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Causes of Early Mortality in Pediatric Trauma Patients

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Abstract

Background: Trauma is the leading cause of death in children, and most deaths occur within 24 hours of injury. A better understanding of the causes of death in the immediate period of hospital care is needed.

Methods: Trauma admissions <18 years old from 2009–2019 at a level 1 pediatric trauma center were reviewed for deaths (n=7145). Patients were stratified into ages 0–6, 7–12, and 13–17 years old. The primary outcome was cause of death, with early death defined as <24 hours after trauma center arrival.

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Results: There were 134 deaths (2%) with a median age of 7 years old. The median time from arrival to death was 14.4 hours (IQR 0.5–87.8). Half (54%) occurred within 24 hours. However, most patients who survived initial resuscitation in the ED died > 24 hours after arrival (69%). Traumatic brain injury was the most common cause of death (66%), followed by anoxia (9.7%) and hemorrhage (8%). Deaths from hemorrhage were most often in patients sustaining gunshot wounds (GSWs, 73% vs. 11% of all other deaths, $p<0.0001$), more likely to occur early (100% vs. 50% of all other deaths, $p=0.0009$), and all died within 6 hours of arrival. Death from hemorrhage was more common in adolescents (21.4% of children aged 13–17 vs. 6.3% of children aged 0–6, and 0% of children aged 7–12 $p = 0.03$). The highest case fatality rates were seen in hangings (38.5%) and GSWs (9.6%).

Conclusions: Half of pediatric trauma deaths occurred within 24 hours. Death from hemorrhage was rare, but all occurred within 6 hours of arrival. This is a critical time for interventions for bleeding control to prevent death from hemorrhage in children. Analysis of these deaths can focus efforts on the urgent need for development of new hemorrhage control adjuncts in children.

Keywords

pediatric trauma; mortality; hemorrhage

Background

Trauma is the leading cause of death in children (1). Of children who die from traumatic injuries, most die within 24 hours of arriving to the hospital (1). When compared to adult trauma patients, children are more likely to die in the emergency department (ED) rather than surviving long enough for hospital admission or transfer to the operating room (1). Traumatic brain injury (TBI) is a leading cause of death in injured children (2), but the proportion of injured children who die from hemorrhage, and the timing of their deaths, is not well understood.

One study assessed cause of death of 105 injured children through autopsy reports, finding TBI was the most common cause of death (40%), with hemorrhage next most common, causing 18.1% of deaths. They further categorized deaths as preventable or potentially preventable, defined as anatomic injuries which are survivable if treated expeditiously, and found that only 14.3% of TBI deaths were preventable or potentially preventable, compared to 47.4% of hemorrhage deaths (3). In children, a study of one thousand pediatric deaths due to firearm violence found that non-compressible torso injuries accounted for 26.3% of mortalities (4). However, there is more robust data in the adult trauma literature, indicating that delays in hemorrhage control have been found to account for 25% of deaths in adult trauma patients (5). In recent years, mortality rates in adult trauma patients have improved due to advances in both resuscitation (6) and hemorrhage control maneuvers such as tourniquets use (7), timely operative hemorrhage control (8), and minimally invasive aortic occlusion via REBOA (9,10). Further work is needed to identify which children are at risk of dying from hemorrhage, and when that risk is highest.

In this study, we aimed to characterize the causes of death of children presenting as trauma activations at a high-volume level 1 trauma center with a large catchment area. Analyses of large registries are limited by the relative paucity of detailed clinical information available in the database. There is no large database study evaluating causes of death in pediatric trauma patients, leaving high-volume single center retrospective analysis as the most effective approach to answer these detailed clinical questions. As shown in previous autopsy studies, we hypothesized that traumatic brain injury and hemorrhage would be seen the leading causes of death and that deaths from hemorrhage would occur early than deaths from other causes.

Methods

Study Design and Setting

Following local institutional review board approval (IRB# 1582638) and approved waiver of consent, we reviewed our level 1 pediatric trauma center's prospectively collected trauma registry for all deaths < 18 years old between January 1, 2009 and December 31, 2019. We included patients who died after arrival at the emergency department (ED), including those who were declared dead shortly after arrival. Data extracted from our trauma registry included demographics, injury date and time, ED arrival date and time, injury mechanism, transfer status, admission location, admission vital signs, imaging results, injury severity score, hospital and intensive care unit (ICU) length of stay, interventions, in-hospital mortality, death location (ED, operating room (OR), ICU, or ward), and time of death. Shock Index, Pediatric Age-Adjusted (SIPA) was calculated by dividing the heart rate (HR) on arrival by the systolic blood pressure (SBP) upon arrival to the ED (11). If a patient's HR or SBP on arrival was zero, SIPA was not calculated. Data on blood transfusions was collected, and weight-based transfusion volumes were calculated. Massive transfusion was defined as ≥ 40 ml/kg total blood products transfused within first 24 hours.

