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Prehospital traumatic cardiac arrest: management and outcomes from the Resuscitation Outcomes Consortium Epistry-Trauma and PROPHET registries

C.C. Evans, MD¹, A. Petersen, BA², E.N. Meier, MS², J.E. Buick, MSc, PCP³, M. Schreiber, MD⁴, D. Kannas, RN, MSN⁵, M.A. Austin, BSc, MBBS⁶, and the Resuscitation Outcomes Consortium Investigators

A. Petersen: ajpete@u.washington.edu; E.N. Meier: emeier11@uw.edu; J.E. Buick: buickj@smh.ca; M. Schreiber: schreibm@ohsu.edu; D. Kannas: deloresk@uw.edu; M.A. Austin: maustin@toh.on.ca

¹Department of Emergency Medicine, Queen's University, Kingston, ON

²Department of Biostatistics, University of Washington, Seattle, WA

³Rescu, Li Ka Shing Knowledge Institute, St. Michael's Hospital, University of Toronto, Toronto, ON

⁴Department of Surgery, Oregon Health and Science University, Portland OR

⁵Clinical Trials Center, University of Washington, Seattle, WA

⁶Department of Emergency Medicine, University of Ottawa, Ottawa, ON

Abstract

Background—Traumatic arrests have historically had poor survival rates. Identifying salvageable patients and ideal management is challenging. We aimed to: 1) Describe the management and outcomes of prehospital traumatic arrests; 2) Determine regional variation in survival; and 3) Identify Advanced Life Support (ALS) procedures associated with survival.

Methods—This was a secondary analysis of cases from the Resuscitation Outcomes Consortium Epistry-Trauma and Prospective Observational Prehospital and Hospital Registry for Trauma registries. Patients were included if they suffered a blunt or penetrating injury and received CPR. Logistic regression analyses were used to determine the association between ALS procedures and survival.

Results—We included 2300 patients who were predominately young (Epistry mean: 39 years, SD: 20 years; PROPHET mean: 40 years, SD: 19 years), males (79%), injured by blunt trauma (Epistry: 68%, PROPHET: 67%), and treated by ALS paramedics (Epistry: 93%, PROPHET: 98%). A total of 145 patients (6.3%) survived to hospital discharge. More patients with blunt

Corresponding author: Chris Evans, MD FRCPC, Department of Emergency Medicine, Queen's University, Kingston General Hospital, 76 Stuart Street, Kingston, Ontario, K7L 2V7, Tel: 613 548-2368, Fax: 613 548-1374, c.evans@queensu.ca.

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(Epistry 8.3%, PROPHET: 6.5%) vs. penetrating injuries (Epistry 4.6%, PROPHET: 2.7%) survived. Most survivors (81%) had vitals on EMS arrival. Rates of survival varied significantly between the 12 study sites ($p=0.048$) in the Epistry but not PROPHET ($p=0.14$) registries.

PROPHET patients who received a supraglottic airway insertion or intubation experienced decreased odds of survival (Adjusted ORs: 0.27, 95% CI: 0.08-0.93, and 0.37, 95% CI: 0.17-0.78, respectively) compared to those receiving bag-mask ventilation. No other procedures were associated with survival.

Conclusions—Survival from traumatic arrest may be higher than expected, particularly in blunt trauma and patients with vitals on EMS arrival. Although limited by confounding and statistical power, no ALS procedures were associated with an increased odds of survival.

Level of Evidence—Level IV, prognostic study

Keywords

cardiac arrest; prehospital; emergency medical services; resuscitation; intubation

Background

Traumatic cardiac arrest occurs when a severely injured patient ceases to produce spontaneous cardiac output. Survival rates from traumatic arrest have been poor, with approximately 2% of patients surviving to hospital discharge(1). However, more contemporary studies from diverse settings and locations including military experience(2), Australia(3), England(4), the United States(5), Spain(6), and a recent systematic review(7) report survival rates between 5-8%.

