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Pediatric and adult trauma centers differ in evaluation, treatment, and outcomes for severely injured adolescents

Ashley E. Walther^a, Richard A. Falcone^b, Timothy A. Pritts^a, Dennis J. Hanseman^a, and Bryce R.H. Robinson^{c,*}

^aDivision of Trauma and Critical Care, Department of Surgery, University of Cincinnati College of Medicine, USA

^bDivision of Pediatric General and Thoracic Surgery, Cincinnati Children's Hospital Medical Center, Department of Surgery, University of Cincinnati College of Medicine, USA

^cDivision of Trauma, Critical Care, and Burns, Department of Surgery, University of Washington, USA

Abstract

Background/purpose—This study aims to investigate differences in imaging, procedure utilization, and clinical outcomes of severely injured adolescents treated at adult versus pediatric trauma centers.

Methods—The National Trauma Data Bank was queried retrospectively for adolescents, 15–19 years old, with a length of stay (LOS) > 1 day and Injury Severity Score (ISS) >25 treated at adult (ATC) or pediatric (PTC) Level 1 trauma centers from 2007 to 2011. Patient demographics and utilization of imaging and procedures were analyzed. Univariate and multivariate regression analysis was used to compare outcomes.

Results—Of 12,861 adolescents, 51% were treated at ATC. Older age and more nonwhites were seen at ATC ($p < 0.01$). Imaging and invasive procedures were more common at ATC ($p < 0.01$). Shorter LOS ($p = 0.03$) and higher home discharge rates ($p < 0.01$) were seen at PTC. ISS and mortality did not differ. Age, race, ATC care (all $p < 0.01$), and admission systolic blood pressure (SBP) ($p = 0.03$) were predictors of CT utilization. ISS, SBP, and race ($p < 0.01$) were risk factors for overall mortality; SBP ($p = 0.03$) and ISS ($p < 0.01$) predicted death from penetrating injury.

Conclusions—Severely injured adolescents experience improved outcomes and decreased imaging and invasive procedures without additional mortality risk when treated at PTC. PTC is an appropriate destination for severely injured adolescents.

Keywords

Pediatric trauma center; Adult trauma center; Adolescents; Trauma outcomes; Imaging

*Corresponding author at: Department of Surgery, Box 359796, Harborview Medical Center, 325 Ninth Avenue, Seattle, WA, 98104-2499, USA. Tel.: +1 206 744 8485; fax: +1 206 744 3656.

Accidental injury is the leading cause of morbidity and mortality in adolescents aged 15–19 in the United States. These injuries accounted for 3652 deaths in 2013 and are responsible for a significant number of years of potential life lost [1,2]. Deaths from homicide contributed an additional 1407 deaths [1]. According to the Center for Disease Control, motor vehicle collisions and firearms are the leading causes of injury for this demographic group [1]. Regional trauma systems, including the development and coordination of pediatric-only trauma centers (PTC) with adult trauma centers (ATC) continue to evolve. When both PTC and ATC are available in a given region, the optimal location for treatment of injured adolescents remains unclear [3,4].

The ideal treatment setting for pediatric trauma patients, ages 0 to 18, has been investigated using various statewide and clinical databases with conflicting findings. Several state-based studies demonstrated lower mortality at PTC but lacked control for injury severity as a potential cofounder [5,6]. Wang et al. [7] failed to demonstrate a difference in mortality when examining severely injured children treated at PTC versus ATC. More recently, Sathya et al. [8] determined that young children (< 5 years old) had a higher risk of dying when treated at ATC but there was no association between center type and risk of death for older children (6–11 years old) and adolescents (12–18 years old). Matsushima et al. [4] examined the treatment of adolescents (ages 14–17) in Pennsylvania and found a significant difference in the use of computed tomography (CT) scanning and emergent laparotomy but no significant differences in risk-adjusted outcomes between PTC and ATC. In our recent study of injured adolescents treated at PTC versus ATC in the state of Ohio, no significant difference in outcomes was found between the two center types even after controlling for blunt and penetrating mechanisms of injury [3]. Utilization of national databases failed to clarify the optimal treatment location, with one study showing lower mortality at ACS-verified PTC while another failed to show a difference between ATC and PTC when controlling for factors such as injury severity [9,10].

