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Evaluating initial spine trauma response: injury time to trauma center in PA, USA.

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Keywords: SCI, timing, trauma, Cranial, Neurologic, transportation

Abstract

Historical perceptions regarding the acuity of traumatic spinal cord injury has led to considerable disparity in triage to tertiary care centers. This article retrospectively reviews a large regional trauma database to analyze whether the diagnosis of spinal trauma affected patient transfer timing and patterns. The Pennsylvania Trauma database, was retrospectively reviewed. All acute trauma patients' entries for level I and II centers were categorized diagnosis, mechanism, and location of injury, analyzing transportation modality and its influence on time of arrival. 1162 trauma patients were identified, (1014 blunt injuries, 135 penetrating injuries and 12 other) with a mean transport time of 3.9 hours and a majority of patients arriving within seven hours (>75%). Spine trauma patients had the longest mean arrival time (5.2 hours) compared to blunt trauma (4.2 hours), cranial neurologic injuries (4.35 hours), and penetrating injuries (2.13 hours, $p<0.0001$). There was a statistically significant correlation between earlier arrivals and both cranial trauma ($p=0.0085$) and penetrating trauma ($p<0.0001$). The fastest modality was a fire-rescue (0.93hrs) or police (0.63hrs) vehicle with Philadelphia County (1.1hr) having the quickest arrival times. Most trauma patients arrived to a specialty center within 7 hours of injury. However subsets analysis revealed that spine trauma patients had the greatest transit times. Present research trials for spinal cord injuries suggest earlier intervention may lead to improved recovery. Therefore, it is important to focus on improvement of the transportation triage system for traumatic spinal patients.

Keywords: SCI, timing, trauma, Cranial, Neurologic, transportation, epidemiology, triage, regional trauma database, cervical spine injury

Introduction

The development of advanced trauma transportation networks has evolved over the last century. The regionalization and networking of trauma resources and facilities has increased the speed in which severely injured patients can be transported to specialized centers. Concurrently, over the last several decades the treatment of spinal fractures and spinal cord injuries has also significantly improved, with evidence supporting that results may be time sensitive.[1, 2] Spine trauma literature suggests that early decompression and stabilization of spinal trauma patients may improve outcomes and decrease length of stay, morbidities, and, potentially, mortality, particularly, when intervention is within 24 hours. However, the timing, transportation, coordination and mobilization of these spine injured patients are not often directed by the spine surgeons. Unlike penetrating injuries where there is an overall recognition of the need for emergent and rapid transportation, there is a perception that spinal trauma does not require emergent, but only urgent, triage to specialty centers. This article retrospectively reviews a large regional trauma database, The Pennsylvania Trauma Outcome Study (PTOS), to analyze whether the diagnosis of spinal trauma affected patient transfer timing and patterns. Given the relatively increased complexity of this disease, the authors hypothesize that spinal trauma patients have a relatively prolonged transfer time. This would be an important finding since current best evidence guidelines support the urgent decompression and stabilization of unstable traumatic spinal cord injuries.[3-6]

Methods

The Pennsylvania Trauma Systems Foundation's State Registry, Pennsylvania Trauma Outcome Study (PTOS), is a prospectively collected database that maintains the diagnosis and triage management of the state of Pennsylvania's accredited level I and II trauma centers. This registry is administrated by the Pennsylvania Trauma Systems Foundation (PTSF), a state organization which manages the accreditation process for all Pennsylvania State trauma centers as well as administrates over data submitted directly to the PTOS by the participating centers.[7] The integrity of this submission process is verified by PTSF employees on a biannual basis. A full-time dedicated registry director manages the database, appointed by the board of directors of the PTSF. Specifically, there were 23 adult level I and II trauma centers included in the analysis. (11 level I and 12 level II centers). [figure 1] This trauma registry was retrospectively reviewed over a one year period for the adult (>18yo) trauma admissions from

1/1/10 and 12/31/10. Patients are distinguished by their trauma center county of origin only, and not by the name of the trauma center.

The patients were categorized per protocol of the PTOS into one of three categories (blunt, penetrating, others/burns). The data was then further categorized into: spine trauma (spine fractures, spinal cord injuries), cranial trauma (i.e. subarachnoid hemorrhage, subdural hematoma, intraventricular hemorrhage, traumatic brain injuries,), modality of transportation (ambulance, fire rescue, helicopter, police, private vehicle, and walk-in), time from injury to arrival at level I-II trauma center, day of the week of injury and county/region of injury. Currently, it is estimated that 88.5% and 99.3% of the state's population has access to a level I and level II trauma center within 45 and 60 minutes, respectively.[7]

Statistical Analysis

A logistic regression was performed, controlling for county or origin, diagnosis, transportation modality, and transportation duration. Specifically, a generalized linear model with quasibinomial family to account for variation beyond that expected in ordinary binomial (logistic) regression was utilized. Significance was set at a probability of 0.05 by convention. Statistical analysis was performed using JMP 7.02 (SAS Institute, Cary NC).