Although there has long been the recognition that certain patients suffering traumatic arrest are “salvageable” if the cause for their cardiac arrest is rapidly treated (such as those with airway obstruction, tension pneumothorax, cardiac tamponade, or hypovolemia), it is also recognized that many prehospital traumatic arrest patients are transferred to hospitals under a “lights and sirens” approach, and undergo futile and costly resuscitation efforts, including resuscitative thoracotomies(8, 9). Guidelines have been developed to identify patients for whom resuscitation efforts should be withheld or terminated in the field(1) and emergency department settings(8-10). Concurrently, narrative reviews proposing treatment algorithms for traumatic arrest patients have been published that emphasize the early treatment of reversible causes of arrest(11, 12) and selective use of resuscitative thoracotomy(8, 9).

The issue of identifying potentially salvageable traumatic arrest patients in the prehospital setting is complicated by the competing issues of regional variation in the prehospital management and transport practices of these patients. Approximately 50% of traumatic arrests occur in the prehospital setting(13, 14) and the optimal treatment strategy for these patients is not clear. Recent studies demonstrate wide regional variation in the use of prehospital advanced airways(13, 15), rates of transport following traumatic arrest(13), and overall rates of survival following severe injury(13). Although there is ongoing debate regarding the benefit of prehospital advanced life support interventions in trauma, one recent

study did find that such interventions were associated with decreased mortality in patients with signs of life at the scene of injury(16).

Given the variation in both reported survival rates and clinical management of traumatic arrest patients, we had three objectives: first, to describe the contemporary management and outcomes of prehospital traumatic arrest in a large, North American trauma patient arrest cohort; second, to determine if there was regional variation in the rate of survival following traumatic arrest; and third, to determine if any prehospital ALS procedure was associated with the likelihood of survival to hospital discharge.

Methods

Study Design

This study was a secondary analysis utilizing data from the Resuscitation Outcomes Consortium (ROC). Two different databases were used to capture trauma patients, ROC Epistry-Trauma and PROPHET (Prospective Observational Prehospital and Hospital Registry for Trauma).

Study Setting

The ROC trauma registries have been described in detail previously(15, 17, 18). These registries include severely injured patients cared for within nine EMS regions in the US (Alabama, Dallas-Ft. Worth, Iowa, Memphis, Milwaukee, Pittsburgh, Portland, San Diego, Seattle-King County) and three in Canada (Ottawa, Toronto, British Columbia). Overall, the regions are highly variable in location, size, geography, socioeconomic status, and EMS system configuration(17, 19). All patients with the inclusion criteria described below were included in the registry. Each site obtained REB/IRB approval for the ROC data registries and was granted waiver of consent due to minimal risk.

Selection of Participants

Subjects were selected from the ROC Epistry-Trauma registry (December 1, 2005 to October 26, 2007) and the PROPHET registry (January 1, 2010 to June 30, 2011). These intervals reflect the start and finish dates for each registry. The inclusion and exclusion criteria differed slightly between the two registries. Both registries enrolled patients who had out-of-hospital injury and were evaluated and treated by EMS personnel, in addition to meeting registry-specific criteria. For Epistry-Trauma, patients had to meet one or more the following: systolic blood pressure (SBP) ≥ 90 , respiratory rate <10 or >29 , Glasgow Coma Scale (GCS) ≥ 12 , intubated in the field, or died in the field. For PROPHET, patients had to meet one or more of the following: SBP ≥ 90 or GCS ≥ 8 prior to sedation or placement of an advanced airway with RSI. Additionally, PROPHET patients had to be transported to a Level I/II trauma center or die in the field or en route with the intention of transporting to a Level I/II trauma center. Lastly, patients were excluded from PROPHET if there was declaration of non-survivability without treatment by EMS personnel or if they were a case of hanging, drowning, primary burn, or blunt/penetrating injury with burn injury $>20\%$ of total body surface area.

There was not direct data capture of whether or not a patient had a traumatic arrest in either registry. Thus we defined traumatic arrest as having occurred if a patient was known to have received prehospital CPR by EMS providers. This includes patients who died on the scene and were not transported to the hospital. Patients were excluded from the study if they had unknown survival to discharge status or did not have a blunt or penetrating injury.

Variables

We noted basic demographic features, including age, gender, injury type (blunt vs. penetrating), injury mechanism (fall, motor vehicle collision, motorcycle collision, etc.), location of injury (street/highway, public building, etc.), ROC registry (Epistry-Trauma or PROPHET), and blinded study site.