In the present study, we investigate differences in acute interventions and outcomes of severely injured adolescents, ISS > 25, treated at ATC and PTC. By using a robust national database of participating trauma centers, we sought to identify differences in imaging patterns as well as the performance of invasive procedures between center types. We hypothesized that severely injured adolescent patients, ages 15 to 19 years, have equivalent outcomes, regardless of mechanism of injury, imaging obtained, or invasive procedures performed, when treated at PTC versus ATC. Additionally, we hypothesized that center type may be a risk factor for increased imaging and procedures performed even when adjusted by injury severity.

1. Methods

1.1. Study population

Retrospective trauma registry data was queried from the research dataset of the National Trauma Data Bank (NTDB) from 2007 to 2011. The NTDB is maintained by the American College of Surgeons, Committee on Trauma (ACS COT) [11]. Criteria for analysis included adolescents, age 15–19, with a length of stay (LOS) greater than 1 day, treated at an ACS COT verified Level 1 ATC or PTC. The ACS COT defines adult and pediatric trauma

centers, with a Level 1 PTC providing specialized pediatric care and treatment of at least 200 children annually less than the age of 15. The primary objective was to identify outcome differences between severely injured adolescents, defined as an injury severity score (ISS) >25, treated at each center type. Secondary objectives were to identify differences in utilization of resources, imaging, and procedures performed at ATC versus PTC.

1.2. Patient characteristics

Data abstracted from the NTDB included demographic and clinical variables related to outcomes. Demographics included age, gender, and race. Race was divided into African American, white, and other. Initial emergency department (ED) physiologic parameters, specifically temperature, heart rate (ED HR), systolic blood pressure (ED SBP), respiratory rate (ED RR), and Glasgow Coma Scale (ED GCS) were recorded. GCS was further divided by injury classification into severe (3–8), moderate (9–12), and mild (13–15). The severity of injury was determined using ISS and only patients with an injury severity scores greater than 25 were included.

Utilization of diagnostic imaging, which included CT of the head (ICD-9 87.03), chest (ICD-9 87.41), and abdomen (ICD-9 88.01, 88.38) and abdominal ultrasound (U/S) (ICD-9 88.76), was compared between centers. Further procedures investigated included laparotomy (ICD-9 54.11), thoracotomy (ICD-9 34.02), tube thoracostomy insertion (ICD-9 34.04), intracranial pressure monitor placement (ICD-9 01.1), ventriculostomy (ICD-9 02.2), and craniotomy (ICD-9 01.2).

1.3. Outcomes

The primary outcome examined was mortality. Secondary outcomes examined included intensive care unit (ICU) length of stay (LOS), hospital LOS, number of days in 28 free from mechanical ventilation (vent-free days), and discharge disposition. Discharge disposition to home was compared to other locations that included facilities for rehabilitation, long-term care, skilled nursing, intermediate care, and other hospitals. Outcomes were analyzed by ATC versus PTC.

1.4. Statistical analysis

Adolescents admitted to an ATC were compared with those admitted to a PTC. Chi-square test, t tests, and Wilcoxon rank-sum tests were employed, when appropriate, to compare baseline characteristics of center type, differences in utilization of imaging studies and invasive procedures performed, and outcomes of interest. Logistic regression models were employed utilizing SAS version 9.4 (SAS Institute Inc., Cary NC) to investigate the effect of center type on mortality and CT utilization, after adjustment for clinically significant covariates. Statistical significance was defined as $p < 0.05$.

2. Results

A total of 12,861 severely injured adolescents were treated for injury at Level I ATC or Level I PTC during the 5-year study period. Of these patients, 51% were treated at an ATC. The majority of the cohort (89%) sustained blunt injury.

Demographics were compared to evaluate baseline differences (Table 1). Adolescents treated at ATC were on average older (17.5 vs. 17.4 years, $p < 0.01$), had higher temperatures on ED presentation (35.1 vs. 34.6 C, $p < 0.01$), and were more likely to be nonwhite (34.2% vs. 28.7%, $p < 0.01$). Gender, injury type, initial ED vital signs, GCS, and ISS did not statistically differ by treating institution type.

