LOGISTICS OF AIR MEDICAL TRANSPORT: WHEN & WHERE DOES HELICOPTER TRANSPORT REDUCE PREHOSPITAL TIME?

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Objectives: Trauma is a time sensitive disease. Helicopter emergency medical services (HEMS) have shown benefits over ground EMS (GEMS), and may be partly due to reducing prehospital time. The distance at which this time benefit emerges depends on many factors that can vary across regions. Our objective was to determine the threshold distance at which HEMS has shorter prehospital time than GEMS under different conditions.

Methods: Patients in the PA trauma registry 2000-13 were included. Distance between zip centroid and trauma center was calculated using straight-line distance for HEMS and driving distance from GIS network analysis for GEMS. Contrast margins from linear regression identified the threshold distance at which HEMS had a significantly lower prehospital time than GEMS indicated by non-overlapping 95%confidence intervals. The effect of peak traffic times and adverse weather on the threshold distance was evaluated. Geographic effects across EMS regions were also evaluated.

Results: 144,741 patients were included with 19% transported by HEMS. Overall, HEMS became faster than GEMS at 7.7miles from the trauma center ($p<0.05$, FIG1). When evaluating traffic times, HEMS became faster at 6.5miles during peak traffic compared to 7.9miles during off-peak traffic ($p<0.05$). Adverse weather increased the distance at which HEMS was faster to 17.1miles from 7.3miles in clear weather ($p<0.05$). Significant variation occurred across EMS regions, with distances ranging from 4.4miles to 31.6miles (FIG2).

Conclusions: This is the first study to demonstrate that traffic, weather, and geographic region can significantly impact the threshold distance at which HEMS is faster than GEMS. HEMS was faster at shorter distances during peak traffic while adverse weather increased this distance. The threshold distance varied widely across geographic region. These factors must be considered to guide appropriate HEMS triage protocols.
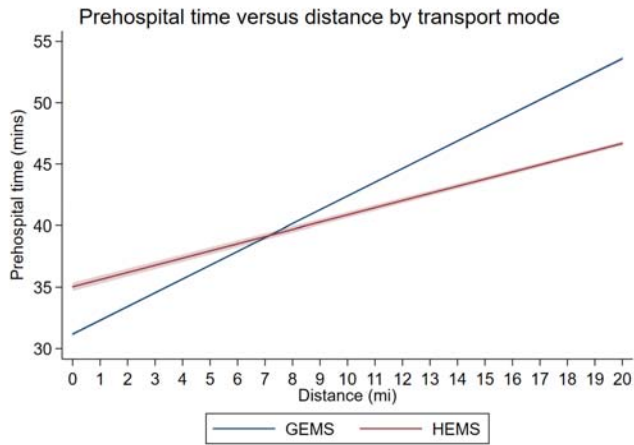
Total prehospital time versus distance by transport mode from linear regression.
Shaded areas represent 95% confidence intervals.
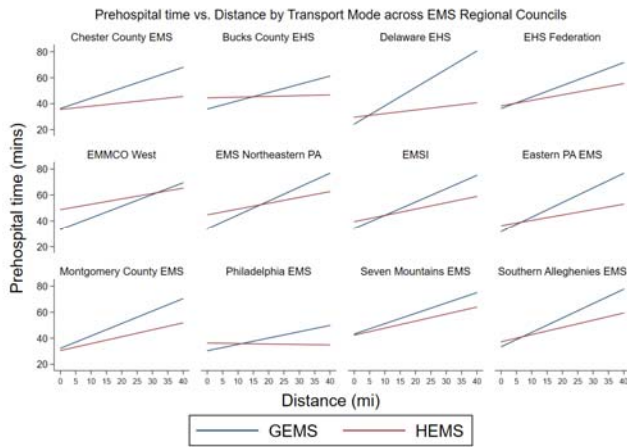
Total prehospital time versus distance by transport mode from linear regression across
Pennsylvania state EMS regional councils.

Pediatric Train Injuries: A 10 Year Review from the Pennsylvania Trauma Outcomes Study Database

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Background: Train accidents involving children can result in severe injuries requiring significant resource utilization. We sought to review train-related trauma in the state of Pennsylvania to determine the burden of these injuries on the pediatric trauma system.