The following prehospital interventions were considered as predictive variables in the regression model: ALS trained paramedic crew first on scene (vs. BLS crew first on scene), Supraglottic airway insertion, endotracheal intubation, needle thoracostomy, intravenous (IV) fluid administration, intraosseous (IO) fluid administration, and external hemorrhage control. These interventions were all dichotomous or categorical variables.

Outcomes

The primary outcome was survival to hospital discharge. The secondary outcome, neurologic status at discharge (measured within 72 hours of hospital discharge by Glasgow Outcome Scale(20) for patients with documented GCS < 15 and assumed good for patients with GCS of 15), was evaluated only in surviving patients from the PROPHET registry. Neurologic status at discharge was not documented in Epistry-Trauma. This outcome was determined by non-blinded data abstractors based on review of clinical documentation.

Statistical Analysis

Data were collected from the prehospital and in-hospital setting using dispatch, EMS, and hospital records based on Utstein data definitions(21). Standardized data collection forms were collated at each of the study sites and de-identified information was submitted via a secure, web-based server to a central coordinating center(17). Quality assurance mechanisms included EMS provider training, data range and consistency checks, site-specific mechanisms, and annual site visits(17).

We used descriptive statistics (means and standard deviations (SD) for continuous variables, frequencies and percentages for categorical variables) to assess the traumatic arrest cohort in terms of demographics, types and mechanisms of injury, location of injury, prehospital interventions, and outcomes. Chi-square and Fisher's exact tests were used to assess for associations between categorical exposure variables and survival outcomes. The primary outcome was described for: 1) the entire cohort 2) by type of injury, 3) by study site, and 4) by prehospital procedures received. Results are presented stratified by registry because of the differing enrollment periods and inclusion criteria for the Epistry and PROPHET registries.

We used multiple logistic regression to estimate the associations (adjusted odds ratios with 95% confidence intervals (CI)) between prehospital interventions and survival to hospital discharge. The *independent variables* in this model were the prehospital interventions and the *dependent variable* was the primary outcome (survival to hospital discharge). *Covariates* included in the model were patient age (as a continuous variable) and other possible confounding variables.

We identified *a priori* that the presence of vitals on EMS arrival, type of injury, and ROC study site could be *confounding variables*. “Vitals on EMS arrival” was defined as the known presence of any vital sign (heart rate, blood pressure, or respiratory rate) upon initial assessment by EMS providers. This was based on the first set of vitals recorded by EMS regardless of the time at which they were taken. Vital sign times were only recorded in PROPHET and for those patients with available times (57%), the time from arrival at patient side to taking the first set of vital signs has a median of 2 minutes (25th and 75th percentiles: 0 and 7 minutes). Initial vital signs are important predictors of survival following traumatic arrest and were used as a surrogate marker of injury severity(1, 5). Other markers of injury severity such as presenting cardiac rhythm or signs of life at the scene (such as reactive pupils) were not collected in either data registry.

Type of injury was identified as a confounding variable because it has previously been shown to be associated with outcome from traumatic arrest(1, 8, 22) and we felt this could influence whether EMS providers perform critical procedures or transport patients to the hospital. ROC study site was adjusted for as a way to control for unmeasured confounders at the research site level.

While we fit separate models for each registry, the variables included in the models were the same between registries with one exception. The prehospital intervention of needle thoracostomy was only included in the PROPHET model, as this data was not collected in Epistry.

Notably, all of the variables in our model were specified *a priori* to examining the data. However, we did originally consider the same model but with an interaction term between type of injury and each prehospital intervention to assess for differing associations between interventions and survival for those with penetrating versus blunt injuries. Here, we present the model without these interactions included. The variables included in the model, as well as the rates of missing data for each variable, are summarized in Appendix 1.

To retain power and reduce bias, we used multiple imputation(23) to handle the missing data. Twenty multiply imputed data sets were generated and analyzed separately using standard logistic regression. Then results from each of these models were combined using the results of Rubin (1987)(23) to properly account for the uncertainty inherent in imputing the missing data. All baseline variables (i.e. those listed in Table 1), variables included in the logistic regression model (i.e. those listed in Appendix 1), an indicator of whether the patient was an adult, and the outcome of survival were used in the imputation procedure to predict missing covariate values. We assessed model fit using the Hosmer-Lemeshow goodness-of-fit test. Likelihood ratio tests were performed for each of the prehospital interventions to test

the hypothesis that the odds of survival differed between those receiving and not receiving the intervention(24).

