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Mortality following helicopter versus ground transport of injured children

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ABSTRACT

Introduction: Injured children may be transported to trauma centers by helicopter air ambulance (HAA); however, a benefit in outcomes to this expensive resource has not been consistently shown in the literature and there is concern that HAA is over-utilized. A study that adequately controls for selection bieases in transport mode is needed to determine which injured children benefit from HAA. The purpose of this study was to determine if HAA impacts mortality differently in minimally and severely injured children and if there are predictors of over-triage of HAA in children that can be identified.
Methods: Children ≤18 years of age transported by HAA or ground ambulance (GA) from scene to a trauma center were identified from the 2010–2011 National Trauma Data Bank. Analysis was stratified by Injury Severity Score (ISS) into low ISS (≤15) and high ISS (>15) groups. Following propensity score matching of HAA to GA patients, conditional multivariable logistic regression was performed to determine if transport mode independently impacted mortality in each stratum. Rates and predictors of over-triage of HAA were also determined.
Results: Transport by HAA occurred in 8218 children (5574 low ISS, 2644 high ISS) and by GA in 35305 (30506 low ISS, 4799 high ISS). Overall mortality was greater in HAA patients (4.0 vs 1.4%, $p < 0.001$). After propensity score matching, mortality was equivalent between HAA and GA for low ISS patients (0.2 vs 0.2%, $p = 0.82$) but, for high ISS patients, mortality was lower in HAA (9.0 vs 11.1% $p = 0.014$). On multivariable analysis, HAA was associated with decreased mortality in high ISS patients (OR = 0.66, $p = 0.017$) but not in low ISS patients (OR = 1.13, $p = 0.73$). Discharge within 24 h of HAA transport occurred in 36.5% of low ISS patients versus 7.4% high ISS patients ($p < 0.001$).
Conclusions: Based on a national cohort adjusted for nonrandom assignment of transport mode, a survival benefit to HAA transport exists only for severely injured children with ISS >15. Many children with minor injuries are transported by helicopter despite frequent dismissal within 24 h and no mortality benefit.

Introduction

Trauma is the leading cause of morbidity and mortality in children [1]. Injured patients who receive care at trauma centers are known to have better outcomes; thus, expeditious transport to these centers is critical in avoiding early death [2,3]. To this end, helicopter air ambulances (HAA) are often used to transport severely injured children. Not surprisingly, HAA transport is more expensive than ground ambulance (GA); it has been estimated that a 15% mortality reduction associated with HAA is needed to make it cost-effective [4]. Thus, it is necessary to justify its use by studying outcomes of children transported by HAA versus GA.

Effectiveness of HAA in reducing mortality in trauma patients is difficult to demonstrate, as prospective trials randomizing patients to HAA or GA are not feasible. To reduce selection bias, retrospective studies have used propensity scores to compare HAA patients to those transported by GA who may have been eligible for helicopter transport. Through propensity score matching, causal inferences between treatment and outcomes may be estimated from observational data [5]. Propensity score matched comparisons of HAA versus GA transport in adult trauma

Abbreviations: HAA, helicopter air ambulance; GA, ground ambulance; NTDB, National Trauma Data Bank; ACS, American College of Surgeons; RDS, research data set; MVA, motor vehicle accident; ISS, injury severity score.

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patients have demonstrated improved survival in severely injured patients transported by HAA [6,7]. Minimally injured patients, however, are often transported by HAA without a mortality benefit [8,9]. Though studies of pediatric trauma patients transported by HAA also suggest overutilization of this resource, a survival benefit has not been clearly demonstrated in this population, regardless of injury severity [10,11].

To date, there have been no national studies comparing HAA and GA transportation in pediatric trauma patients which appropriately control for selection bias of transport mode and account for the fundamental differences in minimally injured and severely injured children. Given that the vast majority of pediatric trauma patients are minimally injured and the case fatality rate for injured children is low overall, statistical differences in mortality are especially difficult to detect in this population [12]. Therefore, the purpose of this study was to determine if there is a survival benefit to HAA transport of injured children through analysis of propensity-scored matched patients in the National Trauma Data Bank (NTDB). We hypothesized that HAA would be associated with decreased mortality only in severely injured patients.

Methods

Patient identification and data source

Children $\leq$18 years of age were identified from the 2010–2011 NTDB [13]. Only those transported from the scene of injury by HAA or GA to an American College of Surgeons (ACS) adult or pediatric level I or II trauma center were included; those arriving by other modalities of transportation and those treated at facilities without at least 6 HAA transports per year were excluded. Patients with missing data for ACS verification level, mode of transportation, or mortality were also excluded, as were those transferred to or from another acute care hospital and those who were dead on arrival. The NTDB is a national trauma registry maintained by the ACS Committee on Trauma. The NTDB Research Data Set (RDS) is released on an annual basis. In 2011, it contained more than five million patient entries provided voluntarily by more than 900 institutions in the United States and Puerto Rico. Contributing institutions utilize a standard set of inclusion criteria and variable definitions outlined in the NTDB data dictionary. Data is screened for accuracy by validation software prior to inclusion in the RDS.