The primary outcome was cause of death, determined by detailed chart review of physician assessment notes, imaging reports, and operative reports. Causes of death were categorized as hemorrhage, traumatic brain injury, anoxic brain injury, other causes or a combination of causes, or unknown. Death due to hemorrhage was defined as patients who died with injuries that resulted in hemorrhage, including solid organ injury, vascular injury, or thoracic hemorrhage from cardiac or pulmonary injury in the absence of other significant injuries. Death due to traumatic brain injury was defined as isolated trauma to head, or imaging findings of subarachnoid hemorrhage (SAH), subdural hemorrhage (SDH), epidural hemorrhage (EDH), intraparenchymal hemorrhage (IPH), intraventricular hemorrhage (IVH), or diffuse cerebral edema. Anoxic brain injury was defined as death following inhalation injury, hanging, or imaging findings of anoxia. If patients had more than one contributing factor, i.e. hemorrhage and TBI, the cause of death was categorized as other. If insufficient information was available to determine a cause of death, the cause was classified as unknown.

Patients were additionally divided into early mortality (< 24 hours after arrival to trauma center) and late mortality (> 24 hours after arrival to trauma center) (1). Time to death (TTD) was calculated as time of death minus arrival time to our institution. Time from injury to death is not available as time of injury was missing in many patients. Secondary outcomes included ISS, elevated SIPA on admission, location of in-hospital death, and interventions performed. Patients with death due to hemorrhage were compared to all other deaths. Case fatality rates were calculated for the most common mechanisms of injury, defined as the number of fatalities divided by the total number of patients presenting with a given mechanism of injury. All pediatric trauma mortalities were compared to surviving patients to identify differences in demographics and injury mechanisms that were associated with dying. Changes in mortality over time were evaluated by dividing patients into an early cohort (2009–2013) and a recent cohort (2014–2019). A subgroup analysis of trauma mortalities was performed after dividing patients into three age groups: 0–6 years old, 7–12 years old, and 13–17 years old. Lastly, a subgroup analysis of patients who died was performed comparing transferred patients to patients arriving from the scene of injury.

Statistical Analysis

Descriptive statistics were performed for baseline characteristics. Categorical data are presented as proportions and percentages. Continuous data are presented as median and interquartile range (IQR). Categorical variables were compared using Fisher's exact test or chi-square tests. Continuous variables were compared using Mann-Whitney-U tests. The level of significance was set at $p < 0.05$. Analyses were conducted using SAS (SAS, version 9.45; SAS Institute Inc).

Results

Overall results

There were 7135 pediatric trauma admissions between July 1, 2009 and December 31, 2019 (Table 1). The median age was 7 years old (IQR 3–13) and 63.7% of patients were male. The vast majority were injured by blunt trauma (91.3%), with 618 patients injured by penetrating trauma. The most common mechanisms were falls (39.6%) and motor vehicle collisions (18.0%). They were overall not severely injured, with a median ISS of 5 (IQR 4–10) and a length of stay of 1 day (IQR 1–3).

One hundred thirty-four patients died (2%). When compared to surviving patients (Table 2), there were no age or sex differences. However, a higher proportion of surviving patients presented as transfers from referring hospitals (50.9% vs. 38.1%, $p = 0.003$). Mechanism of injury differed between mortalities and surviving patients, with significantly higher rates of penetrating trauma in the cohort of children and adolescents who died (18.7% vs. 8.5%, $p < 0.0001$), and higher rates of GSWs among patients who died (16.4% vs. 2.9%, $p < 0.0001$). The case fatality rate was highest for victims of hanging (5/13, 38.5%), followed by GSWs (22/228, 9.6%) and assaults (15/291, 5.2%). The two most common mechanisms of injury, falls and MVCs, had low case fatality rates, 0.28% for falls and 3.0% for MVCs. As expected, patients who die were sicker on admission, with lower GCS (3 vs. 15, $p < 0.0001$), more frequently elevated SIPA (64.7% vs. 29.4%, $p < 0.0001$), and higher ISS (26.5 vs. 5, $p < 0.0001$).

Patients were characterized into early (2009–2013) and recent (2014–2019) cohorts to evaluate trends over time. Although the overall pediatric trauma volume increased over time from 2,378 patients in the early cohort to 4,757 patients in the recent cohort, the mortality rate decreased from 2.4% to 1.6% (p = 0.02, Figure 1).