Additionally, a likelihood ratio test was used to test the hypothesis that the odds of survival following traumatic arrest vary with ROC study site. We compared the primary model to the reduced model that does not include adjustment for ROC site. An alpha level of 5% was used to determine statistical significance. All analyses were conducted using R version 3.0.2 and the R package mice(25).

Results

There were 13,291 patients enrolled in Epistry-Trauma and 6258 patients enrolled in PROPHET during the study period. Of these patients, 1412 (10%), and 1012 (16%) patients, respectively, received prehospital CPR. Out of those patients receiving CPR, 85 (6.0%) patients in Epistry-Trauma did not suffer a blunt or penetrating injury and were excluded. Of the remaining patients who suffered a blunt or penetrating trauma and received CPR, 35 from Epistry-Trauma and four from PROPHET were excluded because their discharge status was unknown (Figure 1).

Baseline characteristics of the traumatic arrest cohort, stratified by registry and survival status are presented in Table 1. The study population included 2300 traumatic arrest patients who were predominately young (Epistry mean: 39 years, SD: 20 years; PROPHET mean: 40 years, SD: 19 years), male (79%), and injured by blunt trauma (Epistry: 68%, PROPHET: 67%). The three most common injury mechanisms were motor vehicle collisions (Epistry: 28%, PROPHET: 24%), gun shot wounds (Epistry: 24%, PROPHET: 26%), and falls (Epistry: 14%, PROPHET: 15%). Most traumatic arrests occurred on streets and highways (Epistry: 55%, PROPHET: 56%), followed by the patient's home (Epistry: 25%, PROPHET: 28%), and other public property (store, bar, restaurant, etc.) (Epistry: 11%, PROPHET: 9%).

Outcomes following traumatic arrest are summarized in Tables 1 and 2.

Overall, 145 (6.3%) patients survived to hospital discharge following traumatic arrest. Survival rates were similar between Epistry and PROPHET patients (7.1% vs. 5.3%, $p = 0.082$). More patients in PROPHET (39%) than Epistry (25%) had vital signs initially present on EMS arrival ($p < 0.001$). Eighty-one percent of the surviving patients had vital signs on EMS arrival. Approximately 70% of patients were transported and admitted to an ED with a minority of patients having a pulse present at ED admission. Amongst patients with a pulse present at ED admission, rates of survival were 26% (Epistry) and 22% (PROPHET). In comparison only 7.0% (Epistry) and 1.7% (PROPHET) who were receiving CPR at ED admission survived to hospital discharge.

When stratified by the presence or absence of vital signs upon EMS arrival, rates of survival were 23% (95% CI: 19-28%) and 1.8% (95% CI: 1.1-3.0%), respectively, in Epistry and 11% (95% CI: 8.2-15%) and 1.6% (95% CI: 0.83-3.1%), respectively, in PROPHET. Traumatic arrest patients who suffered a fall were the most likely to survive to discharge (11%), whereas those suffering one or more gun shot wounds were the least likely (2.1%) (Table 1). Overall, patients suffering blunt traumatic arrest had higher rates of survival

(Epistry 8.3%, PROPHET: 6.5%) than those suffering traumatic arrest from penetrating mechanisms (Epistry 4.6%, PROPHET: 2.7%). Although the absolute number of survivors with a documented neurologic outcome within 72 hours of hospital discharge was small, there were survivors in both the blunt and penetrating traumatic arrest cohorts who made a good neurologic recovery (41% for blunt and 89% for penetrating, Table 2).

Across ROC sites, overall survival following traumatic arrest ranged from 2.9% (95% CI: 0.95-7.8%) to 14% (95% CI: 8.2-24%) (Figure 2). A likelihood ratio test provided evidence that the odds of survival following traumatic arrest differed among ROC study sites in the Epistry ($p=0.048$) but not PROPHET registry ($p=0.14$).

