Impact of Direct Transport vs. Transfer on Out-of-Hospital Traumatic Cardiac Arrest

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ABSTRACT

BACKGROUND: Injured patients benefit from direct transport to a trauma center; however, it is unknown whether patients with traumatic out-of-hospital cardiac arrest (OHCA) benefit from initial resuscitation at the nearest emergency department (ED) if a trauma center is farther away. We hypothesized that patients with traumatic OHCA transported directly to a trauma center have less in-hospital mortality after initial resuscitation compared to those transferred from non-trauma centers.

METHODS: We examined patients presenting with traumatic OHCA within our institutional trauma registry and the National Trauma Data Bank (NTDB) and excluded patients with ED mortality. Our primary outcome was all-cause mortality during index hospitalization; multiple logistic regression controlled for age, sex, injury severity score, mechanism of injury, signs of life, emergency surgery, and level I trauma center designation.

RESULTS: We identified 271 and 1,138 adult patients with traumatic OHCA in our registry and the NTDB; 28% and 16% were transferred from another facility, respectively. Following initial resuscitation, patients transferred to a trauma center had higher in-hospital mortality than those transported directly in both our local and national cohorts (aOR: 2.27, 95%CI: 1.03-4.98, and aOR: 2.66, 95%CI: 1.35 – 5.26, respectively).

DISCUSSION: Patients with traumatic OHCA transported directly to a trauma center may have increased survival to discharge compared to those transferred from another facility, even accounting for initial resuscitation. Further investigation should examine the impact of both physiologic and logistic factors including distance to trauma center, traffic, and weather patterns that may impact prehospital decision-making and destination selection.

KEYWORDS: prehospital care, emergency medical services, cardiac arrest, trauma

BACKGROUND

Injured patients benefit from direct transport to a tertiary trauma center.[1,2] Patients with traumatic out-of-hospital cardiac arrest (OHCA) have significant risk of mortality, and effective resuscitation is hindered by delay in arrival to a trauma center where advanced resuscitation or operative intervention may be provided.[3–5] In some trauma systems, patients with traumatic OHCA are transported by emergency medical services (EMS) to the nearest emergency department (ED) – regardless of trauma center designation. In theory, this facilitates the early provision of lifesaving interventions such as blood transfusion or needle thoracostomy that may or may not be available prehospitally, depending on level of care and available resources. In these cases, Advanced Trauma Life Support guidelines recommend the prompt transfer of survivors to a trauma center after stabilization. However, the decision to transport patients with traumatic OHCA to the nearest non-trauma center may paradoxically delay the provision of advanced trauma care if the aforementioned interventions are not readily available on presentation to the community ED.

Our Level I Trauma Center is the only ACS- and State-designated trauma center in our state. Patients from suburban and rural areas in our large catchment area frequently receive their initial care and resuscitation efforts at another facility prior to transfer to our institution. Therefore, we receive injured patients who have survived both their initial traumatic OHCA in the field as well as their initial resuscitation and transfer from an external facility. These types of interfacility transfers are commonplace in our nation. Therefore, it is important to better characterize their outcomes in order to improve care on a systems level. We hypothesized that despite successful resuscitation at a non-trauma center (NTC), patients with traumatic OHCA transported directly to a trauma center (TC) have higher rates of survival to discharge.

METHODS

We aimed to evaluate our center's experience with traumatic OHCA, and to frame these results within the context of the analogous national outcomes. Thus, we studied two databases separately – our institution's trauma registry and the National Trauma Data Bank (NTDB). The National Sample