Methods: We queried the Pennsylvania Trauma Outcomes Study Database to identify all patients <21 years of age suffering traumatic injuries resulting from a train accident between 2007-2016. Demographics, patterns of injury, resource utilization, and outcomes were reviewed.

Results: Forty-eight patients suffered train-related injuries with an average age of 15.3 years (range 1-20). A majority of patients were urban dwelling (81.3%), male (77.1%), and Caucasian (60.4%). Alcohol and drug screens were positive in 12.5% and 20.8% of patients, respectively. Children were most commonly injured as pedestrians struck by a train (68.0%) and falls in, on, or from a train (12.0%).

Severe injury was common with 43.8% of patients having an ISS≥16. Orthopedic injuries were the most common with 37.5% experiencing a long-bone or pelvic fracture and 16.7% suffering traumatic amputation. Concussion occurred in 27.7% of patients, intracranial hemorrhage in 25.5%, and pneumothorax in 20.8%. Solid organ injuries occurred in 14.6% of patients with the most common being splenic injuries (8.3%).

The average length of stay was 12.4 days (range 0-121). Twenty-five percent of patients were intubated on arrival. Over half of patients (56.3%) required ICU admission with an average ICU stay of 5.3 days. On average, 7.1 services were consulted per patient, most commonly physical and occupational therapy (64.5%), social services (60.4%), and orthopedic surgery (52.1%). Surgical management of injuries was common with 64.6% of patients requiring at least one operative intervention, most commonly internal fixation of a fracture (35.4%), debridement (29.2%), or amputation (20.8%). Laparotomy was rare (6.3%), as was thoracotomy (4.2%).

Overall mortality was 10.4%. Of the 43 surviving patients, Functional Independence Measure (FIM) Score at discharge was 16.4 and 37.5% required discharge to a rehabilitation or long-term care facility. Overall, 77.1% suffered a serious injury, defined as one resulting in death, requiring surgery, or resulting in discharge to a rehabilitation or long-term care facility.

Conclusions: Injuries caused by trains can be severe, with a majority of admitted patients experiencing a serious injury. Orthopedic injuries are the most common followed by traumatic brain injuries. Train traumas in children can be costly injuries that require a multi-disciplinary approach to care.

DEVELOPMENT OF A CLINICAL TRACHEOSTOMY SCORE TO IDENTIFY SPINAL CORD INJURY PATIENTS
REQUIRING PROLONGED VENTILATOR SUPPORT
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Objectives

Cervical spinal cord injuries (CSCI) often necessitate ventilator support (VS). Prolonged endotrachial tube use has conveyed substantial morbidity in prospective study. Tracheostomy is recommended if VS is anticipated to be =7 days. Identifying these patients on arrival and before tracheostomy need is readily evident could prevent morbidity while lowering hospital costs. We aimed to create a Clinical Tracheostomy Score to identify patients requiring =7 days of VS.

Methods

A review of patients with cervical spine fractures and CSCI from 2005 to 2014 from the Pennsylvania Trauma Outcome Study database was performed. Patients were excluded for missing data, no use of VS or death in <7 days. Logistic regression was used to identify independent predictors of prolonged VS. Baseline data on 37 risk factors were included in the logistic regression. p≤0.05 was significant. A predictive model for ≥7 days of VS was established using univariate and multivariate logistical regression with Hosmer-Lemeshow goodness of fit testing.
Results

770 patients were identified. 220 C1-C4 and 275 C5-7 CSCI patients were included. 3 factors were associated with ≥7 days VS: type of cord injury (TCI, p<0.001), highest cervical spine fracture level (HCFL, p=0.001), and AIS face (p=0.007). Our score was obtained from this equation: 4.138 - 0.981(TCI) - 0.344(HCFL) + 0.419(AIS face). TCI was complete = 1, anterior = 2 or central = 3. The equation positive predictive value for ≥7 days of VS is 82.3% for a score ≥1.

