged activated partial thromboplastin time.

During the first 24 hours after arrival, no differences were observed in the volumes of whole blood, packed red blood cells, plasma, or total transfusion volume. However, patients with blunt trauma received higher volumes of platelet transfusion.

Characteristics and comparisons between patients with stab wounds and gunshot wounds are presented in Additional Table 1 and Additional Table 2. Patients with gunshot wounds were younger, had fewer comorbidities, higher Injury Severity Scores, and higher mortality.

Discussion

In this study we compared characteristics between blunt and penetrating trauma patients in an urban Scandinavian context. In line with our hypothesis, penetrating patients were younger, had fewer comorbidities and presented more acidotic and more often in shock on arrival to hospital. However, we could not detect a survival difference between the groups, neither in an unadjusted nor an adjusted statistical model.

In our cohort, the penetrating trauma patient was characterised by a high need of emergency surgery and more often required blood transfusion. Non-survivors after penetrating injuries died early, usually within the first day after injury, with haemorrhagic shock being the dominant cause of death. In our subgroup of transfused patients, penetrating trauma was not associated with a higher incidence of traumatic coagulopathy despite a trend toward greater transfusion requirements; instead, these patients exhibited higher platelet counts, higher fibrinogen levels and shorter activated partial thromboplastin time.

In contrast, blunt trauma patients required fewer immediate surgical interventions but had a greater need for intensive care and longer hospital length of stay. Functional outcomes were also worse among blunt trauma patients at discharge, which is likely driven by the higher incidence of TBI, a well-established determinant of long-term disability and mortality after trauma [11]. The predominance of TBI as the leading cause of death in blunt trauma in our cohort is consistent with prior studies from high-income trauma systems, where improvements in haemorrhage control have shifted the burden of mortality towards neurological injury [11]. Moreover, the number of deaths classified as 'Other' was high among blunt trauma patients, partly explained by the high number of non-traumatic deaths in this group.

Despite clear differences in injury patterns and early management, we did not observe a difference in adjusted 30-day mortality between penetrating and blunt trauma after excluding non-traumatic deaths. This finding contrasts with some previous studies reporting higher mortality in penetrating trauma, particularly in settings with a high prevalence of firearm-related injuries [12, 13]. However, in the subgroup of transfused patients, mortality was higher after blunt trauma, consistent with findings reported by Donohue et al [14]. In our cohort, only a minority of penetrating injuries were due to gunshot wounds, which may partly explain the relatively low mortality observed, as firearm injuries are typically associated with more extensive tissue destruction and higher mortality [15].

An interesting finding of the present study is the difference in early haemostatic profiles between blunt and penetrating injuries. Although the incidence of traumatic coagulopathy defined by INR did not differ, blunt trauma patients demonstrated lower fibrinogen levels, lower platelet counts, and prolonged activated partial thromboplastin time compared with penetrating trauma patients. This suggests a more complex and systemic coagulopathic response in blunt trauma, possibly reflecting the combined effects of tissue injury, hypoperfusion, and inflammation [16, 17]. In contrast, penetrating trauma may more often represent a "pure" haemorrhagic phenotype, where bleeding is driven primarily by mechanical vascular disruption rather than systemic coagulopathy. These findings have potential implications for resuscitation strategies. The lower levels of fibrinogen and platelets in blunt trauma support early and targeted haemostatic resuscitation in this group, including consideration of fibrinogen supplementation and platelet transfusion. Conversely, in penetrating trauma, rapid surgical haemorrhage control remains the cornerstone of management.

The present study has several strengths. It is based on a large, prospectively collected cohort from a well-defined trauma system with high data completeness. The integration of registry data with detailed

physiological and laboratory measurements allowed for a comprehensive comparison of early responses to injury. Furthermore, the inclusion of a predefined early transfusion subgroup enabled more detailed analysis of patients with severe haemorrhage.

Several limitations should be acknowledged. First, the single-centre design may limit generalisability to other settings, particularly regions with different injury patterns, such as a higher prevalence of firearm-related penetrating trauma. Second, although we adjusted for key confounders including age, sex, injury severity, and comorbidity, residual confounding cannot be excluded. Third, long-term functional outcomes beyond hospital discharge were not assessed. Finally, no formal missing data analysis was performed; all analyses relied on available cases. However, data completeness was high given the prospective study design and systematic registry review, and missing data are not expected to have materially influenced the results.