Program (NSP) datasets of the NTDB from 2012 and 2013 were purchased from the American College of Surgeons since these were the only available datasets that included prehospital cardiac arrest as a variable at the time of analysis. Traumatic OHCA was defined to occur in the setting of known or presumed trauma. For our local data, we obtained Institutional Review Board (IRB) approval to perform a retrospective cohort study of adult patients presenting to our ED following traumatic OHCA between January 2012 and February 2017. Of note, there were significant changes within our statewide EMS protocols for out-of-hospital cardiac arrest after that time point such as a mandatory 30-minute on-scene resuscitation for arrests with non-traumatic etiology. Though trauma patients were exempted from this requirement, our prehospital protocols within the studied time period were better matched to the national standards that patients were exposed to within the NTDB dataset. Additionally, we excluded patients who were directly transported to a TC and died in the ED from our final analytic sample. This was done to account for the absence of patients who did not survive their initial resuscitation at an NTC prior to transfer, as well as to generate two physiologically comparable groups of patients with salvageable traumatic OHCA.

We defined our primary outcome as all-cause mortality during index hospitalization. Trauma center designation levels were categorized as ACS level I or level II, state-designated level I or II, or other. Distances between injury site and referring facility or between injury site and our institution were approximated based on zip codes of injury using Google Maps. Distance between referring hospitals and our institution were calculated using Google Maps based on known addresses of referring hospitals. Signs of life were defined to include the presence of a pupillary response, spontaneous ventilation, carotid pulse, measurable or palpable blood pressure, extremity movement, or cardiac electrical activity according to the 2001 definition from the American College of Surgeons Committee on Trauma.[6] Demographic data, physiologic data upon arrival, injury mechanism and severity, procedures performed, and outcome data were collected.

Parametric categorical data were analyzed with bivariate analysis. We applied Pearson's Chi square test, with Fisher exact test for sparse values, to test independence. Parametric continuous data were compared using Student t-test. Nonparametric data were analyzed using the Wilcoxon rank sum test. Statistical significance was set at α=0.05. We performed simple and multiple logistic regression analyses on the weighted population estimates to obtain crude and adjusted odds radios of mortality. We completed all analyses using Stata/SE statistical software, version 14.0 for Windows 10, copyright 1985–2015 Statacorp LP, College Station, TX, USA.

RESULTS

Local Data

We identified 271 adult patients who were treated at our institution between January 2012 and February 2017 with traumatic OHCA. Of those, 194 patients were male (71.6%) and 76 (28.0%) were transferred to our ED after resuscitation at an NTC (**Table 1**). The median [IQR] distance from the prehospital scene of injury to our ED for the directly transported cohort was 6.6 [3.9, 13.3] miles. For transferred patients, the median distance between prehospital scene of injury and the transferring hospital was 4.1 [2.3, 8.5] miles compared to a hypothetical distance of 21.3 [13.3, 33.2] miles if direct transport to our TC had been initiated. Our all-cause mortality rate was 82.3% for all comers, and the majority of deaths occurred in the ED. There was a higher rate of both ED (76.9 vs. 18.4%, p<0.001) and overall mortality (87% vs. 71%, p=0.002) within our direct transport vs. transferred cohorts.

Table 1. Local Data – Patient Characteristics

Characteristics of analytic sample and comparison groups within our local data: direct transport to a trauma center vs. transferred from another facility.

	Total (N=271)	Direct (n=195)	Transfer (n=76)	P value
Gender – Male, n (%)	194 (71.6)	149 (76.4)	45 (59.2)	0.005
Age, mean (SD)	47.7 (22.8)	45.6 (22.3)	53.3 (23.2)	0.01
EMS Time (minutes), median [IQR]	33 [27, 52]	30 [25, 40]	75 [61, 91]	<0.001
Outside Hospital (minutes)	N/A	N/A	77 (50–167)	
Mechanism, n (%)				0.007
Blunt	364 (62.5)	230 (57.5)	134 (75.3)	
Penetration	97 (21.4)	71 (25.3)	21 (11.5)	
Other	77 (16.1)	50 (17.%)	27 (13.2)	
ISS, median [IQR]	14 [5, 25]	13.5 [5, 25]	17, [10, 25.5]	0.03
ED GCS, median [IQR]	3 [3, 4]	3 [3, 3]	3 [3, 3]	NS
Mortality, n (%)				0.04
ED Mortality	164 (60.5)	150 (76.9)	14 (18.4)	< 0.001
Overall Mortality	224 (82.7)	170 (87.2)	54 (71.1)	0.002
*Among ED Survivors	60 (56.1)	20 (44.4)	40 (64.5)	< 0.001
Emergency surgery, n(%)	17 (6.3)	8 (4.1)	9 (11.8)	0.03
*Among ED Survivors	17 (15.9)	8 (17.8)	9 (14.5)	NS
Hospital LOS (days), median [IQR]	3 [2, 7]	5 [2, 8]	3 [2, 6]	0.02