Differences in imaging and procedures were evaluated by mechanism of injury (Table 2). All forms of imaging were more common at ATC after blunt trauma ($p < 0.01$), while only U/S abdomen was statistically more common at ATC after penetrating trauma (11.5% vs. 5.4%, $p < 0.01$). Laparotomy, ventriculostomy, and craniotomy were more common at ATC (11.3% vs. 9.3%, 8.8% vs. 7.3%, 8.8% vs. 6.1%, all $p < 0.01$) after blunt trauma. The use of thoracotomy trends toward significance, with thoracotomies performed more often at ATC versus PTC after blunt trauma (1.0% vs. 0.7%, $p = 0.05$). ICP monitor insertion was more common at PTC after blunt trauma (6.9% vs. 8.5%, $p < 0.01$). Laparotomy was the only statistically significant difference between ATC and PTC after penetrating trauma, with more patients undergoing laparotomy at adult-only centers (35.2% vs. 29.2%, $p = 0.02$).

To examine differences in common outcomes, a series of variables were evaluated for the overall population and then compared between blunt and penetrating trauma patients treated at ATC and PTC (Table 3). Adolescent patients sustaining blunt trauma treated at PTC had shorter median ICU (5 [2–12] vs. 4 [2–12], $p < 0.01$) and hospital LOS (10 [6–20] vs. 10 [5–20], $p = 0.02$). Additionally, those patients treated at PTC were more likely to be discharged home (48.7% vs. 51.8%, $p < 0.01$). More adolescents treated at ATC were discharged to rehab facilities or long term care facilities (28.8% vs. 20.3%) and skilled nursing facilities (3.1% vs. 2.2%). There was no difference in the number of ventilator-free days in 28 or in overall mortality between the two types of centers.

To identify risk factors predicting mortality of adolescents with severe injury, univariate and multivariate logistic regression was performed (Table 4). Analysis of severely injured adolescents with ED GCS < 8 was performed to identify mortality predictors in adolescents with severe traumatic brain injury (TBI). Nonwhite race, ED SBP < 90 mmHg, and increasing ISS ($p < 0.01$) were identified as risk factors in both univariate and multivariate logistic regression. Mortality predictors were then examined for severely injured adolescents after penetrating injury. ED SBP < 90 mmHg and increasing ISS ($p < 0.01$) were identified as predictive of mortality on univariate analysis. On multivariate analysis, ED SBP < 90 mmHg (1.66 [1.06–2.62], $p = 0.03$) and increasing ISS (1.03 [1.02–1.04], $p < 0.01$) remained as predictive factors of mortality. Treatment at an adult center was not a risk factor for mortality in either analysis.

Predictors of undergoing CT of the head, chest or abdomen in adolescents after severe injury were examined (Table 5). Age (0.97 [0.94–1.00], $p = 0.03$), male gender (0.90 [0.83–0.97], $p < 0.01$), nonwhite race (0.78 [0.72–0.84], $p < 0.01$), ED systolic blood pressure < 90 mmHg (0.83 [0.72–0.96], $p = 0.01$), ED heart rate > 110 beats per minute (0.93 [0.86–1.00], $p = 0.04$) and treatment at an ATC (1.81 [1.69–1.95], $p < 0.01$) were determined to be predictive of undergoing CT on univariate analysis. Age (0.96 [0.93–0.99], $p < 0.01$), nonwhite race (0.74 [0.68–0.81], $p < 0.01$), ED systolic blood pressure < 90 mmHg (0.83 [0.71–0.97], $p =$

0.02), and treatment at ATC (2.05 [1.90–2.22], $p < 0.01$) remained significant on multivariate logistic regression as predictors of having CT performed. Differences between univariate and multivariate analysis remained consistent and below the level indicative of confounding.

3. Discussion

In the present study, our data demonstrates that the care of severely injured adolescents differs between adult and pediatric trauma centers. We undertook this study to increase our understanding of potential differences in acute interventions and outcomes of severely injured adolescents treated at ATC and PTC. Our goal is to use this data to understand aspects of our current trauma system and use this as a means to delineate best practices. Our data, while intriguing, should be interpreted with caution and is not meant to imply that some components of the current trauma system are underperforming.

