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Helicopter versus ground ambulance: review of national database for outcomes in survival in transferred trauma patients in the USA

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ABSTRACT

Background Trauma care has improved substantially in the last decade. The emphasis of the Golden Hour in trauma care has encouraged the creation of faster transport and earlier prehospital intervention. Despite the clear time-saving advantage helicopter emergency medical services (HEMS) held over ground ambulances (GAs) in the past, advances in prehospital care over the last decade have created uncertainty as to whether HEMS transport is still associated with improved patient outcomes. We aimed to determine whether air transportation was associated with better outcomes compared with ground transportation. We hypothesized that air transportation is associated with better patient outcomes.

Methods A retrospective review was performed on the National Trauma Data Bank in 2014 on patients transferred either by helicopter or ground ambulance. Demographic information, mean length of stay, mean ventilator days, and mortality rate was abstracted. All transferred patients and patients with missing information were excluded. χ^2 test was performed to analyze categorical variables and independent t-test was performed to analyze continuous variables. A logistic regression was performed to ascertain the effects of Glasgow Coma Scale score, mechanism of injury (blunt vs penetrating), age, gender, Injury Severity Score (ISS), and method of transportation (HEMS vs GA) on the likelihood of mortality.

Results A total of 469 407 transferred trauma patients were analyzed. Mortality appeared to be increased in trauma patients transported by helicopter ambulance (6.0%) versus GA (2.9%) (p<0.001). However, after adjusting for age, ISS, and gender, trauma patients who were transferred by helicopter were 57.0% less likely to die than those transferred by GA (95% CI 0.41 to 0.44, p<0.0001).

Conclusion The results of this study demonstrate that despite improvements in trauma care, patients have improved survival if transported by helicopter ambulance.

Level of evidence and study type Level IV; Therapeutic/Care Management.

INTRODUCTION

Trauma-related injuries remain one of the leading causes of death in America.[1] Expeditious treatment is crucial to successfully managing trauma victims, as small delays in care may mean the difference between life and death. One of the fundamental tenets of trauma care is the "Golden Hour"—a term coined to emphasize the importance of treating trauma patients as quickly as possible. It represents the first peak in trimodal distribution of trauma mortality, in which the majority of trauma deaths occur within the first hour after the injury. Due to the rapidly deteriorating nature of many trauma injuries, it is believed that morbidity and mortality increase dramatically if patients do not receive definitive medical treatment within this 1-hour window. Despite never having been proven in the literature, the "Golden Hour" is still widely endorsed by trauma medicine.[2]

Trauma accounts for over 41 million visits to the emergency department (ED) each year.[3] In 2003, 14.2% of all ED patients were transported to the hospital by emergency medical services (EMS) using either ground or air ambulances. Helicopter emergency medical services (HEMS) became available to civilians in 1947 and gave hospitals a new opportunity to transport patients when ground transportation was ineffective or unfeasible. HEMS offer clear advantages compared with its ground-based counterpart: faster transport time, air-based travel, and more experienced medical crew.[4] This extended medical access to patients injured in remote or inaccessible locations, or in critically injured trauma patients that necessitated expedited on-scene arrival. The limitations of HEMS include higher cost, less cabin space, fewer number of ambulances, and greater susceptibility to weather interference.

Despite the clear time-saving advantage HEMS held over ground ambulances (GAs) in the past, improvements in prehospital care over the past decade have created uncertainty as to whether HEMS transport is still associated with better outcomes compared with ground transportation.[5–7] This study investigates the differences of outcomes in air versus ground-transported trauma patients. The National Trauma Data Bank (NTDB) was used to examine impact of total prehospital time on trauma outcomes in a modern population. We hypothesized that air transportation is associated with better patient outcomes.

PATIENTS AND METHODS

This was a retrospective, multicenter review that included all trauma patients from the NTDB evaluated between January and December 2014 who were transported by either ground or air ambulance. The NTDB is the most comprehensive national trauma database currently available, which included over 6 million medical records from 746 hospitals in 2014. An exception from our institutional review

Table 1 Demographic information of all trauma transfer patients analyzed in 2014 NTDB database (n=469 407)