The prevalence of prehospital procedures and their association with survival following traumatic arrest is presented in Table 3 and Table 4. Overall, 93% of patients in Epistry and 98% of patients in PROPHET were treated by ALS trained paramedics. ALS trained crews were first on scene in 43% of Epistry cases and 53% of PROPHET cases. The median scene time was 17 minutes in both registries (Epistry 25th and 75th percentiles: 12 and 24, PROPHET 25th and 75th percentiles: 11 and 24 minutes). The median transport time was 8 minutes for Epistry (25th and 75th percentiles: 5 and 13 minutes) and 10 minutes for PROPHET (25th and 75th percentiles: 6 and 15 minutes). The majority of traumatic arrests received either endotracheal intubation (Epistry: 61%, PROPHET: 51%) or bag-mask ventilation (Epistry: 32%, PROPHET: 31%), as well as intravenous fluid resuscitation (Epistry: 57%, PROPHET: 48%). The remainder of the procedures were performed infrequently. PROPHET patients who received a supraglottic airway insertion or intubation experienced decreased odds of survival (Adjusted ORs: 0.27, 95% CI: 0.08-0.93, and 0.37, 95% CI: 0.17-0.78, respectively) compared to those receiving bag-mask ventilation. No other procedures were associated with either increased or decreased odds of survival following traumatic arrest in either registry (Table 4).

There was a lack of fit identified in the Epistry model ($p=0.03$), but not the PROPHET model ($p=0.10$). As a sensitivity analysis, both models were refit with age modeled as a linear spline with a knot at 45 years (compared to linearly as in the original model). The adjusted odds ratios and confidence intervals from these models were very similar to those shown in Table 4.

Discussion

In this large, multi-center, prospective study involving two large trauma registries, we found a contemporary rate of survival from traumatic arrest of approximately 6% (Epistry: 7.1%, PROPHET: 5.3%). This is very similar to the 7.2% rate of survival reported in a recent systematic review that included over 5,000 children and adults with traumatic arrest(7), and higher than the 2% rate of survival reported in a recent position statement on withholding and terminating resuscitation for prehospital traumatic arrest(1).

There are several explanations for the higher than expected rate of survival in the traumatic arrests in our study. The first relates to our definition of cardiac arrest being based on the performance of prehospital CPR by EMS providers. Patients who were pulseless on EMS

arrival or who lost a pulse in the presence of EMS would have received CPR and a tentative diagnosis of cardiac arrest. As noted previously, we acknowledge that that some of these patients could have simply been profoundly hypotensive due to very low cardiac output state but not truly arrested(26). Although our definition of traumatic arrest is consistent with other studies on the topic(27-29), we acknowledge that using more specific criteria (such as absence of all signs of life(29,30), or specific cardiac arrest rhythm), had they been available, may have led us to observe a slightly lower survival rate. However, our data are consistent with recent data from the American College of Surgeons Trauma Quality Improvement Program (ACS TQIP), indicating a 10% rate of survival for patients suffering a prehospital traumatic arrest, when defined as “prehospital cardiac arrest with resuscitative effort by healthcare provider”(29).

The vast majority (Epistry: 80%, PROPHET: 81%) of surviving traumatic arrest patients had their arrest witnessed by paramedics as indicated by at least one vital sign (heart rate, blood pressure, or respiratory rate) being present on EMS arrival. EMS-witnessed loss of vital signs is a well-established indicator of prognosis following the onset of traumatic arrest(1, 5). The ROC trauma registries did not include data on when exactly patients lost vital signs or when CPR was initiated in the prehospital setting, so the proximity to the hospital when patients lost their vital signs remains unknown. The higher than expected rate of survival could then be partially explained by a greater proportion of EMS-witnessed traumatic arrests.

All of the patients in this study were cared for in well-developed regional trauma systems that included advanced prehospital care practices as well as established hospital-based trauma centers. Ninety-five percent of traumatic arrest patients were treated by ALS trained paramedics with approximately half of the patients receiving intubation and fluid resuscitation prior to hospital arrival. Although we did not find any ALS interventions were associated with increased odds of a traumatic arrest patient surviving to hospital discharge, the higher survival rates than previously reported may have been associated with unmeasured aspects of ALS care, such as decision-making around when to attempt procedures vs. rapidly transfer to a trauma-specific hospital.

An unexpected finding, consistent between registries, was the more favorable survival rate from blunt compared to penetrating traumatic arrest. This contradicts a recent systematic review that reported lower rates of survival following blunt trauma (3.3%)(7). Another case series of 909 trauma patients requiring prehospital CPR found a 7.9% and 3.3% survival rate for penetrating and blunt trauma, respectively(4). In that same report, some patients were also classified as having suffered traumatic arrest from asphyxiation (conflagration, drowning, hanging, etc.) or a “medical” event plus trauma and had survival rates of 30% and 11%, respectively(4). In our study, we excluded patients with cardiac arrest following hanging, drowning or significant burns, so we believe our patient population is quite comparable to blunt and penetrating trauma populations reported in previous reviews.