Conclusion

Use of the Clinical Tracheostomy Score identified the majority of patients requiring prolonged ventilator support in our study. An early tracheostomy protocol could using predictive modeling could aid in reduction of ICU length of stay and improving ventilator weaning in these patients. External verification of this predictive tool and of an early tracheostomy protocol is needed.

ANALYSIS OF OUTCOMES POST OPERATIVE MANAGEMENT OF TRUNCAL GSW AT LEVEL I VERSUS LEVEL II TRAUMA CENTERS

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Introduction: While both Level I and II trauma centers have the resources necessary to manage gunshot wounds (GSW), limited research exists comparing outcomes for this injury mechanism between designations. We hypothesized that there would be a difference in mortality and complications following surgical intervention for truncal GSW victims between Levels I vs. II center types because of the lower volume of these cases managed at Level II trauma centers.

Methods: All adult (aged>18) firearm-related admissions to the Pennsylvania Trauma Outcome Study database from 2003-2015 were queried. Dead on arrival, transfer, and cases with a head Abbreviated Injury Scale (AIS) score ≥3 were excluded. The specific population of interest included all patients with truncal injuries (thorax AIS and/or abdomen AIS≥3). Multilevel mixed-effects logistic regression models assessed the adjusted impact of trauma center level (Level I) on overall mortality and complications.

Results: Of the 385,689 adult patients presenting to Pennsylvania Level I-II trauma centers from 2003-2015, 17,465 GSWs were identified, of which 4,761 met inclusion criteria (Level I: 3,949; Level II: 812). Adjusted analysis did not reveal any significant differences between center types in mortality (AOR 1.113, p=0.630) and complication (AOR 1.360, p=0.060) rates post-surgical intervention (Table 1). Of note, when looking at each center level: Level I centers were associated with a 2.967 (p<0.001) and 3.708 (p<0.001) increased adjusted odds ratio of complications and mortality following major surgery and Level II centers were associated with a 4.105(p<0.001) and 39.796 (p=0.002) increased adjusted odds ratio of complications and mortality.

Conclusion: Firearm-injured patients may experience less complications when managed at Level I rather than Level II trauma centers. Within center type, Level II institutions are associated with higher odds of complications in the event of operative management for truncal GSW, which may be attributed to low volume experience in treatment of these injuries.

Table 1. Adjusted odds ratios (AOR) for GSW for mortality and complications.

	Mortality		Complications	
Variable	**AOR** (95% CI)	*p*	**AOR** (95% CI)	*p*
Level II	1.113 [0.721-1.717]	0.630	1.360 [0.987-1.873]	0.060
Major surgery	4.571 [2.942-7.100]	<0.001	3.094 [2.584-3.705]	<0.001
Age	1.024 [1.015-1.033]	0.019	1.017 [1.011-1.023]	<0.001
ISS	1.058 [1.049-1.067]	<0.001	1.026 [1.019-1.032]	<0.001
Motor GCS	0.673 [0.635-0.712]	<0.001	0.971 [0.925-1.019]	0.225
		AUROC: 0.863		**AUROC: 0.692**
*Adjusted for male sex, shock index and injury year				

TRAUMA SUPER-USERS – A DRAIN ON THE SYSTEM

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INTRODUCTION: Extended hospital length of stay is widely associated with significant healthcare costs. We hypothesized that particular characteristics are likely predictive of trauma super-users of healthcare and can be used to characterize this population.

METHODS: The Pennsylvania Trauma Outcome Study database was retrospectively queried from 2003-2017 for all adult (age ≥15) trauma patients admitted to accredited trauma centers in Pennsylvania. Trauma super-users were defined as patients with hospital length of stay two standard deviations above the population mean or ≥22 days. Patient demographics, comorbid conditions and clinical variables were compared between trauma super-users and trauma non super-users to identify potential predictor variables. A multilevel mixed-effects logistic regression model controlling for age, gender, injury severity, admission Glasgow coma score (GCS) and systolic blood pressure assessed the adjusted impact of clinical factors in predicting trauma super-user status.