Outcome variable	HEMS (n=44 637)	Ground ambulance (n=424 770)	P value
Age	40.2 (40.8)	39.1 (23.24)	<0.0001
GCS score	10.5 (6.4)	11.7 (6.1)	<0.0001
Blunt	98.3% (43 900)	98.8% (419 637)	<0.0001
Penetrating	1.7% (737)	1.2% (5132)	<0.0001
Gender (male)	31 587 (70.8%)	250 981 (59.1%)	<0.0001
Ethnicity			<0.0001
White	35 044 (78.5%)	293 344 (69.1%)	<0.0001
Black	3930 (8.8%)	64 737 (15.2%)	
Hispanic	4260 (9.5%)	44 898 (10.6%)	
Asian	540 (1.2%)	9189 (2.2%)	
ISS	16.0 (48.3)	10.9 (46.9)	<0.0001
Mortality	6.0% (2688)	2.9% (12 352)	<0.0001
LOS (days)	8.0 (10.6)	5.2 (7.4)	<0.0001
ICU (days)	3.0 (7.2)	0.5 (4.3)	<0.0001
Ventilator (days)	1.16 (5.6)	−0.4 (3.1)	<0.0001
ISS AIS score	14.8 (33.5)	10.2 (39.4)	<0.0001
Total prehospital time (min)	168.9 (428.1)	109.1 (390.0)	<0.0001

AIS, Abbreviated Injury Scale; GCS, Glasgow Coma Scale; HEMS, helicopter emergency medical services; ICU, intensive care unit; ISS, Injury Severity Score; LOS, length of stay; NTDB, National Trauma Data Bank.

board was obtained given that the data provided by the NTDB were deidentified.

The target patient population was adults (≥18 years old) who sustained a traumatic injury (blunt or penetrating) and were transported to a trauma center by either ground or air ambulance. Patients were stratified into two groups based on mode of transportation: ground or air (eg, helicopter, fixed-wing plane, etc). Demographics, mean Injury Severity Score (ISS), transport times, ED transport times, mean length of stay (LOS), mean ventilator days, and mortality rate were abstracted. Transport time was defined as EMS departure from scene to definitive treatment center arrival. We excluded all transferred patients and patients with missing information.

χ^2 test was performed to analyze categorical variables and independent t-test was performed to analyze continuous variables. A logistic regression was performed to ascertain the effects of Glasgow Coma Scale (GCS) score, age, gender, ISS, mechanism of injury (blunt vs penetrating) and method of transportation (HEMS vs GA) on the likelihood of mortality. GCS has been used in the logistic regression model to predict mortality outcome. The logistic regression model was statistically significant, χ^2=7531.33, p<0.0001. The model explained 4.6% (Nagelkerke R^2) of variance in mortality and correctly classified 96.9% of the cases.

RESULTS

During this study period, a total of 469 407 transferred trauma patients were analyzed. Of those, 424 770 trauma patients were transported by GA and 44 637 were transported by HEMS (table 1). More men (70.8% vs 59.1%) (p<0.0001) were transported by air rather than ground. The mean ISS (16.0 vs 10.9) (p<0.0001) was significantly higher in trauma patients transported via air. Air-transported patients had on average longer LOS and intensive care unit LOS. Mortality appeared to be increased in trauma patients transported by HEMS (6.0%) versus GA (2.9%) (p<0.0001). However, after adjusting for confounders (age, ISS, gender), trauma patients who were transferred by helicopter were 57.0% less likely to die than those transferred by GA (95% CI 0.41 to 0.44, p<0.0001) (table 2). In addition, increased age and ISS score were both associated with increased likelihood of mortality. Gender was not found to be a predictive confounder in the model. Penetrating injury was associated with 2.5 greater odds of mortality compared with blunt injury.

Table 2 Logistic regression model performed to ascertain the effects of GCS score, age, gender, ISS, penetrating vs blunt injury and method of transportation (HemS vs ground ambulance) on the likelihood of mortality

Variable	Odds	95% CI	P value
Helicopter transport	0.43	0.41 to 0.44	<0.0001
GCS score	0.95	0.94 to 0.95	<0.0001
Age	1.003	1.003 to 1.003	<0.0001
Male gender	1.014	0.45 to 2.3	0.973
ISS	1.002	1.002 to 1.002	<0.0001
Penetrating injury	2.5	1.918 to 2.939	<0.0001

GCS, Glasgow Coma Scale; ISS, Injury Severity Score.

Helicopter transferred patients had longer total prehospital times compared with ground transferred patients. HEMS transport total prehospital time was 168.9 with SD (428.1) minutes and GA transport total prehospital time was 109.1 with SD (390) minutes, p<0.0001.