In the present study, the performance of either supraglottic airway insertion or endotracheal intubation was significantly associated with decreased odds of surviving to hospital discharge in PROPHET. The negative association between receiving an advanced airway and

survival could be explained by “confounding by indication”(32, 33). Specifically, patients who are selected to receive bag-mask ventilation rather than either endotracheal intubation or a supraglottic airway may have a more favorable prognosis than those who receive advanced airways in the field. In this potential scenario, the relationship between the treatment being studied (advanced airway) and the outcome (survival) is biased by the uncontrolled confounding effect of injury severity.

A recent meta-analysis of advanced airway management for out-of-hospital cardiac arrest patients (mostly medical arrests) found a similar association between advanced airway placement and survival, but similarly cautioned the interpretation in light of the potential for confounding by indication(33). Previous studies of advanced airway management for the resuscitation of traumatic arrest victims have been small, retrospective studies and similarly found no evidence of benefit(34, 35). Only one randomized controlled trial has been examined the benefit of prehospital intubation for trauma patients(36). That study focused on rapid sequence intubation of brain injured patients rather than arrested trauma patients, and found improved functional outcomes at six months in the intubation group(36).

This study suggests that outcomes following severe trauma vary regionally, at least amongst ROC sites participating in the Epistry registry(13, 37-39). Previous work involving ROC study sites has identified regional variation in withholding and/or terminating prehospital resuscitation efforts for traumatic arrest patients(13) and this could contribute to some of the variation in survival rates. Additionally, there is also considerable variation in the use of ALS procedures such as intubation between sites(15), which could further contribute to the differences observed. Finally, although we were not able to explore the specific factors in the current study, there are likely hospital-specific resuscitation practices that contribute to the variation in survival following traumatic arrest.

This study has a few limitations that warrant discussion. First, patients were not randomized to receive prehospital interventions. Paramedics selected which patients to provide interventions to based on clinical judgment and existing protocols. As discussed previously, selection bias, in the form of confounding by indication is a recognized limitation of this study design. The lack of randomization in this study also means there is possibly an imbalance in confounding variables between patient groups either receiving or not receiving an intervention. Although we did attempt to adjust for known confounders using multiple logistic regression, we were not able to include all variables that affect the prognosis after traumatic arrest or that might influence paramedics' decision-making around procedure use in this setting. Residual confounding, especially regarding injury severity, is thus possible.

External generalizability is another limitation of our study. Patients were predominately cared for by ALS paramedics in large, well-developed EMS systems. Although these EMS systems include a population of almost 24 million people (nearly 10% of the North American population)(40) and span diverse geographic and socioeconomic spectrums, rates of survival or associations between procedures and outcomes may not be applicable to EMS systems with different structures or capabilities (physician-led services(11, 12), for instance).

Finally, despite our large sample size from these two registries, the precision of our effect estimates for many procedures was low due to the poor overall rate of survival from traumatic arrest. For some procedures (like hemorrhage control, or IV and IO fluid administration), it is probable that we did not have sufficient power to demonstrate a statistically significant association.

These limitations are balanced by strengths of the study that include the largest population of pediatric and adult traumatic arrest patients in the literature, prospective data collection, a range of large, diverse EMS systems, high rates of data completeness, and the reporting of neurologic outcomes for many survivors of traumatic arrest.

In conclusion, we have found that contemporary rates of survival from traumatic arrest may be more favorable than historically reported, especially in the blunt trauma population. Patients suffering witnessed traumatic arrests, regardless of type of injury, deserve aggressive resuscitation efforts. Our findings that no prehospital procedure is associated with increased odds of surviving traumatic arrest are limited by the potential for confounding by indication and lack of statistical power for some procedures. Future studies on traumatic arrest patients should include detailed baseline prognostic information on patients to minimize confounding, focus on the indications for and outcomes associated with procedures targeting reversible causes of traumatic arrest (e.g. fluid resuscitation, needle decompression), and characterize within-hospital resuscitative care practices associated with survival.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Study population.

