Air Medical Journal ■■ (2018) ■■–■■

Contents lists available at ScienceDirect

Air Medical Journal

journal homepage: http://www.airmedicaljournal.com/

Original Research

Direct Air Versus Ground Transport Predictors for Rural Pediatric Trauma

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A B S T R A C T

Objective: Traumatic injury is the leading cause of mortality in children and the most common cause of emergency medical services transport in pediatric populations. We aimed to identify what factors are currently associated with selection for helicopter transport (HEMS) over ground ambulance (GEMS) in a primarily rural state.

Methods: We performed a retrospective case-control study of trauma patients younger than 18 years old reported to the Oklahoma State Trauma Registry between 2005 and 2014 who received direct transport from the scene of injury to a tertiary trauma center within the state. Factors associated with HEMS transport over GEMS were identified by multivariate regression analysis.

Results: Of the 1,700 patients in the study group, 50.8% were transported by HEMS. Increased distance (odds ratio [OR] = 6.1-18.6), lower Glasgow Coma Scale (OR = 2.5), multisystem injury (OR = 1.5), intubation (OR = 2.7), motor vehicle collision–related injuries (OR = 2.1), and elevated heart rate (OR = 1.8) were all associated with increased odds of HEMS transport, with distance being the strongest factor.

Conclusion: This study found that the principal determinants of triage to HEMS transport in the case of pediatric trauma in a rural state were primarily distance to a major trauma center and clinical factors relating to the type and severity of injury.

Traumatic injury continues to be the leading cause of mortality in children and is the most common cause of emergency medical services (EMS) transport in pediatric populations.[1,2] Significant research has explored appropriate protocols for treatments in trauma care, and this continues to be an ongoing field of study. Although an abundance of literature exists on the diagnosis, transport, and management of adults, there are fewer studies focused on pediatric populations. Fewer still are studies that address triage practices and protocols for this specialized patient group, especially in rural regions of the United States.

It has been well established that pediatric trauma patients generally have reduced mortality when treated at pediatric trauma centers.[3-7] However, nearly half of the pediatric population in the United States live over 50 miles from a level I or II trauma center.[8] In states with large rural populations, first responders and paramedics are faced with a complex decision after minimal patient contact time of whether to recommend transport to the nearest facility to receive definitive care, to transport to the nearest facility for stabilization and subsequent transfer to a tertiary trauma center, or to opt for direct transport from the scene to the larger facility. Also common are instances in which one scene of injury involves multiple patients. When this occurs, limited local resources for any type of transport may easily be overwhelmed and responders from additional locations requested. In all cases, they must additionally select whether air or ground ambulance is most appropriate.

In predominately rural states, such decisions rest primarily on the judgment of EMS professionals at the scene. Importantly, guidelines may vary according to the EMS agency responding because many states lack a universal policy. In Oklahoma where this study took place, there are regional plans that address the selection of transport mode, but these are variable and focused primarily on time and distance. As is generally the case, there is no statewide policy regarding triage mode. More quality data are needed to better guide these decisions in order to assure the highest standard of care without excess consumption of resources.

The traditional concept of the “golden hour” in trauma care has long spurred the advancement of transportation technology.[9] As a result, helicopter emergency medical services (HEMS) are

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1067-991X/$36.00

https://doi.org/10.1016/j.amj.2018.01.006

increasingly used despite a significantly greater expense than ground emergency medical services (GEMS).[10] Furthermore, there are limited studies regarding improved outcomes of HEMS versus GEMS in pediatric trauma patients.[11,12] Multiple studies using national trauma data sources have shown that overtriage to HEMS from the scene to the trauma center is a common issue observed in pediatric trauma patients.[12-15] Patients with low severity injuries (as determined by the Injury Severity Score [ISS]) or transported over short distances are likely to experience short hospital stays (< 1 day) and are an example of poor resource use when transported by air.[11,16] Regarding how triage rates to HEMS for pediatrics relate to that of adults, one single-center study reported that when comparing both patient populations, pediatric trauma patients transported by HEMS were more likely to have a lower ISS and be discharged directly from the emergency department.[17] There is little consensus overall on what factors are most predictive of triage to direct HEMS transport and how these correlate with clinical outcomes.

Previous studies have concluded that ISS and injury sites were not associated with increased benefit from HEMS above the overall population, whereas patients with a Glasgow Coma Score (GCS) < 9 were found to derive additional benefit from HEMS.[16,18] To what degree factors such as these are used in triage decisions at the scene of injury remains unclear.

Although studies regarding treatment are strengthened by the use of national data banks, the question of appropriate resource use may be better investigated on a more local scale because patient populations, resource access, and geography vary widely from region to region. Because statewide trauma registries vary in inclusion criteria and content, a state-specific system may provide the best view of trauma care within a given area.[19] More studies are needed to determine regional triage patterns in order to tailor recommendations for improvement.