Timing and Location of Death

The majority of patients who died survived beyond initial ED resuscitation (68.7%), and most were admitted to the ICU (45.5%) or taken straight to the operating room (23.1%, Table 3). Patients admitted to the ICU had a median ICU LOS of 3 days. The ICU was the most frequent location of death (61.2%) followed by the ED (31.3%) and the OR (6.7%). One patient died on the ward. The median time to death was 14.4 hours (IQR 0.5–87.8 hours). Overall, 53.7% of patients died within 24 hours of arrival to the trauma center. Of patients who survived out of the ED (n=92), the median time to death was 57.9 hours (IQR 13.1–121.9) and 67.4% died more than 24 hours after arrival.

Causes of Death

Traumatic brain injury (TBI) was the most common cause of death (66.4%). Thirteen patients died of anoxic brain injury (9.7%), and eleven patients died of hemorrhage (8.2%). Of the eight patients with other causes of death, five died due to a combination of severe TBI and hemorrhage. Of the remaining three patients with other causes of death, one died of sudden decompensation from respiratory failure on hospital day 33, one died from anoxic brain injury following exsanguination from a thoracic stab wound, and one died from multisystem organ failure. Thus, in total, hemorrhage was responsible for or contributed to the deaths of 17 patients (12.7%). An additional thirteen patients had no imaging or interventions done prior to dying, and their cause of death was categorized as unknown (9.7%).

Deaths from hemorrhage compared to other causes

Of the 11 deaths due primarily to hemorrhage, the mechanism was most commonly GSW (73% of hemorrhagic deaths vs. 11% of all other deaths, $p < 0.0001$). All primarily hemorrhagic deaths occurred within 6 hours of ED arrival compared to 50% of all other deaths ($p = 0.0009$). Hemorrhagic deaths occurred at a median of 1.0 hours after ED arrival (IQR 0.1–3.5 hours) compared to 22.8 hours (IQR 0.6–94.4 hours, $p = 0.002$). Compared to patients who died from TBIs, hemorrhagic deaths occurred much earlier (1.0 vs. 35.8 hours, $p = 0.0001$). Children who died from hemorrhage had similar injury severity scores (median 32 in hemorrhagic deaths vs. 26 in all other deaths, $p = 0.8$). Of patients with deaths due to hemorrhage, 5 died in the ED (45.5%), 5 died in the OR (45.5%), and one died in the ICU (9.1%), while deaths of all other causes were most likely to occur in the ICU (65.6%) or the ED (30.1%).

Nine of eleven patients with death due to hemorrhage underwent attempted surgical control of hemorrhage. Six had emergency department thoracotomies performed in the trauma bay, with three converted to clamshell thoracotomies. Of these, two died in the ED and four survived long enough to proceed to the OR where exploratory laparotomy was performed (n=3) or clamshell thoracotomy (n=1). Three of these patients died in the OR during attempted hemorrhage control surgery and one died shortly after arrival to the ICU from the OR. A total of six children underwent exploratory laparotomy for hemorrhage control, including one patient was transferred to our ED with a temporary abdominal closure placed at a referring hospital after damage control laparotomy, which was removed in the ED due to hemodynamic collapse on arrival for attempted bedside hemorrhage control. One patient underwent a sternotomy. Hemorrhage control procedures performed included hepatic packing (n=5), splenectomy (n=1), nephrectomy (n=1), pulmonary lobectomy or wedge resection (n=2), repair of cardiac injuries (n=1), attempted repair of inferior or superior vena cava injury (n=2), aortic shunt placement (n=1), repair of iliac artery injury (n=1), and repair of gastrointestinal injuries (n=3). Two patients were declared dead on arrival and did not undergo any interventions; both of these patients sustained GSWs to the chest and arrived under CPR. Further interventions were deemed futile due to the duration of time without attainable vital signs prior to arrival.

Most patients who died from hemorrhage received blood transfusions (n=9/11, 81.8%), and five received massive transfusion (45.5%). Two additional patients received transfusions but did not have weights recorded and volume of blood transfused per body weight could not be calculated. Of the four patients with hemorrhagic causes of death who did not receive massive transfusion, two were not transfused due to being declared dead on arrival. Patients with death due to hemorrhage were significantly more likely to be transfused than patients with deaths from all other causes (81.8% vs. 28.4%, $p = 0.0005$), but rates of massive transfusion were not statistically different among patients for whom weight-based transfusion volumes were recorded (5/9 or 55.6% of patients with deaths due to hemorrhage vs. 45/121 or 37.2% of patients with deaths due to other causes, $p = 0.3$).