Figure 2.

The percentage (with 95% confidence intervals) of cardiac arrest patients surviving to hospital discharge by site and data registry. Enrollment numbers for Epistry-Trauma (top number) and PROPHET (bottom number) are given for each site.

Table 1
Baseline characteristics of traumatic arrest cohort by registry^{1,2}

	Epistery		PROPHET		p value
	Survivors (n = 92)	Non-survivors (n = 1200)	Survivors (n = 53)	Non-survivors (n = 955)	
Gender: male	73 (80%)	939 (78%)	42 (79%)	755 (79%)	1
Age (years)					0.2
<5	3 (3.4%)	30 (2.7%)	2 (3.8%)	21 (2.3%)	
5-9	0 (0%)	12 (1.1%)	0 (0%)	5 (0.54%)	
10-19	12 (13%)	109 (9.6%)	7 (13%)	72 (7.8%)	
20-39	40 (45%)	469 (41%)	17 (33%)	388 (42%)	
40-59	21 (24%)	322 (28%)	21 (40%)	276 (30%)	
60-79	12 (13%)	143 (13%)	5 (9.6%)	123 (13%)	
80	1 (1.1%)	46 (4.1%)	0 (0%)	37 (4%)	
Mechanism of injury ³					
Fall	21 (23%)	158 (13%)	15 (28%)	134 (14%)	0.008
MVC - occupant	30 (33%)	326 (27%)	14 (26%)	226 (24%)	0.77
MVC - motorcycle	3 (3.3%)	62 (5.2%)	2 (3.8%)	59 (6.2%)	0.77
MVC - pedestrian	4 (4.3%)	138 (12%)	2 (3.8%)	118 (12%)	0.097
Gun shot wound	8 (8.7%)	303 (25%)	4 (7.5%)	259 (27%)	0.003
Stab	11 (12%)	82 (6.8%)	5 (9.4%)	64 (6.7%)	0.402
Other	14 (15%)	119 (9.9%)	11 (21%)	126 (13%)	0.175
Injury type: blunt	73 (79%)	802 (67%)	44 (83%)	628 (66%)	0.014
Location of injury					0.021
Street/highway	44 (48%)	670 (56%)	28 (53%)	537 (56%)	
Public building	2 (2.2%)	33 (2.8%)	1 (1.9%)	12 (1.3%)	
Place of recreation	1 (1.1%)	24 (2%)	3 (5.7%)	15 (1.6%)	
Industrial place	1 (1.1%)	34 (2.8%)	0 (0%)	23 (2.4%)	
Home residence	28 (30%)	289 (24%)	10 (19%)	269 (28%)	
Other public	11 (12%)	130 (11%)	8 (15%)	85 (8.9%)	
Other private	5 (5.4%)	20 (1.7%)	3 (5.7%)	14 (1.5%)	

PROPHEt				
Epistry				
Survivors (n = 92)	Non-survivors (n = 1200)	p value	Survivors (n = 53)	Non-survivors (n = 955)
Vital signs present on EMS arrival				
74 (80%)	245 (20%)	<0.001	43 (81%)	348 (36%)
				p value
				<0.001

¹ Summaries are n (%) where percent is of non-missing. Note that p values are presented for descriptive purposes only and no correction for multiple testing has been made.

² Abbreviations used: motor vehicle collision (MVC) and emergency medical service (EMS).

³ Patients may have more than one mechanism of injury.

Table 2

Outcomes in traumatic arrest patients by injury type and registry¹

	Epistery		PROPHET		p value
	Blunt (n = 875)	Penetrating (n = 417)	Blunt (n = 672)	Penetrating (n = 336)	
Prehospital status					<0.001
Prehospital declaration of death without ED admission	237 (27%)	128 (31%)	232 (35%)	79 (24%)	0.2
Transported and admitted to ED	638 (73%)	289 (69%)	440 (65%)	257 (76%)	
Patient status at ED arrival of those admitted					<0.001
Pulse present ²	81 (21%)	25 (14%)	147 (34%)	52 (21%)	0.054
Ongoing resuscitation ²	313 (79%)	160 (86%)	285 (66%)	198 (79%)	
Unknown ³	20 (3.1%)	12 (4.2%)	8 (1.8%)	7 (2.7%)	
Not collected ³	224 (35%)	92 (32%)	0 (0%)	0 (0%)	
Survival to hospital discharge	73 (8.3%)	19 (4.6%)	44 (6.5%)	9 (2.7%)	0.014
Neurologic status of survivors ⁴					0.11
Vegetative state			3 (7.7%)	0 (0%)	
Severely disabled			14 (36%)	1 (11%)	
Moderately disabled			6 (15%)	0 (0%)	
Good recovery			16 (41%)	8 (89%)	

¹ Abbreviation used: emergency department (ED). Note that p values are presented for descriptive purposes only and no correction for multiple testing has been made.