Results

A total of 1161 patients were included in analysis: 1014 blunt injuries, 135 penetrating injuries and 12 patients categorized as other. Mean arrival time to a level I-II facility from onset of injury was 3.95 hours for the entire cohort. The majority of patients arrived within the first seven hours (>75%). (figure 2) There was no correlation between arrival times and the occurrence of the injury by day of the week (Monday-Sunday) (figure 3).

The investigation of factors influencing trauma patients' arrival times was further carried out through a sub-analysis by categorizing patients by initial trauma diagnosis into: (non-craniospinal) penetrating, (non-craniospinal) blunt, spinal and cranial injuries. This analysis revealed that the spinal trauma patients had the longest time from onset of injury to arrival at the level I-II centers, with a mean time of 5.2 hours (figure 4). Patients with blunt trauma (4.2 hours) and cranial neurologic injuries (4.35 hours) had earlier arrival times compared to the spine trauma population. However, the patients with the fastest arrival times from scene to a level I-II center were those with penetrating injuries (2.13hours, $p < 0.0001$). There was a statistically significant correlation between earlier arrivals and both cranial trauma ($p = 0.0085$) and penetrating trauma ($p < 0.0001$). In contradistinction, the spine trauma patients had a significant correlation with longer arrival times ($p < 0.0001$)

There was a variety of transportation modalities that were utilized to carry the patients from the injury site to a Level I-II hospital. The fastest modality was a fire-rescue (0.93hrs) or police (0.63hrs) vehicle. The next quickest transportation modalities in ascending order were: walk-ins (2hrs), ambulance (5.2hrs), and private vehicles (5.4hrs). The longest time from onset of injury to arrival at level I-II trauma center was via helicopter transportation (6.98 hrs). (figure 5)

An analysis of transportation time from site of injury to trauma center based on geographic location showed the following results: Philadelphia County (1.1hr), Montgomery County (4.8hrs), Bucks County (5.08hrs), Delaware County (5.6hrs), and Chester County (5.72hrs).(figure 6) In addition, the transportation time in the state of New Jersey was 5.6 hours and “other” was 6.17 hours. Ambulance transportation was the primary modality in all regions: Bucks County 69.4%, Delaware County 67.1%, Montgomery County 66.1%, New Jersey 66.1%, Chester County 62.0%, and other 56.4%. The exception was Philadelphia County where 62.9% of patients arrived via fire rescue and police vehicles, while ambulances were utilized only 8.5% of the time.

Philadelphia County has the highest number of trauma centers with seven level I trauma centers. Therefore, a trauma patient in Philadelphia County has a greater number of transportation opportunities with a shorter distance to travel. This is reflected in the shortest transportation times in this county (1.1hrs) which was significantly lower than other regions ($p < 0.0001$).

Discussion

The need for rapid intervention has been previously illustrated in the trauma literature, especially in the case of penetrating trauma for which rapid intervention is required for survival. [8-11] Similarly, neurosurgical trauma patient outcomes, particularly for intracranial injuries, are also related to timing of intervention.[5, 12] In USA and Canada, the implementation of trauma centers, paramedic services, and rapid transportation by ambulance and helicopters helped to reduce head injury death rates, deaths at the trauma scene, and deaths upon arrival to the hospital. [11-14] However, room for improvement exists in executing a coordinated transportation and health care system. A study by Lind et al demonstrated that in Australia, deficiencies in timing of intervention for closed head injuries existed.[14] They reviewed 34 closed head injury patients' transportation time to specialty centers over a one year period (2002), finding a mean time of 6.5 hours from injury to arrival.[14] In this study only 33% of the “local” patients, and none from hospitals outside the city, arrived within 4 hours from the onset of their trauma.[15] These authors noted that there was “no special reasons for delayed transfer,” and suggested that a systems-based

approach among hospitals and changes to triaging protocols could impact these results [15]. This concept of streamlining and organizing transportation systems, networks, and protocols can result in improvement in transportation times and potentially in patient outcomes for defined trauma subsets [16]. Tariq et al[17] demonstrate this potential for improved efficiency through early triage and defining a transportation network in the general trauma population. These authors reviewed 191 penetrating chest injury patients' transportation times at a level II trauma hospital in Pakistan and found a 10.8% improvement in speed of time from injury to the trauma hospital over a twenty year period, which they attributed to a defined transportation network and triage improvements.[17]

The overall evolution of the rapid transportation system for trauma patients to specialty centers has resulted in improved clinical outcomes and decreased patient's morbidity and mortality.[17, 18] However, there are multiple factors that influence the arrival and transportation of these patients and not all types of trauma patients are treated similarly.[10, 19] Although there have been significant advances in the care and treatment of trauma patients in general, there arises the question whether various subsets of traumatic injury patients' management and transportation could be further improved.[20] In the state of Pennsylvania, the present transportation schemes appear to be very successful in transporting patients to level I and II trauma centers in a rapid manner, as evinced by the estimated 99.3% of the population having access to these centers within 60 minutes, the widely referred to "Golden Hour" of improved outcomes.[7, 10] Furthermore, it was shown by Branas and colleagues[3] that a relatively higher utilization of helicopters are needed to achieve this time window (36.9-42%), a factor that is more common in rural settings. In contrast, after arrival to a trauma center, the majority of patients arrive to a tertiary care center in less than four hours from the onset of the trauma (figure2). However, transportation times for spine trauma patients are statistically longer than that for other trauma patients irrespective of geographic location.