Our objective was to examine HEMS and GEMS transport of pediatric trauma patients in a predominantly rural region of the United States directly from the scene of injury to a major trauma center to determine factors associated with triage to HEMS use over GEMS. The central questions were what observations could be made regarding pediatric trauma resulting in direct ground or air transport to higher level centers and what factors are associated with selection for helicopter transportation in this primarily rural area. These results will also assist in identifying selection biases and guide the application of propensity scores in subsequent studies of transport outcomes within the same region.

Methods

Study Design and Setting

This study was a retrospective case-control study of all trauma patients younger than 18 years old and reported to the Oklahoma State Trauma Registry between 2005 and 2014 who received direct transport from the scene of injury to a tertiary trauma center (TTC) within the state. Although some change in designated care level occurred during the study period, 3 centers maintained services consistent with that of a TTC. The level I trauma center is located centrally in the state (Oklahoma City), whereas the 2 level II trauma facilities are located in the northeastern region of the state (Tulsa). The 2 centers receiving the largest volume (Oklahoma City and the larger Tulsa center) do have designated children's hospitals. Both areas make up the state's 2 primary urban regions and represented 66.2% of the total population (3,751,351) according to the 2010 census.[20]

The Oklahoma State Department of Health maintains a mandatory data collection system for trauma, and all acute care hospitals within the state are required to report data to the state trauma registry on a monthly basis. Case inclusion and exclusion criteria are shown in Appendix 1. After approval from the institutional review boards of the University of Oklahoma Health Science Center and the Oklahoma State Department of Health, the state trauma registry was queried to provide deidentified data on the study population.

Study Population

Inclusion criteria included patients under 18 years old at the time of hospitalization receiving ground or helicopter ambulance transport to an Oklahoma TTC directly from the scene of injury (N = 3,620). Exclusion criteria included burn injuries (n = 39), missing injury zip code (n = 142, 2.8% of total GEMS and 7.1% of total HEMS), and transport within 10 miles of a TTC (n = 1,739). Primary burn injuries were excluded because there were relatively few, and thermal trauma will frequently be triaged differently than blunt or penetrating injuries. Relatedly, the trauma registry does not require reporting on patients with injuries in which the primary mechanism involves submersion, strangulation, electrocution, and so on. The complete list of exclusion criteria for reporting is shown in Appendix 1. After applying exclusion criteria, 1,700 patients were included in the analysis.

Variables and Statistical Analysis

To identify factors associated with the decision to use GEMS or HEMS for direct transport, a case-control design was used in which HEMS patients were designated "cases" and GEMS patients were "controls." Factors considered for analysis were documented by the receiving facility. Prehospital vitals and GCS documented by EMS were used when present. If prehospital vitals were not documented, the initial vitals from the receiving facility were used in their place. (The percents substituted were 20.2% for heart rate [HR], 4.1% for respiratory rate [RR], 2.1% for systolic blood pressure [SBP], and 3.5% for GCS.)

The nonclinical factors of interest included age, sex, injury location by zip code, insurance status, hour of transport (6 am-6 pm vs. 6 pm-6 am), and whether transport occurred on the weekend (Saturday or Sunday). Insurance status was categorized as private, public (Medicare or Medicaid), or uninsured/self-pay.

The clinical factors included trauma type (blunt or penetrating), injury mechanism (motor vehicle collision [MVC], gunshot, falls, and so on), GCS, vital signs (including HR, RR, and SBP), prehospital intubation status, ISS, and multisystem injury (based on Abbreviated Injury Scale values > 1 in at least 2 ISS body regions). Vital signs were converted to categoric variables based on age and corresponding ranges previously established in the literature. Because categorization of abnormal signs (eg, bradycardia, tachypnea, and so on) is controversial, patient HR, RR, and SBP were simply classified as low, normal, or elevated according to the *Advanced Pediatric Life Support* manual.[21] ISS was similarly grouped according to severity.

Categoric groupings of vital signs and ISS are shown in Appendix 2. Shock status was considered and defined as SBP < 70 in patients less than 1 year old, SBP < (70 + 2 × age) in patients 1 to 10 years old, and SBP < 90 in patients over 10 years old.[21]

Distance was calculated in miles as the linear path from the injury zip code centrum to the receiving hospital. Distances of 10 miles or less were excluded from analysis because this constitutes the "no-fly zone" as outlined in Protocol 17D of the EMS Medical Control Board of Oklahoma City and Tulsa,[22] and HEMS deployment within this radius would generally be seen only in unusual circumstances. Patients were then classified as short (11-25 miles), intermediate (26-40 miles), or long-distance transports (> 40 miles). The model fit was poor when distance was entered as a continuous variable. Because there is no consensus on distance stratification in the literature, the stated group cutoffs were selected based on what cutoff would yield a sufficient sample size for analysis and