SD: Standard Deviation, IQR: Interquartile Range, EMS: Emergency Medical Services, ISS: Injury Severity Score, ED: Emergency Department, GCS: Glasgow coma scale, LOS: length of stay.

Our final analytic sample included 107 (39.5%) patients who survived their ED resuscitation and were admitted to the hospital. Among these ED survivors, there was higher in-hospital mortality among transferred vs. directly transported patients (64.5% vs. 44.4%, p=0.03, aOR: 2.27, CI: 1.03-4.98). Seventeen patients underwent emergency surgery, of which 11 (64.7%) subsequently experienced in-hospital mortality. There was a higher rate of emergency surgery within the transferred cohort overall; however, this difference was not significant when adjusting for ED survivors.

National Sample Program Data

Between 2012 and 2013, the NSP recorded 1,138 adult patients that presented to either an ACS- or State-designated level I or II trauma center with traumatic OHCA. Of these, 956 patients were directly transported to a TC and 182 (16%) were transferred from another facility. Of the total sample, 75.8% were males, 31.3% sustained penetrating trauma, and the median ISS was 25. The mean age was 43.5 years, and patients within the direct transport cohort were younger than those in the transferred cohort (42 vs. 52 years, p<0.001). On arrival to the TC, 585 (52.4%) patients had documented signs of life (SOL). Including all comers, transferred patients had SOL on arrival in 90.3% compared to 45.3% in the direct group. The overall mortality rate was 83.7% and 68% of deaths occurred in the ED. Including all patients, the direct transport cohort experienced higher mortality both overall (85.3 vs. 72.4%, p=0.003) and within the ED (73.1 vs. 27.3%, p<0.001).

Table 2. National Trauma Data Bank – Patient Characteristics

Characteristics of analytic sample and comparison groups within the National Trauma Data Bank (NTDB): direct transport to a trauma center vs. transferred from another facility. Results are presented as number of patients in our sample and percentages from weighted population estimates.

	Total (N=538)	Direct (n=356)	Transfer (n=182)	P value
Gender – Male, n (%)	379 (70.5)	253 (71.1)	126 (69.2)	NS
Age, mean (SD)	47.9 (18.9)	45.9 (17.7)	51.9 (20.6)	<0.001
Trauma Center				NS
ACS Level I	346 (58.4)	237 (58.1)	109 (59.3)	
ACS Level II	61 (10.7)	34 (10.1)	27 (12.2)	
State Level I	126 (29.7)	81 (30.4)	45 (28)	
State Level II	5 (1.2)	4 (1.4)	1 (5)	
EMS Time (minutes), median [IQR]	56 [35, 112]	41 [31, 66]	101 [69, 1440]	<0.001
Mechanism, n (%)				0.007
Blunt	364 (62.5)	230 (57.5)	134 (75.3)	
Penetration	97 (21.4)	71 (25.3)	21 (11.5)	
Other	77 (16.1)	50 (17.2)	27 (13.2)	
ISS, median [IQR]	22 [9, 30]	21 [10, 29]	22 [9, 33]	NS
SOL on ED Arrival, n (%)	464 (82.9)	306 (79.6)	158 (91.5)	0.001
ED GCS, median [IQR]	3 [3, 6]	3 [3, 6]	3 [3, 6]	NS
Overall Mortality, n (%)	356 (63.8)	232 (60.3)	124 (72.8)	0.04
Emergency surgery, n (%)	126 (23.3)	105 (27.9)	21 (11.5)	0.001
Hospital LOS (days), median [IQR]	3 [1, 7]	3 [1, 7]	2 [1, 7]	NS