Conclusion

Blunt and penetrating trauma represent distinct clinical phenotypes with different patterns of injury, physiological response, and resource utilisation. Penetrating trauma was characterised by early haemorrhagic instability and a greater need for emergency surgery, whereas blunt trauma was associated with differences in coagulation parameters suggestive of a more pronounced coagulopathic profile, higher rates of traumatic brain injury, and worse functional outcomes. Despite these differences, no significant difference in adjusted 30-day mortality was observed between groups. These findings highlight the importance of mechanism-specific approaches to trauma resuscitation and management.

Abbreviations

ASA	American Society of Anesthesiologists
CI	Confidence Interval
CT	Computed Tomography
GCS	Glasgow Coma Scale
GOS	Glasgow Outcome Scale
INR	International Normalised Ratio
IQR	Interquartile Range
ISS	Injury Severity Score

OR
Odds Ratio
PRBC
Packed Red Blood Cells
SD
Standard Deviation
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology
TBI
Traumatic Brain Injury

Declarations

Ethics approval and consent to participate

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was granted by the Swedish Ethical Review Authority (Dnr 2021-04394), with a waiver of informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the authors on reasonable request and in compliance with the General data protection regulation and Swedish legislation.

Competing interests

The authors declare that they have no competing interests.

Funding

This research was supported by funding from Region Stockholm and the Karolinska Institute. EvO was supported by Region Stockholm clinical postdoctoral appointment (grant number 2023-0869); Swedish Society of Medicine grant number SLS-985471 and SLS-985302 and David and Astrid Hagelén foundation. JE was supported by Region Stockholm's clinical postdoctoral appointment (grant number 2022-0705).

Authors' contributions

The authors confirm contribution to the paper as follows; study conception and design: EvO, JE, BA, DO, MJF, MH; data collection: BA, DO, AG, AH, MH; analysis of the results: EvO, JE, MH; interpretation of

results: EvO, JE, BA, DO, MJF, MH; manuscript draft: EvO, MH. All authors critically reviewed the manuscript and approved the final version.

Acknowledgements

The authors would like to thank the staff of the trauma unit at Karolinska University Hospital for collecting prospective data and the staff of the Karolinska Trauma Registry for their excellent support.

References

1. Hay SI, Ong KL, Santomauro DF, et al. Burden of 375 diseases and injuries, risk-attributable burden of 88 risk factors, and healthy life expectancy in 204 countries and territories, including 660 subnational locations, 1990–2023: a systematic analysis for the Global Burden of Disease Study 2023. *Lancet*. 2025;406:1873–922.
2. van Breugel JMM, Niemeyer MJS, Houwert RM, Groenwold RHH, Leenen LPH, van Wessem KJP. Global changes in mortality rates in polytrauma patients admitted to the ICU: a systematic review. *World J Emerg Surg*. 2020;15(1):55.
3. Holmberg L, Mani K, Linder F, Wanhainen A, Wahlgren CM, Andréasson H. Penetrating trauma on the rise: nine-year trends of severe trauma in Sweden. *Eur J Trauma Emerg Surg*. 2024;50(6):3189–97.
4. Günther M, Dahlberg M, Rostami A, Azadali A, Arborelius UP, Linder F, et al. Incidence, demographics, and outcomes of penetrating trauma in Sweden during the past decade. *Front Neurol*. 2021;12:730405.
5. Swedish National Council for Crime Prevention. A study of gun violence trends in the criminal milieu since the mid-2000s. Stockholm: Swedish National Council for Crime Prevention. 2024. Report No.: 2024:7.
6. Swedish Trauma Registry (SweTrau). Årsrapport 2024. Stockholm: SweTrau. 2024. Available from: <https://www.swetrau.se>
7. Rikken QG, Chadid A, Peters J, Geeraedts LM, Giannakopoulos GF, Tan EC. Epidemiology of penetrating injury in an urban versus rural level 1 trauma center in the Netherlands. *Hong Kong J Emerg Med*. 2022;29(1):38–45.
8. Bernhardt I, Moore EE, Sauaia A. Timing of trauma deaths due to uncontrolled bleeding have not changed in three decades: a multicenter study of patients in hemorrhagic shock. *Am J Surg*. 2025;250.
9. Gutiérrez-Gutiérrez J, Barea-Mendoza JA, García-Fuentes C, Llompарт-Pou JA, Guardiola-Grau B, Durán-Suquía M, et al. Penetrating trauma in Spain: analysis of the Spanish trauma registry (RETRAUCI). *Med Intensiva (Engl Ed)*. 2025;49(6):502165.
10. Ludvigsson JF, Otterblad-Olausson P, Pettersson BU, Ekblom A. The Swedish personal identity number: possibilities and pitfalls in healthcare and medical research. *Eur J Epidemiol*. 2009;24(11):659–67.