Analysis of mortalities by age

There were several important differences in pediatric trauma mortalities noted by age (Table 4). Penetrating mechanisms accounted for 50% (n=19/38) of adolescent (age 13–17) trauma deaths, while blunt mechanisms accounted for the vast majority (n = 90/96, 93.8%) of deaths in children younger than 13 years old ($p < 0.0001$). Children in the youngest group, ages 0–6, accounted for nearly half of all trauma deaths (n = 64, 47.8%), while there were 32 deaths among children aged 7–12 (23.9%), and 38 deaths among children aged 13–17 (28.4%). the youngest age groups, the most common mechanism resulting in death was MVC, while for adolescents the most common fatal mechanism was GSW ($p < 0.0001$). There was no difference in injury severity, or frequency of transfusion or MTP use. While TBI was the most common cause of death in all age groups, the second most common cause of death in patients aged 7–12 was anoxia, likely due to the high rate of hangings in that age group. Nearly one-fifth (18.4%) of adolescents died due to hemorrhage, compared to 6.3% of young children aged 0–6 and no children aged 7–12 ($p = 0.03$).

Transferred patients compared to direct from field patients

Patients who died after presenting to our institution from the scene of injury accounted for 61.9% of deaths (n=83). When compared to transferred patients who died (Table 5), there was a higher proportion of injuries due to MVC (37.4% vs. 15.7%), and a lower proportion of injuries due to assault (6.0% vs. 19.6%, $p = 0.04$). Patients arriving to our trauma center from the scene of injury were more likely to die in the ED (43.4% vs. 11.8%) while transferred patients were more likely to die in the ICU (84.3% vs. 47%, $p = 0.0003$). The median time to death for non-transferred patients was shorter (3.8 vs. 43.9 hours, p = 0.0007), and patients were more likely to die within 24 hours of arrival (61.5% vs. 41.2%, p = 0.02). Causes of mortality also differed depending on transfer status, although TBI was the most common cause of death in both groups (61.5% of scene patients vs. 74.5% of transferred patients). Most of the hemorrhage deaths were patients who arrived from the scene (n=9/11, 81.8%).

Discussion

In this study of 134 pediatric trauma deaths at a level 1 pediatric trauma center, half occurred within 24 hours (54%) and TBI was the most common cause of death (66.4%). Hemorrhage was the primary cause of death in 8.2% of patients and contributed to a total of 12.7% of deaths. All deaths from hemorrhage alone occurred within 6 hours of arrival at our institution, and most children who died from hemorrhage arrived from the scene of injury rather than as transfers from referring institutions. Death from hemorrhage was most common in adolescents, accounting for 18.4% of adolescent deaths, and was rare in younger children. In addition, 82% of children who died from hemorrhage underwent immediate surgical intervention in the ED or the operating room.

Trauma is the leading cause of morbidity and mortality in children (1) and understanding the epidemiology of fatal pediatric trauma is necessary to target interventions aimed at saving these lives. As confirmed with this current study, TBI is the most common cause of death in children. In one autopsy study, TBI accounted for 40% of pediatric trauma deaths, with few of those deaths potentially preventable (3). Deaths from hemorrhage, in comparison, were found to account for 18% of deaths in the same study, but nearly half were consider potentially preventable (3). This proportion of 18% of pediatric trauma deaths is higher than that found in our study, where we found that hemorrhage was primarily responsible for 8.2% of pediatric trauma deaths and in total, contributed to 12.7% of deaths. However, this difference is not surprising, given that the autopsy study included pre-hospital deaths. Data on mortality rates due to hemorrhage are a critical piece of information that is needed to inform early management of severely injured children. Additionally, most hemorrhagic deaths in our study were identified in the cohort of patients who arrived from the scene of injury, rather than as transfers from referring hospitals, which may be in part due to survival bias, as transferred patients must survive for a longer interval between injury and arrival at a level 1 trauma center.

As opposed to the detailed causes of death, the timing of trauma-related mortality, however, has been studied. In a large analysis of over 5,000 pediatric (age < 14) trauma deaths from the National Trauma Data Bank, patients were younger (median 5 years old vs. 7 years old in our cohort), with similar rates of blunt trauma (83.3% vs. 81.3% in our cohort) (1). When injured children die, they are most likely to do so within the first 24 hours, which has been found in an analysis of the National Trauma Data Bank (1) and is supported by our data as well. In fact, half of pediatric trauma deaths reported in the NTDB occurred in the ED (51.2%), which is higher than the proportion we found (31.3%). Together this data points toward the first 24 hours as a key window for intervention to prevent death from injury (12). One study of adult trauma mortalities found a significant rise in mortality within the first 30 minutes of pre-hospital time in patients with severe torso injuries (13), indicating that the „golden hour‟ may be much shorter than previously thought in severely injured patients. Additionally, in an autopsy study of adult trauma deaths, 12% were found to be potentially survivable with enhanced pre-hospital care, indicating a potential role for earlier intervention in the field (14). Children who die prior to reaching medical care are a hidden mortality, masking a much higher rate of death from hemorrhage than physicians may encounter at a single institution.