Rapid intervention in Spinal Cord Injury

Spinal cord injury has been perceived as an urgent but not emergent clinical disorder partly due to the historical lack of treatment algorithms. However, evidence supports a biological benefit of earlier decompression of traumatic spinal cord injury patients in terms of neurologic recovery as well as a decrease in patients morbidities as illustrated by decreased length of stay and associated hospital costs.[4, 21] Further, recent evidence from the Surgical Treatment for Acute Spinal Cord Injury Study (STASCIS) also demonstrates clinical evidence of a

neurological benefit with early surgery.[1] Recent consensus guidelines from AOSpine and Spine Trauma Study Groups reiterate that early decompression for spinal cord injury (SCI) is considered best practice because it reduces neurologic morbidity/impairment.[1, 3] The ability to hasten treatment of spinal cord injured patients will be essential to improve outcomes for these patients.

As witnessed in other trauma populations, wider availability of emergency and trauma systems has decreased death and disability seen in traumatic SCI.[10] Regionalization of these services with a focus on rapid transportation for SCI patients may help to allow SCI patients to be seen, evaluated, and treated promptly by spine specialists. Such evaluation and treatment by spine specialists at SCI centers can result in improved outcomes.[9] Triage of patients to tertiary care centers also improves patient access to investigational therapies. Basic science research has identified secondary injury mechanisms that follow initial spinal cord injury which lead to neuronal cell death and adverse clinical outcomes. Trial medications including riluzole and minocycline attempt to thwart these effects, but these also rely on prompt intervention.[22, 23]

With the goal of prompt intervention in spine trauma in mind, Furlan et al identifies systems-based practices which resulted in transportation delays in SCI patients at the Toronto Western Hospital. They note that the “extrinsic factors” including delays in patient assessment, delays in imaging evaluation, and delays in transportation to SCI centers were modifiable variables that could be changed by revisions in clinical practice guidelines. Attacking these variables in the Pennsylvania trauma triage system may help to improve the discrepancy seen in transportation times between spine and non-spine trauma.[24] Unfortunately, data on the presence or absence of a neurologic deficit was lacking on the spine trauma database and will need to be improved to derive more meaningful data.

Conclusion

Evaluation of Pennsylvania Trauma Outcome Study (PTOS) illustrates that the majority of trauma patients in the region arrive to a specialty center within 7 hours of injury, with a mean of approximately 4 hours. Among subsets, spine trauma patients suffered the longest transit times. Transportation modalities varied by geographical region as did time from injury site to treatment centers. With growing evidence that treatment speed may affect patient outcome, it is important to focus on triage mechanisms and transportation infrastructure in order to improve the system efficiency in bringing patients to appropriate treatment facilities as soon as possible.

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Figure Legend

Figure 1 Level I and II Trauma centers in Pennsylvania: *Participating Trauma Centers in the Pennsylvania trauma registry*. 1. Abington Memorial Hospital; 2. Albert Einstein Medical Center; 3. Allegheny General Hospital; 4. Altoona Hospital; 5. Aria Health- Torresdale Campus; 6. The Children's Hospital of Philadelphia. 7. The Children's Hospital of Pittsburgh; 8. Geisinger-Community Medical Center; 9. Conemaugh Memorial Medical Center; 10. Crozer-Chester Medical Center; 11. Geisinger Medical Center; 12. Geisinger Wyoming Valley Medical Center; 13. Hahnemann University Hospital; 14. UPMC Hamot; 15. Lancaster General Hospital; 16. Lehigh Valley Health Network Cedar Crest; 17. Paoli Hospital; 18. Penn State Milton S. Hershey Medical Center; 19. Pocono Medical Center; 20. The Reading Hospital and Medical Center; 21. Robert Packer Hospital; St. Christopher's Hospital for Children. 21. Robert Packer Hospital; 22. St. Christopher's Hospital for Children ; 23. St. Luke's University Hospital; 24. St. Mary Medical Center; 25. Temple University Hospital; 26. Thomas Jefferson University Hospital; 27. University of Pennsylvania Medical Center; 28. University of Pittsburgh Medical Center (UPMC) Mercy; 29. UPMC Presbyterian; 30. York Hospital;

Figure 2 Trauma Triage Time. A distribution of the duration of patient transfer in hours.

Figure 3. Patient Transfer Volume, by Day. A comparison of patient transfer volumes show a trend for the greatest volume on the weekend, but did not reach statistical significance ($P < 0.005$).

Figure 4 Transfer Duration by Injury. A comparison of triage duration by injury mechanism, showing prolonged durations of processing and transport in spinal injury patients.

Figure 5 Transfer Duration by Modality of Transportation. A comparison of triage duration by modality of transport showing travel times longest in the helicopter method.

Figure 6. Arrival Time by County. A comparison of patient transfer times by Philadelphia Local Counties. 'Other', specifies additional counties that transfer patients to Philadelphia at a low frequency.