11. McCrea MA, Giacino JT, Barber J, et al. Functional outcomes over the first year after moderate to severe traumatic brain injury in the prospective, longitudinal TRACK-TBI study. *JAMA Neurol.* 2021;78(8):982–92.

12. Ruelas OS, Tschautscher CF, Lohse CM, Sztajnkrzyer MD. Analysis of prehospital scene times and interventions on mortality outcomes in a national cohort of penetrating and blunt trauma patients. *Prehosp Emerg Care.* 2018;22(6):691–7.

13. Demetriades D, Kimbrell B, Salim A, Velmahos G, Rhee P, Preston C, et al. Trauma deaths in a mature urban trauma system: is trimodal distribution a valid concept? *J Am Coll Surg.* 2005;201(3):343–8.

14. Donohue JK, Gruen DS, Iyanna N, Lorence JM, Brown JB, Guyette FX, et al. Mechanism matters: mortality and endothelial cell damage marker differences between blunt and penetrating traumatic injuries across three prehospital clinical trials. *Sci Rep.* 2024;14(1):2747.

15. Ramsey WA, O'Neil CF Jr, Shatz CD, Lyons NB, Cohen BL, Saberi RA, et al. Nationwide analysis of firearm injury versus other penetrating trauma: it's not all the same caliber. *J Surg Res.* 2024;294:106–11.

16. Vulliamy P, Kornblith LZ, Kutcher ME, Cohen MJ, Brohi K, Neal MD. Alterations in platelet behavior after major trauma: adaptive or maladaptive? *Platelets.* 2021;32(3):295–304.

17. Moore EE, Moore HB, Kornblith LZ, Neal MD, Hoffman M, Mutch NJ, et al. Trauma-induced coagulopathy. *Nat Rev Dis Primers.* 2021;7(1):30.

Figures

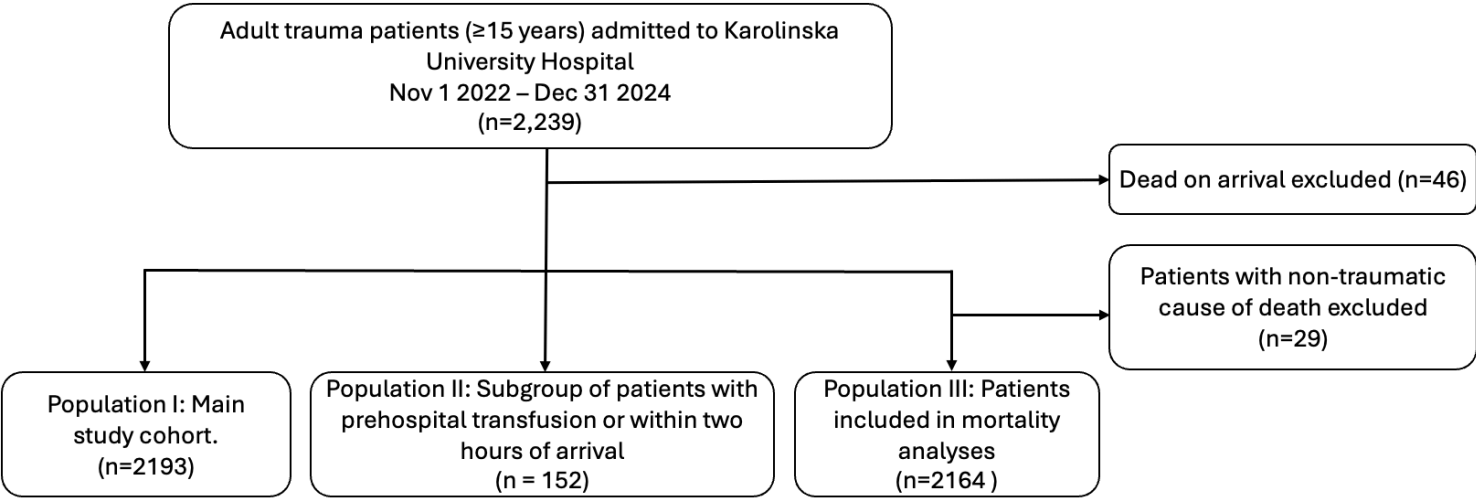


Figure 1

Flow chart of included patients.