Although not clinically significant, patients treated at ATC were older than those treated at PTC. A higher proportion of nonwhite adolescents were treated at ATC. Although there was no difference in gender, ED GCS, ISS, and mortality, we found that PTC obtained less imaging and performed fewer invasive procedures, with the exception of ICP monitoring, which was more prevalent at PTC. Chest tube insertion was performed at equivalent rates at both sites. Adolescents had improved outcomes, including shorter ICU LOS and discharge to home, when treated at a PTC. Differences in hospital LOS, while statistically significant, were not clinically meaningful. In-hospital mortality differences were not significantly different between ATC and PTC.

More than half (51%) of the adolescents identified in this study were treated at ATC. Previous studies examining the delivery and outcomes of care in pediatric injury demonstrated that the majority of pediatric patients were cared for at adult centers [4,12]. In the present study, we specifically examined only severely injured adolescents (ages 15–19) with an ISS > 25 and length of stay > 1 day. Previous studies suggested that significantly injured pediatric and adolescent patients were more often taken to ATC [3,4,7,10,13]. The balanced number of adolescents being treated at ATC and PTC in our study may be attributed to the growing number of PTC.

In the setting of adult blunt trauma, more routine use of the “pan scan” has been noted [14]. A significant difference in the use of imaging between ATC and PTC for injured adolescents was demonstrated, with ATC more commonly utilizing CT head, chest, and abdomen and abdominal U/S. The more frequent use of CT and U/S was consistent with previously published studies evaluating the use of imaging in pediatric trauma [3,4]. Kharbanda et al. [15] demonstrated that the majority of radiation exposure to pediatric patients is secondary to CT. In light of increased awareness about the risks of radiation, efforts exist to decrease pediatric exposure to radiation [16,17]. Children’s smaller size, greater radiosensitivity, and longer life expectancy may contribute to radiation-induced malignancy [18–21]. A number of studies have evaluated the use of CT in pediatric trauma patients and argue for the importance of selective use [22–24]. Selective CT imaging has been suggested in the workup of injured children by several groups in an attempt to mitigate the risks of radiation [25,26].

The utility of abdominal CT for blunt injury evaluation of pediatric trauma patients has been questioned because of high false-negative rates and the idea that clinical findings ultimately dictate the decision to operate [27]. As reflected in our result, adolescents treated at ATC were more likely to undergo abdominal U/S. In a study of the Focused Abdominal Sonography for Trauma (FAST) examination, a small percentage (15%) of children's hospitals as compared to the majority (96%) of adult hospitals utilized FAST [28]. Several reports indicate that FAST is not sensitive in pediatric patients leading to its decreased application in this population [29–31].

Exploratory laparotomy was more commonly performed on severely injured adolescents at ATC in our study after both blunt and penetrating injury. Previous reports suggest that, in the setting of similar injury severity, children treated at ATC for blunt splenic and liver injuries are far more likely to undergo operative management than at PTC [4,5,13,32]. Our data is consistent with the findings of these previous studies and suggests a tendency to treat adolescents operatively like adults when evaluated at adult centers.

The management of head injuries differed between adult and pediatric centers, with more ICP monitors placed at PTC and more ventriculostomies and craniotomies performed at ATC. This finding was seen in the cohort as a whole and for adolescents after blunt trauma; however, these differences were not present in the management of penetrating trauma. The use of ICP monitoring in children with traumatic brain injuries has been supported to prevent secondary brain injury; nonetheless, some studies question their impact upon mortality [33]. Previous literature is in opposition to the findings in our study. Hall et al. [34] demonstrated improved outcomes for blunt head injuries treated at PTC because of more aggressive management of head injury, including placement of ICP monitor. Potoka et al. [5] reported that a higher proportion of children with severe head injury (GCS 3–8) underwent neurosurgical procedures (craniotomy, placement of external ventricular drain, repair of skull fracture) at PTC versus ATC. Furthermore, an earlier study utilizing the NTDB demonstrated a higher percentage of ICP monitor usage at ATC but a higher percentage of craniectomy/craniotomy at PTC [35]. In contrast, Kernic et al. [36] reported that children with moderate to severe TBI underwent more procedures at adult centers, though this study failed to control for injury severity. The difference seen in our study versus the aforementioned literature may be because of the different study populations, as the previous studies examined children of all ages.