The patients who died from hemorrhage in this cohort underwent a variety of hemorrhage control procedures. Aside from two patients declared dead on arrival, 66.7% underwent ED thoracotomy, and 55.6% underwent exploratory laparotomy. Pediatric trauma patients rarely undergo invasive procedures, with one studying finding only 0.6% of all trauma activations requiring intervention (15). However, severely injured patients such as those who die from hemorrhage likely have a much higher rate of intervention, in particular when they arrive with signs of life after penetrating trauma (16–19). Identifying pediatric trauma patients who are at risk of death from hemorrhage is an area of active research, with multiple risk scores developed to stratify patients (15,20). Our data lends support to the use of SIPA to identify severely injured patients at risk for death, as an elevated SIPA was significantly more common in patients who died (64.7% vs. 29.4% of surviving patients, $p < 0.0001$). As our data suggests, when children die from hemorrhage, it occurs early and quickly, at a median of one hour after ED arrival, which aligns with timing of death for adult trauma patients with severe chest or abdominal trauma (21). Although need for intervention in pediatric trauma is rare, providers must remain vigilant and prepared to act quickly to prevent unnecessary loss of life from hemorrhage. Activation of the massive transfusion protocol has been found to be associated with need for hemorrhage control procedures and early mortality (22) and may alert physicians to the potential need for intervention. In our cohort, patients with deaths due to hemorrhage were significantly more likely than patients with deaths due to other causes to receive blood products, but our numbers were too small to determine the utility of massive transfusion in predicting deaths due to hemorrhage. Detailed analysis of pediatric trauma deaths can focus efforts for development of hemorrhage control adjuncts, such as resuscitative endovascular balloon occlusion of the aorta (REBOA) (23) and may aid in earlier identification of the patients at highest risk for mortality due to their injuries.

Our study has several important limitations. It is a single center retrospective review, and thus our findings may not be applicable to all pediatric trauma centers. Additionally, our data is limited by information available in the chart, which may be incomplete. In particular, a large portion of patients had their race listed as ‘other,’ which limits our ability to interpret demographic differences between groups. Autopsy reports were not available for patients who were declared dead on arrival, and a proportion of those patients may have exsanguinated prior to presentation. Additionally, we included all patients, including transfers, whose time prior to arrival at our trauma center is longer than patients who arrived from the scene of injury. However, we addressed this by performing a separate subgroup analysis accounting for transfer status.

Conclusion

More than half of pediatric trauma deaths occurred within 24 hours. Death from hemorrhage was uncommon (8.2%) overall but accounted for 18.4% of adolescent trauma deaths. All patients who died from hemorrhage did so within 6 hours of arrival. This represents a critical time to target interventions to reduce deaths from hemorrhage in pediatric trauma patients. The need for development of timely and novel hemorrhage control adjuncts for pediatric trauma patients is supported by our data.