DISCUSSION

In this study, we sought to investigate the effect of transport times on trauma outcomes and if there were any differences between air and ground ambulances. Although it may appear intuitive that HEMS would lead to better patient outcomes when compared with GA, the topic has been hotly debated. Some studies show improved patient outcomes with shorter transport times.[8–10] Kotwal *et al* investigate prehospital time in trauma patients on the battlefield between 2001 and 2014 and found an association between shorter prehospital transport time and decreased mortality, despite a simultaneous increase in ISS over the years as warfare injuries evolved.[10] Other studies suggest that extended transport time does not lead to poorer outcomes.[11–13] Newgard *et al* assessed the "Golden Hour" in EMS and found that shorter prehospital times were associated with no survival benefit among injured adults, a finding that persisted across many subgroups, including level of first responding EMS provider, mode of transport, country, age, injury type, and more severe physiologic derangement.[11] Brown *et al* investigated prehospital time in trauma patients between GA and HEMS transport and found that HEMS only increased survival between 6 and 30 min of prehospital transport time, whereas transport time less than 5 min and greater than 30 min was not impacted by transport type.[12] Our results indicate that trauma patients transported by HEMS were 57.0% less likely to die than those transported by GA after adjusting analysis for confounders.

The faster the ambulance is able to reach the trauma victim, the quicker medical treatment may be initiated. The short time period immediately after traumatic injuries may be the most deciding factor of mortality, especially in patients with wounds that need immediate care, such as rapid exsanguination. It has been shown that proximity to an airbase, and therefore a shorter

dispatch time, is associated with reduced mortality in trauma patients.[14] Since helicopters are often capable of arriving to the scene before a ground vehicle, it seems probable that this is one of the major factors responsible for the reduced mortality with HEMS. However, it should be noted that we do not have data for on-scene arrival times and therefore must limit our speculation.

In the HEMS cohort, we observed a 58.4% longer total prehospital time compared with the GA cohort. This is likely due to helicopters having to travel greater distances and rescuing more severely injured patients. Trauma patients who are more seriously wounded may require additional interventions or advanced life-saving procedures that increase total prehospital time. For example, the patient may need immediate intubation or extrication from a vehicle. Every effort should be made to minimize the time required to transport the patient back to the hospital.

Two noteworthy demographic differences between HEMS and GA populations were observed. There was a significantly greater proportion of whites and men in the helicopter group compared with the GA group. This may be related to HEMS being utilized more frequently in rural areas.

The findings in our study confirm our hypothesis that air transportation of trauma victims is associated with better patient outcomes. This is an expected finding since HEMS travel much faster than GA (and thus can arrive and provide care faster than GA) and contain better trained medical professionals. Despite these advantages, helicopters are unlikely to replace ground-based transport due to their exorbitant cost and inability to provide care in highly dense cities. Deeper investigation of this topic should seek to further refine our understanding of the differences between ground and air emergency transportation so that we can maximize patient outcomes while minimizing superfluous spending.

Limitations

There are some limitations to our study. First, these results stem from a center with a large proportion of rural transfers in a wide geographic area and is not generalizable to densely populated urban settings. Second, this study used the NTDB database which does not have data on prehospital deaths; thus, deaths occurring before access to EMS are not captured. Third, this study is a retrospective analysis using the NTDB. Some data (such as extrication times, specific life-saving interventions, and ongoing cardiopulmonary resuscitation in transport) would have enhanced our study but were unavailable in the NTDB. Fourth, the HEMS cohort demographic may not be representative of the general population. Fifth, we were limited to using ISS and trauma severity indexes to categorize injuries; more specific information regarding injury pattern (eg, blunt vs penetrating trauma) may help elucidate more specific findings. Sixth, we recognize that in both HEMS and GA cohorts, the mean total prehospital time was beyond the “Golden Hour”. This finding may be influenced by a difference in penetrating and blunt injuries, but a subset analysis investigating this disparity was beyond the scope of this study.

CONCLUSION

Our findings in this study demonstrated that despite improvements in trauma care in recent years, patients had improved survival if transported by helicopter ambulance. After adjusted analysis, we found that helicopter use is associated with decreased mortality in trauma patients. The higher level of care provided by helicopter medical personnel and the faster on-scene arrival of air transport is still associated with better outcomes compared with ground transportation. Over-triaging and excessive use of HEMS on less severely injured patients could contribute to the better outcomes seen in the air-transported cohort.

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