Our study found that overall ICU LOS is shorter at PTC. Potoka et al. [37] also demonstrated that median LOS was significantly shorter at PTC compared to ATC for severely injured children. Additionally, more adolescents treated at PTC were discharged home. A previous study examined functional outcomes for severely injured children, including feeding, locomotion, transfer mobility, social interaction, and expression, after treatment at PTC versus ATC, which demonstrated improved functional outcomes for children treated at PTC [37]. While this study examined all children, it is not directly applicable to our adolescent population. No studies were identified that investigated discharge disposition or functional outcomes of an adolescent-only population. Difference in discharge location may be a factor of the social work structure and resources available to get patients home with services.

On subgroup analysis, findings were similar for adolescents sustaining blunt trauma, with decreased ICU and statistically shorter hospital LOS, although not clinically significant, and more discharges home from PTC. These findings of decreased ICU and overall LOS are consistent with data published on adolescents experiencing blunt splenic injury [13]. In the penetrating group, a shorter ICU LOS was seen at PTC. In both the blunt and penetrating trauma subgroups, there was no statistically significant difference in mortality at PTC versus ATC. Previous studies report varied findings in respect to mortality rates for children treated at PTC versus ATC. Osler et al. [10], using the National Pediatric Trauma Registry, showed that overall mortality rates were lower at PTC than ATC; however, these differences were not statistically significant after controlling for ISS, mechanism of injury, age, and sex. Conflicting results are seen in several state-based studies, with findings in Florida demonstrating a reduction in mortality with treatment at PTC [6] whereas California failed to identify any mortality benefit with treatment at PTC [7]. In contrast, Densmore et al. [12] demonstrated a lower mortality for pediatric trauma patients treated at children's hospitals versus adult hospitals for all injury types after adjusting for ISS through use of the Kid's Inpatient Database. The findings of our study are consistent with previously published data looking at the adolescent population, where no difference in mortality was seen [3,4].

We performed a series of logistic regression analyses in order to determine predictors of mortality in severely injured adolescents. Nonwhite gender, ED SBP <90 mmHg and increasing ISS were predictors of mortality in those with significant TBI. In the setting of penetrating injury, ED SBP <90 mmHg and higher ISS were statistically significant predictors of mortality. While ED SBP <90 mmHg and ISS are correlated with the severity of injury, the factor of race as a predictor of mortality is not as clear. A number of studies have explored minority race as a predictor of outcome after injury of both adults and children [38,39]. Cassidy et al. reports on disparities in pediatric trauma in Wisconsin, noting a higher percentage of penetrating trauma in African American children and the highest risk of mortality in Hispanic children [40]. Factors associated with worse outcomes for minorities include increased exposure to violence, care at lower quality hospitals, and differences in preinjury medical care, including preventive medicine. Of note, no previous studies of the impact of race on adolescent trauma patients were found on literature review.

Several limitations exist in this study, including the retrospective nature of the investigation, the lack of classification by type of intraabdominal procedures performed, and the inability to assess nontraditional outcomes. The voluntary nature of the center participation in the NTDB is another limitation, with less than 50% of total trauma centers submitting annually during the study period. Unlike previous studies, we did not examine the management and outcomes based on the type of procedure performed, such as splenectomy or hepatorrhaphy. Further limitations to the database include the inability to determine if imaging performance, procedural intervention, and timing is protocol driven or provider preference, which may also be impacted by volume and system differences. The ability of adult and pediatric centers to provide support and care for posttraumatic stress disorder and physical and psychological rehabilitation may differ. This difference may impact LOS measurements and discharge location appropriateness. While we were able to determine location of discharge, additional factors including cost, patient and family satisfaction, and readmission rates could not be determined with use of the dataset. Additionally, we did not determine the impact of

socioeconomic status on outcome of care. While transfer occurred at an equal incidence at ATC and PTC (5.5% and 5.4%), the study is unable to account for the effects of transfer.

In conclusion, despite significant differences in the imaging obtained in the evaluation and the procedures performed in the treatment of severely injured adolescents between ATC and PTC, there is no significant difference in mortality. Treatment at PTC portended a shorter LOS and higher rate of discharge to home while having decreased radiation exposure. With several favorable outcomes and no difference in mortality, PTC is an appropriate destination for the treatment of severely injured adolescents regardless of mechanism of injury.