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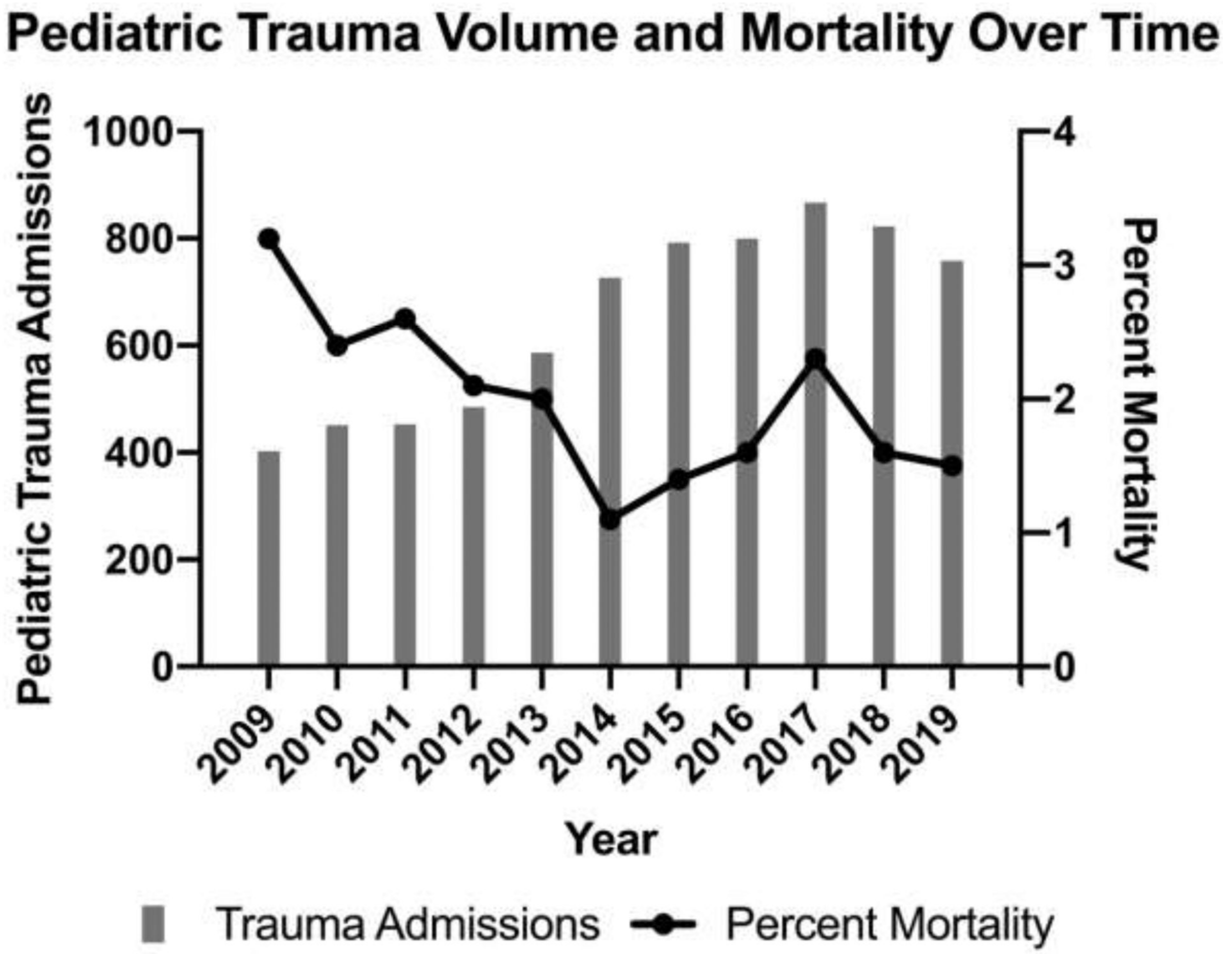

Figure 1:

Trends in pediatric trauma mortality over time

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Table 1:

Overall characteristics and outcomes of all pediatric trauma admissions

Variable	**All pediatric trauma admissions n = 7135**
Age, years: median (IQR)	7 (3–13)
Male sex: n (%)	4547 (63.7)
Transfer: n (%)	3616 (50.7)
Mechanism, blunt: n (%)	6517 (91.3)
Mechanism, detailed: n (%)	
MVC	1285 (18.0)
MCC	282 (4.0)
GSW	228 (3.2)
Stabbing	79 (1.1)
Auto vs. pedestrian	555 (7.8)
Assault	291 (4.1)
Recreational vehicle	684 (9.6)
Fall	2825 (39.6)
Hanging	8 (0.1)
Other	898 (12.6)
Admission GCS: median (IQR)	15 (15–15)
Elevated initial SIPA: n (%)	2110/7086 (29.8)
ISS, median (IQR)	5 (4–10)
ICU LOS, days: n (%)	1 (1–3)
Ventilator days: n (%)	2 (1–4)
LOS, days: n (%)	1 (1–3)

IQR: Interquartile range; MVC: motor vehicle collision; GSW: gunshot wound; Auto vs. pedestrian: pedestrian struck by vehicle; Recreational vehicle: injury sustained due to bicycle, boat, ATV, swimming, scooter, or jet ski accident; Other mechanism: injuries by animals, burns, found down, sports injuries, burns, non-accidental trauma, and hit by falling object; GCS: Glasgow Coma Scale; SIPA: Shock Index, Pediatric Age-Adjusted; ISS: Injury Severity Score; ICU: Intensive Care Unit; LOS: Length of stay.

Table 2:

Comparison of pediatric trauma mortalities and survivors

Variable	Mortalities n = 134	Surviving Traumas n = 7001	p-value
Age, years: median (IQR)	7 (2–13)	8 (3–13)	0.4
Male sex: n (%)	92 (68.7)	4455 (63.6)	0.2
Transfer: n (%)	51 (38.1)	3565 (50.9)	0.003
Mechanism, blunt: n (%)	109 (81.3)	6408 (91.5)	<0.0001
Mechanism, detailed: n (%)			<0.0001
MVC	39 (29.1)	1246 (17.8)	
MCC	0 (0)	282 (4.0)	
GSW	22 (16.4)	206 (2.9)	
Stabbing	2 (1.5)	77 (1.1)	
Auto vs. pedestrian	20 (14.9)	535 (7.6)	
Assault	15 (11.2)	276 (3.9)	
Recreational vehicle	10 (7.5)	674 (9.6)	
Fall	8 (6.0)	2817 (40.2)	
Hanging	5 (3.7)	3 (0.04)	
Other	13 (9.7)	885 (12.6)	
Admission GCS: median (IQR)	3 (3–3)	15 (15–15)	<0.0001
Elevated initial SIPA: n (%)	55/85 (64.7)	2055/7001 (29.4)	<0.0001
ISS, median (IQR)	26.5 (25–38)	5 (4–10)	<0.0001
ICU LOS, days: n (%)	3 (1–5)	1 (1–3)	<0.0001
Ventilator days: n (%)	3 (1–5)	2 (1–4)	0.4
LOS, days: n (%)	1 (1–4)	1 (1–3)	0.5