SD: Standard Deviation, IQR: Interquartile Range, ACS: American College of Surgeons, EMS: Emergency Medical Services, ISS: Injury Severity Score, SOL: Signs of life, ED: Emergency Department, GCS: Glasgow coma scale, LOS: length of stay

To generate our final analytic sample, we excluded 580 patients that expired in the ED following direct transport to a TC as well as those without available data for the primary outcome (n=10). Thus, our final analysis included 538 patients, of whom 356 (66.2%) were directly transported and 182 (33.8%) were transferred from another facility to the final TC (**Table 2**). There was no difference in gender, race, ISS, GCS on arrival, length of stay, or level of trauma center. Patients who were directly transported to TC were younger (45 vs. 51.9 years, p<0.001) and underwent emergency surgery more frequently (27.9 vs. 11.5%, p=0.001). There was a higher rate of penetrating trauma within the direct vs. transferred cohorts (25.3 vs. 11.5%, p=0.007). Transferred patients took longer to arrive at a TC (101 vs. 41 minutes, p<0.001), with prehospital time only including time from referral hospital to TC – not including scene times prior to transfer. Mortality was lower in the direct transport group compared to the transferred group (60.3 vs. 72.8%, *p*=0.04). Penetrating injuries resulted in higher mortality than blunt injuries (73.5 vs. 61.2%), but there was no difference in mortality between the transfer or direct groups within this subgroup of penetrating injury. However, among the subgroups with traumatic OHCA after blunt trauma, there was higher in-hospital mortality in the transferred vs. direct cohort (72.5 vs. 55.7%, p=0.02). Adjusting for age, gender, injury severity score, mechanism of injury, presence of SOL on ED arrival, requirement for emergency surgery, and Level I TC designation, patients with traumatic OHCA who were transferred from another facility to a trauma center had higher odds of mortality (aOR: 2.66, 95% confidence interval: 1.35–5.26).

DISCUSSION

In this study, we used local and national databases to examine the outcomes of patients with traumatic out-of-hospital cardiac arrest who were directly transported to a trauma center compared to those who were initially transported to the closest emergency department for initial resuscitation prior to being transferred to a trauma center. We observed a significantly higher rate of both ED and overall mortality in patients who were directly transported to a trauma center. Despite this initial indication of a survival advantage, we found that patients who were eventually transferred from a non-trauma center to a Level I trauma center subsequently experienced significantly higher rates of all-cause in-hospital mortality compared to those who were directly transported when adjusted for those who experienced ED mortality at the trauma center.

The prehospital management of traumatic OHCA is entirely different from cardiac arrest secondary to medical etiologies including acute coronary syndrome or arrhythmia, which are more commonly encountered by prehospital providers. In the case of non-traumatic OHCA, prehospital providers may remain on scene for up to thirty minutes to optimize resuscitation by maximizing chest compression fraction and limiting the interruptions to cardiopulmonary resuscitation.[7] This is a reasonable approach when the majority of evidence-based interventions fall within the scope of both basic and advanced life support prehospital personnel. However, the principles of traumatic OHCA management are fundamentally different and are focused on the rapid control of hemorrhage, the relief of obstructive shock (i.e., tension pneumothorax or cardiac tamponade), and the establishment of a definitive airway. While some interventions such as needle thoracostomy are commonly within the paramedic scope of practice, they may be less frequently performed by individual providers outside of trauma centers and are associated with variable success rates.[8,9] While lifesaving procedures including emergency thoracotomy have been successfully deployed prehospitally by physician-led teams,[10] they remain exceedingly rare for most clinicians. As such, ideal conditions include performance by a specialized trauma team in a well-equipped trauma center. Whether they occur within a non-trauma center or during a prolonged direct transport, delays to receiving appropriate trauma care result in increased mortality and may render further interventions as futile.[3,11]