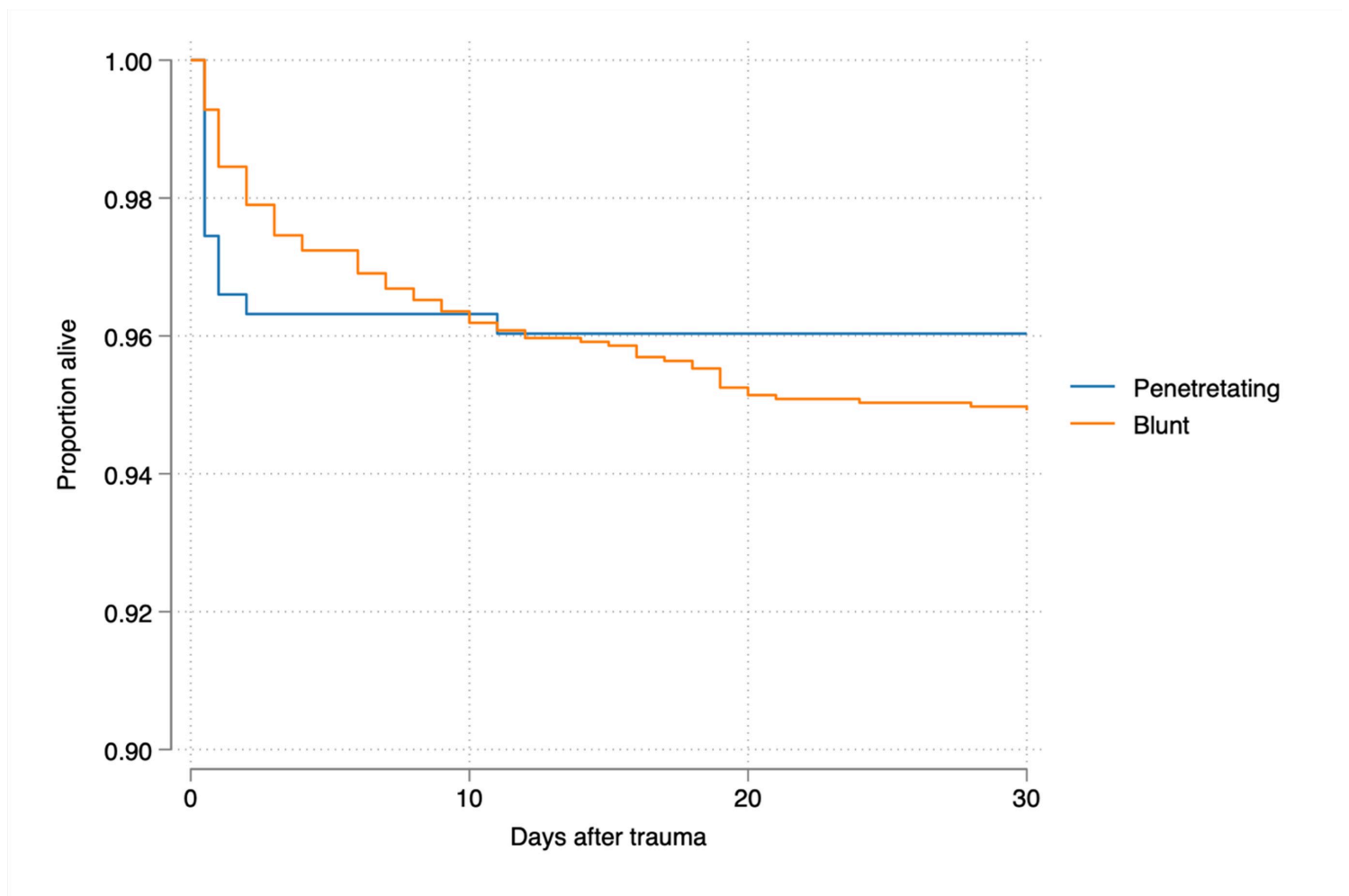


Figure 2

Kaplan–Meier survival curves stratified by injury type.

Kaplan–Meier estimates of survival up to 30 days after trauma comparing patients with penetrating versus blunt injury. The x-axis shows days after trauma and the y-axis shows proportion alive.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [AdditionalTables.docx](#)