IQR: interquartile range; MVC: motor vehicle collision; GSW: gunshot wound; Auto vs. pedestrian: pedestrian struck by vehicle; Recreational vehicle: injury sustained due to bicycle, boat, ATV, swimming, scooter, or jet ski accident; Other mechanism: injuries by animals, burns, found down, sports injuries, burns, non-accidental trauma, and hit by falling object; GCS: Glasgow Coma Scale; SIPA: Shock Index, Pediatric Age-Adjusted; ISS: Injury Severity Score; ICU: Intensive Care Unit; LOS: length of stay.

Table 3:

Overall Outcomes of pediatric trauma mortalities

Variable	**Results**
Any transfusion: n (%)	89 (66.4)
Massive transfusion: n (%)	50 (37.3)
ED disposition: n (%)	
Died in ED	42 (31.3)
ICU	61 (45.5)
OR	31 (23.1)
Time to death, hours: median (IQR)	14.4 (0.5–87.8)
Time to death, days: median (IQR)	1 (1–4)
Early mortality: n (%)	72 (53.7)
Location of death: n (%)	
ED	42 (31.3)
ICU	82 (61.2)
OR	9 (6.7)
Ward	1 (0.8)
Cause of death: n (%)	
TBI	89 (66.4)
Anoxia	13 (9.7)
Hemorrhage	11 (8.2)
Other	8 (6.0)
Unknown	13 (9.7)

ED: Emergency Department; ICU: Intensive Care Unit; OR: Operating Room; LOS: length of stay; IQR: interquartile range; TBI: traumatic brain injury; Massive transfusion defined as > 40 ml/kg of blood product. ICU LOS is calculated for patients admitted to the ICU only.

Table 4:

Pediatric trauma mortalities by age group

Variable	Age 0–6 n=64	Age 7–12 n=32	Age 13–17 n=38	p-value
Age, years: median (IQR)	2 (1–4)	10 (8–12)	15.5 (14–17)	<0.0001
Male sex: n (%)	43 (67.2)	19 (59.4)	30 (79.0)	0.2
Transfer: n (%)	27 (42.2)	10 (31.3)	14 (36.8)	0.6
Mechanism, blunt: n (%)	60 (93.8)	30 (93.8)	19 (50.0)	<0.0001
Mechanism, detailed: n (%)				<0.0001
MVC	18 (28.1)	13 (40.6)	8 (21.1)	
GSW	3 (4.7)	2 (6.3)	17 (44.7)	
Auto vs. pedestrian	10 (15.6)	7 (21.9)	3 (7.9)	
Assault	13 (20.3)	1 (3.1)	1 (2.6)	
Recreational vehicle	2 (3.1)	3 (9.4)	5 (13.2)	
Fall	8 (12.5)	0 (0)	0 (0)	
Hanging	0 (0)	3 (9.4)	2 (5.3)	
Other	10 (15.6)	3 (9.4)	2 (5.3)	
Admission GCS: median (IQR)	3 (3–3)	3 (3–3)	3 (3–3)	0.4
Elevated initial SIPA: n (%)	25/39 (64.1)	14/21 (66.7)	22/31 (71.0)	0.8
ISS, median (IQR)	26 (20–36)	29 (25–43)	26.5 (25–42)	0.3
Any transfusion: n (%)	44 (68.8)	20 (62.5)	26 (68.4)	0.8
Massive transfusion: n (%)	25 (39.1)	13 (40.6)	12 (35.3)	0.9
ED disposition: n (%)				0.1
N/A, died in ED	20 (31.3)	11 (34.4)	11 (29.0)	
Admitted to ICU	34 (53.1)	9 (28.1)	18 (47.4)	
Admitted to OR	10 (15.6)	12 (37.5)	9 (23.7)	
ICU LOS, days: median (IQR)	2 (1–5)	4 (1–6)	3.5 (1–7)	0.4
Time to death, hours: median (IQR)	14.4 (0.6–72.2)	9.6 (0.4–111.1)	32.5 (1.0–92.4)	0.8
Time to death, days: median (IQR)	1 (1–3)	1 (1–4.5)	15 (1–4)	0.5
Early mortality: n (%)	38 (59.4)	17 (53.1)	17 (44.7)	0.4
Location of death: n (%)				0.7
ED	20 (31.3)	11 (34.4)	11 (29.0)	
ICU	39 (60.9)	20 (62.5)	23 (60.5)	
OR	5 (7.8)	1 (3.1)	3 (7.9)	
Ward	0 (0)	0 (0)	1 (2.6)	
Cause of death: n (%)				0.03
TBI	47 (73.4)	21 (65.6)	21 (55.3)	
Anoxia	2 (3.1)	6 (18.8)	5 (13.2)	
Hemorrhage	4 (6.3)	0 (0)	7 (18.4)	
Other	4 (6.3)	1 (3.1)	3 (7.9)	
Unknown	4 (6.3)	4 (12.5)	2 (5.3)	