Unfortunately, trauma is not restricted to a one-mile radius around the trauma center. While we identified a subsequent in-hospital survival advantage for traumatic OHCA survivors who were directly transported to a trauma center, there are only so many miles of transport that a trauma patient can tolerate without relief of an obstructed airway or tension pneumothorax. Thus for many patients, the question of "How far from a trauma center is too far to consider direct transport?" remains unanswered. Certainly, some prehospital providers in rural systems or austere environments may have no choice but to transport to the nearest facility, regardless of trauma center designation. In these cases, our study highlights the important fact that despite an initial survival advantage, patients brought to the nearest non-trauma center after traumatic OHCA are still at risk of higher long-term mortality when compared to those who were directly transported to a trauma center.

In considering the rationale for this finding, we believe that it is important to recognize that physicians at trauma and non-trauma centers may have differing definitions of futility for patients with traumatic cardiac arrest. While a surgeon at a Level I trauma center may not offer invasive procedures such as resuscitative thoracotomy to a patient with a blunt mechanism or prolonged arrest time in accordance with the Eastern Association for the Surgery of Trauma's practice management guidelines, the same patient might undergo thoracotomy in the community setting despite perceived futility in the trauma center. Should that patient survive their eventual transfer to the trauma center, the long-term utility of further interventions on survival or functional status remains unknown since they would have been pronounced dead on arrival if directly transported. In our local data, we showed similar rates of subsequent surgical intervention among ED survivors who were directly transported or subsequently transferred to our institution. Despite similar rates of intervention among these survivors, patients who were directly transported to a Level I trauma center had lower subsequent rates of in-hospital mortality.

One-third of injured patients are transported to a non-trauma center initially,[12] and it is likely that individual EMS provider judgment, distance to a trauma center, and patient demographic factors play a role in selection of optimal transport destination.[13–16] Several studies have established the benefit of direct transport to a trauma center rather than undertriage to a non-trauma center,[17–19] and for this reason, the establishment of well-coordinated trauma systems results has resulted in decreased risk of mortality.[20] Our work adds to the body of evidence that patients who are eventually transferred to a trauma center compared to those who are directly transported may experience higher rates of mortality in the longer term.

LIMITATIONS

In our comparison of outcomes between patients transferred to and directly transported to a trauma center, we are unable to account for those who were pronounced dead or non-survivable in the field or at outside hospitals. To reduce bias and increase the direct comparability of our cohorts, we excluded patients who were pronounced dead in the emergency department from our final analysis and thus created an artificial sample of patients in whom the immediate-term outcome of ED survival was already known. This severely limits the generalizability of our results which should thus be used for hypothesis generation rather than direct implementation within prehospital protocols. Additionally, because the NTDB only contains data from contributing trauma centers until the date of discharge, we were unable to assess important post-discharge outcomes including mortality and functional status. As with all retrospective research, there are limitations due to missing values.

In our analysis of NTDB data, we were unable to control for geographic differences across the U.S. because two thirds of values for the region variable were missing in our sample. Also, the reported prehospital time in the NTDB does not include time spent at the referring non-trauma or Level II trauma center. However, if total prehospital time prior to arrival at a non-trauma center was reported, this would have increased the difference that we found in our results.

CONCLUSION

In our analysis of both local and national data, patients with traumatic out-of-hospital cardiac arrest who were transferred to a trauma center after successful resuscitation at a non-trauma center have higher odds of in-hospital mortality compared to those who were directly transported to a trauma center. Educational efforts in a regional trauma system should emphasize the importance of minimizing delays to the provision of evidence-based trauma care both during initial care at non-trauma centers and throughout inter-facility transfer. While our findings should be considered exploratory in nature, they highlight the important fact that the optimal cut point in transportation time for prehospital destination selection after traumatic cardiac arrest remains unknown.

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