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Abbreviations

ATC	Adult trauma center
ACS COT	American College of Surgery Committee on Trauma
CT	Computed tomography
ED	Emergency department
GCS	Glasgow Coma Scale
HR	Heart rate
ISS	Injury Severity Score
ICU	Intensive care unit
LOS	Length of stay
PTC	Pediatric trauma center
RR	Respiratory rate
SBP	Systolic blood pressure

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Table 1

Demographics of adolescent trauma patients with severe injury (n = 12,861).

	<u>ATC</u> (n = 6582)	<u>PTC</u> (n = 6279)	p Value
Age (years)	17.5 (1.3)	17.4 (1.3)	<0.01 *
Male gender	69.1%	70.5%	0.10
Race			<0.01 *
African American	15.6%	18.1%	
White	65.8%	71.3%	
Other	18.6%	10.6%	
Injury type			0.93
Blunt	89.1%	89.0%	
Penetrating	10.9%	11.0%	
ED temp	35.1 (5.7)	34.6 (6.7)	<0.01 *
ED HR	101.6 (30.2)	100.8 (30.9)	0.10
ED SBP	127.3 (27.8)	127.3 (27.8)	0.62
ED RR	17.3 (10.7)	16.7 (9.6)	0.18
ED GCS total			0.93
13–15	48.6%	48.9%	
9–12	5.9%	5.8%	
3–8	45.5%	45.3%	
ISS	33 (29–38) ^a	33 (29–38) ^a	0.33

Values provided in means (standard deviation) for normally distributed variables and in medians (interquartile range) for nonsymmetrically distributed variables (ISS).

ATC: adult trauma centers, PTC: pediatric trauma centers, ED: emergency department, temp: temperature; HR: heart rate; SBP: systolic blood pressure in mmHg, RR: respiratory rate in breaths per minute, GCS: Glasgow Coma Scale, ISS: injury severity score, CT: computed tomography, Abd: abdominal, U/S: ultrasound.

* p < 0.05.

^a Nonsymmetrically distributed variables.

Table 2

Imaging and procedures by mechanism for adolescents treated at ATC versus PTC.

Imaging	ATC	PTC	p Value
Blunt trauma	(n = 5865)	(n = 5588)	
CT head	40.5%	27.9%	<0.01 *
CT chest	28.0%	22.1%	<0.01 *
CT abdomen	43.1%	29.4%	<0.01 *
U/S abdomen	16.8%	5.1%	<0.01 *
Penetrating trauma	(n = 717)	(n = 691)	
CT head	15.8%	14.5%	0.48
CT chest	15.7%	15.6%	0.98
CT abdomen	27.6%	23.9%	0.11
U/S abdomen	11.5%	5.4%	<0.01 *
Procedures			
Blunt trauma	(n = 5865)	(n = 5588)	
Laparotomy	11.3%	9.3%	<0.01 *
Tube thoracostomy	20.4%	20.3%	0.94
Thoracotomy	1.0%	0.7%	0.05
ICP monitor insertion	6.9%	8.5%	<0.01 *
Ventriculostomy	8.8%	7.3%	<0.01 *
Craniotomy	8.8%	6.1%	<0.01 *
Penetrating trauma	(n = 717)	(n = 691)	
Laparotomy	35.2%	29.2%	0.02 *
Tube thoracostomy	39.7%	40.5%	0.74
Thoracotomy	6.7%	4.8%	0.13
ICP monitor insertion	2.2%	1.9%	0.65
Ventriculostomy	3.1%	3.0%	0.99
Craniotomy	3.3%	3.2%	0.88

CT: computed tomography, U/S: ultrasound, ATC: adult trauma centers, PTC: pediatric trauma centers.

*
p < 0.05.

Table 3

Outcomes by mechanism for adolescents treated at ATC versus PTC.