Data collection

Demographic and clinical data were recorded including age, gender, comorbidities, mechanism and type of injury, mode of transport, injury severity, trauma center verification level, and in-hospital outcomes. ICD-9-CM E codes were used to classify mechanism of injuries into falls, motor vehicle accidents (MVA), other vehicle accidents, self-inflicted injuries, striking against or struck, and all other mechanisms. Data on prehospital times were missing in 20% of patients and were not included. Patients were stratified into two groups based on injury severity scores (ISS) for

Table 1
Characteristics of Patients Overall and Stratified by Injury Severity.

		All Patients			Low ISS			High ISS		
		GA	HAA	*p* value	GA	HAA	*p* value	GA	HAA	*p* value
N		35305	8218		30506	5574		4799	2644	
Age	0–14	21218 (60.1)	4352 (53.0)	<0.001	18720 (61.4)	3172 (56.9)	<0.001	2498 (52.1)	1180 (44.6)	<0.001
	15–18	14087 (39.9)	3866 (47.0)		11786 (38.6)	2402 (43.1)		2301 (47.9)	1464 (55.4)	
% Female		11888 (33.7)	2867 (34.9)	0.036	10359 (34.0)	1959 (35.1)	0.09	1529 (31.9)	908 (34.3)	0.029
Race	White	19937 (56.5)	6269 (76.3)	<0.001	17359 (56.9)	4258 (76.4)	<0.001	2578 (53.7)	2011 (76.1)	<0.001
	African American	7246 (20.5)	523 (6.4)		6233 (20.4)	353 (6.3)		1013 (21.1)	170 (6.4)	
	Other	8122 (23.0)	1426 (17.4)		6914 (22.7)	963 (17.3)		1208 (25.2)	463 (17.5)	
Hispanic Ethnicity		6701 (19.0)	1195 (14.5)	<0.001	5696 (18.7)	846 (15.2)	<0.001	1005 (20.9)	349 (13.2)	<0.001
Payer Status	Private	12687 (35.9)	3388 (41.2)	<0.001	11184 (36.7)	2335 (41.9)	<0.001	1503 (31.3)	1053 (39.8)	<0.001
	Government	11262 (31.9)	2109 (25.7)		9723 (31.9)	1463 (26.2)		1539 (32.1)	646 (24.4)	
	Self-pay	3092 (8.8)	811 (9.9)		2633 (8.6)	572 (10.3)		459 (9.6)	239 (9.0)	
	Other	8264 (23.4)	1910 (23.2)		6966 (22.8)	1204 (21.6)		1298 (27.0)	706 (26.7)	
Type of Injury	Blunt	29193 (82.7)	7340 (89.3)	<0.001	25487 (83.5)	4945 (88.7)	<0.001	3706 (77.2)	2395 (90.6)	<0.001
	Penetrating	3456 (9.8)	456 (5.5)		2804 (9.2)	317 (5.7)		652 (13.6)	139 (5.3)	
	Other	2656 (7.5)	422 (5.1)		2215 (7.3)	312 (5.6)		441 (9.2)	110 (4.2)	
Mechanism of Injury	Falls	7378 (20.9)	926 (11.3)	<0.001	6820 (22.4)	745 (13.4)	<0.001	558 (11.6)	181 (6.8)	<0.001
	MVA	17405 (49.3)	5792 (70.5)		14603 (47.9)	3702 (66.4)		2802 (58.4)	2090 (79.0)	
	Other vehicle	87 (0.2)	87 (1.1)		79 (0.3)	59 (1.1)		8 (0.2)	28 (1.1)	
	Self-inflicted	4071 (11.5)	421 (5.1)		3150 (10.3)	273 (4.9)		921 (19.2)	148 (5.6)	
	Striking against or struck	2883 (8.2)	384 (4.7)		2686 (8.8)	322 (5.8)		197 (4.1)	62 (2.3)	
	All other	3481 (9.9)	608 (7.4)		3168 (10.4)	473 (8.5)		313 (6.5)	135 (5.1)	
ACS Level I facility		19981 (56.6)	4937 (60.1)	<0.001	17031 (55.8)	3236 (58.1)	0.002	2950 (61.5)	1701 (64.3)	0.015
Pediatric Trauma Center		17276 (48.9)	3664 (44.6)	<0.001	15152 (49.7)	2454 (44.0)	<0.001	2124 (44.3)	1210 (45.8)	0.212
Initial Vital Signs, mean	SBP	123.2 (22.2)	124.1 (22.8)	<0.001	124.8 (18.5)	126.6 (18.1)	<0.001	112.8 (36.5)	118.8 (29.8)	<0.001
	Pulse	102.1 (25.1)	102.6 (25.8)	0.18	102.3 (23.0)	102.1 (23.3)	0.17	101.0 (35.7)	103.7 (30.4)	0.007
	RR	21.0 (6.4)	19.5 (7.2)	<0.001	21.2 (5.7)	20.3 (6.1)	<0.001	20.1 (9.4)	17.8 (8.9)	<0.001
	GCS motor	5.7 (1.0)	5.1 (1.8)	<0.001	5.9 (0.6)	5.6 (1.2)	<0.001	4.6 (1.9)	3.9 (2.2)	<0.001
ISS, mean		7.9 (8.5)	13.1 (11.7)	<0.001	5.2 (3.5)	6.6 (3.9)	<0.001	24.6 (11.2)	26.8 (10.9)	<0.001
In-hospital mortality		501 (1.4)	327 (4.0)	<0.001	36 (0.1%)	12 (0.2)	0.07	465 (9.7)	315 (11.9)	0.003

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