IQR: interquartile range; MVC: motor vehicle collision; GSW: gunshot wound; Auto vs. pedestrian: pedestrian struck by vehicle; Recreational vehicle: injury sustained due to bicycle, boat, ATV, or jet ski accident; Other mechanism: burns, stab wound, non-accidental trauma, hit by falling object; GCS: Glasgow Coma Scale; SIPA: Shock Index, Pediatric Age-Adjusted; ED: Emergency Department; ISS: Injury Severity Score; ICU: Intensive Care Unit; LOS: length of stay; OR: operating room; TBI: traumatic brain injury. Massive transfusion defined as ≥ 40ml/kg of blood product. ICU LOS is calculated for patients admitted to the ICU only.

Table 5:

Comparison of Demographics, Initial Assessments, and Outcomes of Transferred vs. Direct from Field Trauma Mortalities

Variable	Transfer Patients n=51	Direct from Field Patients n=83	p-value
Age, years: median (IQR)	6 (1.1–13)	7 (3–14)	0.09
Male sex: n (%)	35 (68.6)	57 (68.7)	1.0
Mechanism, blunt: n (%)	42 (82.4)	67 (80.7)	1.0
Mechanism, detailed: n (%)			0.04
MVC	8 (15.7)	31 (37.4)	
GSW	9 (17.7)	13 (15.7)	
Auto vs. pedestrian	6 (11.8)	14 (16.9)	
Assault	10 (19.6)	5 (6.0)	
Recreational vehicle	4 (7.8)	6 (7.2)	
Fall	4 (7.8)	4 (4.8)	
Hanging	4 (7.8)	1 (12)	
Other	6 (11.8)	6 (10.8)	
Admission GCS: median (IQR)	3 (3–3)	3 (3–3)	0.3
Elevated initial SIPA: n (%)	27/44 (61.4)	28/41 (68.3)	0.7
ISS, median (IQR)	26 (25–36)	29 (25–41)	0.6
Any transfusion: n (%)	38 (74.5)	52 (62.7)	0.2
Massive transfusion: n (%)	20 (40.8%)	30 (37.0)	0.7
ED disposition: n (%)			0.0001
N/A, died in ED	6 (11.8)	36 (43.4)	
Admitted to ICU	34 (66.7)	27 (32.5)	
Admitted to OR	11 (21.6)	20 (24.1)	
ICU LOS, days: median (IQR)	2 (1–5)	3 (1–6)	0.3
Time to death, hours: median (IQR)	43.9 (10.2–103.1)	3.8 (0.12–63.5)	0.0007
Time to death, days: median (IQR)	2 (1–4)	1 (1–3)	0.02
Early mortality: n (%)	21 (41.2)	51 (61.5)	0.02
Location of death: n (%)			0.0003
ED	6 (11.8)	36 (43.4)	
ICU	43 (84.3)	39 (47.0)	
OR	2 (3.9)	7 (8.4)	
Ward	0 (0)	1 (12)	
Cause of death: n (%)			0.0002
TBI	38 (74.5)	51 (61.5)	
Anoxia	9 (17.7)	4 (4.8)	
Hemorrhage	2 (3.9)	9 (10.8)	
Other	2 (3.9)	6 (7.2)	
Unknown	0 (0)	13 (15.7)	

IQR: interquartile range; MVC: motor vehicle collision; GSW: gunshot wound; Auto vs. pedestrian: pedestrian struck by vehicle; Recreational vehicle: injury sustained due to bicycle, boat, ATV, or jet ski accident; Other mechanism: burns, stab wound, non-accidental trauma, hit by falling object; GCS: Glasgow Coma Scale; SIPA: Shock Index, Pediatric Age-Adjusted; ED: Emergency Department; ISS: Injury Severity Score; ICU: Intensive Care Unit; LOS: length of stay; OR: operating room; TBI: traumatic brain injury. Massive transfusion defined as ≥ 40 ml/kg of blood product. ICU LOS is calculated for patients admitted to the ICU only.

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