	<u>ATC</u>	<u>PTC</u>	<u>p Value</u>
Overall	(n = 6582)	(n = 6279)	
ICU LOS	5 (2–12)	4 (2–11)	< 0.01 *
Hospital LOS	11 (6–20)	10 (6–20)	0.03 *
Ventilator-free days in 28	26 (16–28)	26 (16–28)	0.08
Discharged home	49.9%	52.6%	<0.01 *
Mortality	9.0%	8.7%	0.57
Blunt trauma	(n = 5865)	(n = 5588)	
ICU LOS	5 (2–12)	4 (2–12)	<0.01 *
Hospital LOS	10 (6–20)	10 (5–20)	0.02 *
Ventilator-free days in 28	26 (16–28)	26 (16–28)	0.12
Discharged home	48.7%	51.8%	<0.01 *
Mortality	8.6%	8.3%	0.61
Penetrating trauma	(n = 717)	(n = 691)	
ICU LOS	4 (2–10)	4 (2–9)	0.04 *
Hospital LOS	11 (6–21)	11 (6–21)	0.76
Ventilator-free days in 28	25 (16–28)	26 (15–28)	0.36
Discharge home	60.5%	59.3%	0.67
Mortality	12.5%	12.0%	0.79

Values provided in medians (interquartile ranges).

ATC: adult trauma centers, PTC: pediatric trauma centers, ICU: intensive care unit, LOS: length of stay.

*
p < 0.05.

Table 4

Mortality predictors of adolescents with severe injury.

	Univariate	p Value	Multivariate	p Value
With GCS <8 on ED evaluation				
Age (years)	1.02 (0.97–1.08)	0.43	1.02 (0.96–1.08)	0.58
Male gender	1.01 (0.87–1.18)	0.86	0.98 (0.83–1.15)	0.78
Nonwhite	1.56 (1.34–1.82)	<0.01 *	1.55 (1.32–1.81)	<0.01 *
ED SBP ≥ 90 mmHg	2.16 (1.76–2.65)	<0.01 *	1.85 (1.48–2.31)	<0.01 *
ED HR > 110 BPM	0.91 (0.79–1.05)	0.20	0.87 (0.74–1.01)	0.06
ISS	1.04 (1.03–1.05)	<0.01 *	1.04 (1.03–1.05)	<0.01 *
Adult trauma center	0.98 (0.86–1.13)	0.81	0.97 (0.84–1.13)	0.73
With penetrating mechanism				
Age (years)	0.91 (0.80–1.02)	0.11	0.88 (0.77–1.01)	0.06
Male gender	0.80 (0.47–1.36)	0.40	1.02 (0.56–1.88)	0.94
Nonwhite	0.71 (0.48–1.05)	0.09	0.73 (0.48–1.11)	0.14
ED SBP <90 mmHg	2.08 (1.39–3.11)	<0.01 *	1.66 (1.06–2.62)	0.03 *
ED HR > 110 BPM	0.84 (0.61–1.16)	0.28	0.75 (0.53–1.08)	0.12
ISS	1.03 (1.02–1.05)	<0.01 *	1.03 (1.02–1.04)	<0.01 *
Adult trauma center	1.05 (0.76–1.45)	0.76	1.14 (0.80–1.63)	0.46

Values provided in odds ratios (95% confidence intervals).

ED: emergency department, SBP: systolic blood pressure, HR: heart rate, BPM: beats per minute, ISS: injury severity score.

*
p < 0.05.

Table 5

Predictors of having CT (head or chest or abdomen) in adolescents with severe injury.

	Univariate	p Value	Multivariate	p Value
Age (years)	0.97 (0.94–1.00)	0.03	0.96 (0.93–0.99)	<0.01*
Male gender	0.90 (0.83–0.97)	<0.01*	0.95 (0.87–1.03)	0.19
Nonwhite	0.78 (0.72–0.84)	<0.01*	0.74 (0.68–0.81)	<0.01*
ED SBP <90 mmHg	0.83 (0.72–0.96)	0.01*	0.83 (0.71–0.97)	0.02*
ED HR > 110 BPM	0.93 (0.86–1.00)	0.04*	0.94 (0.87–1.02)	0.12
ISS	1.00 (1.00–1.00)	0.60	1.00 (1.00–1.01)	0.84
Adult trauma center	1.81 (1.69–1.95)	<0.01*	2.05 (1.90–2.22)	<0.01*

Values provided in odds ratios (95% confidence intervals).

ED: emergency department, SBP: systolic blood pressure, HR: heart rate, BPM: beats per minute, ISS: injury severity score.

* p < 0.05.