RESULTS: 489,027 patients met inclusion criteria [super-user: 17,544 (3.59%); non super-user: 471,483 (96.41%)]. Compared to non super-user counterparts, super-user patients were significantly more severely injured (ISS: 10.58 vs. 22.53, p<0.001) and had a higher incidence of chronic alcohol abuse. In adjusted analysis, gunshot wound to the abdomen, undergoing major surgery and reintubation were significantly associated with trauma super-users (Table 1). Penetrating injury overall was associated with decreased risk of being a super-user.

CONCLUSION: Reintubation, major surgery and gunshot wounds to abdomen are strongly predictive of trauma super-users. Understanding the profile of the super-user will allow clinicians to proactively put processes in place to streamline care and potentially reduce costs and hospital lengths of stay.

Table 1. Risk-adjusted predictors of trauma super-users.

Variable	Trauma super-user AOR (95% CI)	p
GSW (abdomen)	**1.82** [1.63-2.03]	**<0.001**
Penetrating MOI	0.624 [0.581-0.671]	<0.001
Major surgery	**1.90** [1.83-1.97]	**<0.001**
Reintubation	**11.55** [10.84-12.30]	**<0.001**
Age	1.001 [1.000-1.002]	0.018
Male sex	1.411 [1.351-1.474]	<0.001
ISS		
0-8	Reference	---
9-15	2.48 [2.33-2.63]	<0.001
16-25	5.31 [4.99-5.63]	<0.001
26-75	10.41 [9.79-11.06]	<0.001
Admission GCS	0.93 [0.925-0.932]	<0.001
Admission SBP	1.001 [1.000-1.001]	0.001
	AUROC: 0.815	

Off-Hours Outcomes of Hypotensive Trauma Patients in Pennsylvania Level 1 and 2 Trauma Centers

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Introduction: There is conflicting data as to the outcomes of trauma patients who present on weekends and at night compared with those arriving during daytime weekday hours. The outcomes of hypotensive patients by time and day of arrival has not been studied. We hypothesize that hypotensive patients presenting to trauma centers in the weekends or at night have an increased risk of death.

Method: Data from level 1 and 2 trauma centers (TCs) from the Pennsylvania Trauma Outcomes Study over a five-year period (2012-2016) were analyzed. Patients were categorized into four groups by arrival time and day: (1) weekday day (Monday-Friday 0700-1859); (2) weekday night (Monday to Friday 1900-0659 Saturday); (3) weekend day (Saturday and Sunday, 0700-1859) and weekend night (Saturday and Sunday 1900-0659 Monday) with group 1 being the reference group. Hypotension was defined as a presenting systolic blood pressure (SBP) of <90 mmHg. The primary outcome was inhospital mortality. Exclusion criteria were patients with injury time to arrival > 1 day, concomitant burns, trauma centers with <20 patients in the study period, purely pediatric trauma centers, transfer patients and patients <16 years of age. Plausible variables associated with mortality were entered into a logistic regression model with mortality as the dependent variable and time of day as the random effects independent variable.

Results: 5922 patients from 26 TCs met criteria (Group 1, 2161 [37%]); Group 2, 1974 [33%]; Group 3, 787 [13%] and group 4, 1000 [17%]). Unadjusted mortality rates for the groups were 43%, 47%, 40% and 43% respectively (p=0.009). After controlling for Glasgow Coma Scale (GCS) score, age, Injury Severity Score (ISS), SBP, pulse, intubation or assisted ventilation on arrival, penetrating mechanism, group 4 was associated with lower risk of death (odds ratio [95% confidence interval, 0.64 [0.48-0.84]), while groups 2 and 3 had similar risks of death compared to group 1. The effect persisted when patients with both SBP=0 and pulse=0 were excluded. When each of the 26 TCs were analyzed separately with the same regression model, only three TCs demonstrated a decreased risk of death for group 4 patients, and two other TCs showed a decreased risk for group 2 patients. No TC showed an increased risk of death in any group compared to group 1.

Conclusion: Hypotensive patients arriving at level 1 and 2 Pennsylvania trauma centers on weekends or at night were not at increased risk of death. Weekend night presentation was associated with reduced odds of death.