² Summaries are n (%) where percent is of those admitted to the ED with known status of pulse present or ongoing resuscitation.

³ Summaries are n (%) where percent is of those admitted to the ED. Not collected refers to the period at the beginning of Epistery during which this information was not collected.

⁴ Summaries are n (%) where percent is of survivors with non-missing status. This was only measured in PROPHET. Of the 53 PROPHET patients who survived, 5 (8%) blunt injury patients were missing this outcome.

Table 3
Prehospital procedures and outcomes in traumatic arrest patients by registry¹

Intervention	Epistery		PROPHET	
	Patients receiving n (%) ²	Survival to hospital discharge n (%)	Patients receiving n (%) ²	Survival to hospital discharge n (%)
EMS training of first rig: ALS				
Yes	546 (43%)	45 (8.2%)	526 (53%)	27 (5.1%)
No	712 (57%)	40 (5.6%)	461 (47%)	25 (5.4%)
Airway intervention				
Bag-mask ventilation only	401 (32%)	24 (6%)	314 (31%)	22 (7%)
Supraglottic airway ³	92 (7.3%)	2 (2.2%)	181 (18%)	4 (2.2%)
Endotracheal intubation	769 (61%)	46 (6%)	513 (51%)	27 (5.3%)
Needle thoracostomy ⁴				
Yes			138 (14%)	6 (4.3%)
No			870 (86%)	47 (5.4%)
Hemorrhage control				
Yes	173 (15%)	12 (6.9%)	163 (16%)	11 (6.7%)
No	994 (85%)	56 (5.6%)	845 (84%)	42 (5%)
Intravenous fluid administration				
Yes	735 (57%)	66 (9%)	471 (48%)	32 (6.8%)
No	557 (43%)	26 (4.7%)	504 (52%)	18 (3.6%)
Intraosseous fluid administration				
Yes	75 (5.8%)	2 (2.7%)	138 (14%)	4 (2.9%)
No	1217 (94%)	90 (7.4%)	847 (86%)	49 (5.8%)

¹ Abbreviation used: emergency medical service (EMS). Note that p values are presented for descriptive purposes only and no correction for multiple testing has been made.

² Percent is of non-missing.

³ With no endotracheal intubation.

⁴ This was only collected for PROPHET patients.

Table 4
Multivariable logistic regression models of survival to hospital discharge¹

Intervention	Epistery		PROPHET	
	Adjusted OR (95% CI) ²	p value	Adjusted OR (95% CI) ²	p value
EMS training of first rig: ALS	1.09 (0.54 - 2.22)		0.99 (0.44 - 2.21)	0.98
Airway intervention		0.81		0.015
Bag-mask ventilation only	Reference	0.25	Reference	
Supraglottic airway ³	0.35 (0.08 - 1.55)		0.27 (0.08 - 0.93)	
Endotracheal intubation	0.70 (0.38 - 1.31)		0.37 (0.17 - 0.78)	
Needle thoracostomy ⁴			0.68 (0.26 - 1.79)	0.42
Hemorrhage control	0.76 (0.37 - 1.59)	0.47	1.10 (0.50 - 2.44)	0.82
Intravenous fluid administration	1.40 (0.78 - 2.49)	0.25	1.41 (0.66 - 3.01)	0.37
Intraosseous fluid administration	0.32 (0.07 - 1.52)	0.11	0.44 (0.14 - 1.37)	0.13

¹ Abbreviations used: odds ratio (OR), confidence interval (CI), and emergency medical service (EMS).

² Adjustment includes listed interventions, as well as ROC study site, age, presence of any vital signs at EMS arrival, and type of injury. Details are provided in Appendix 1.

³ With no endotracheal intubation.

⁴ This was only collected for PROPHET patients.