Prehospital Procedures Before Emergency Department Thoracotomy: "Scoop and Run" Saves Lives

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Background: The role of prehospital healthcare personnel in the management of acutely injured patients is rapidly evolving. However, the performance of prehospital procedures on unstable, penetrating trauma patients remains controversial. The objective of this study is to test the hypothesis that survival of most critically injured penetrating trauma patients requiring emergency department thoracotomy (EDT) would be improved if procedures were restricted until arrival to the trauma bay.

Methods: A retrospective chart review on 180 consecutive penetrating trauma patients (2000–2005) who underwent EDT was performed. Patients were divided into two groups by mode of transportation and compared on the basis of demographics, clinical and physiologic parameters, prehospital procedures, and survival.

Results: Eighty-eight patients arrived by emergency medical services (EMS), and 92 were brought by police or private vehicle. Groups were similar with respect to demographics. Seven of 88 (8.0%) EMS-transported patients survived until hospital discharge, and 16 of 92 (17.4%) survived after police or private transportation. Overall, 137 prehospital procedures were performed in 78 of 88 (88.6%) EMS-transported patients, but no police- or private-transported patient underwent field procedures. Multivariate logistic regression analyses identified prehospital procedures as the sole independent predictor of mortality. For each procedure, patients were 2.63 times more likely to die before hospital discharge (OR = 0.38, 95% CI = 0.18–0.79, $p = 0.0096$).

Conclusions: The performance of prehospital procedures in critical, penetrating trauma victims had a negative impact on survival after EDT in our study population. Paramedics should adhere to a minimal or "scoop and run" approach to prehospital transportation in this setting.

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Since the 1980s when paramedics began to implement Advanced Life Support measures in the prehospital setting, the extent and magnitude of these field interventions performed by emergency medical services (EMS) personnel has remained controversial. Although evidence is quite clear that prehospital procedures such as endotracheal intubation and intravenous (IV) line placement benefit rural blunt trauma victims with prolonged transportation time,[1–14] data are less convincing for critical patients with penetrating injuries in the urban setting who are rapidly transported to the hospital.[15–21] We theorized that prehospital healthcare personnel are performing more procedures in the field today, thereby delaying arrival to the hospital and the administration of definitive care—namely emergency department thoracotomy (EDT) and surgery. The objective of this study was to test the hypothesis that survival of most critically injured penetrating trauma patients requiring EDT would be improved if procedures were restricted until arrival to the trauma bay. Additionally, we sought to identify any risk factors that would adversely impact patient survival.

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METHODS

Temple University Hospital is a Level I trauma center located within the inner city of Philadelphia. Most trauma patients are brought from within a 2-mile radius of the hospital by ambulance, police, or private vehicle. EMS personnel perform all prehospital procedures in Philadelphia, and police and private citizens perform none.

Emergency department thoracotomies were performed immediately upon arrival to the emergency department by the trauma surgery team consisting of an attending trauma surgeon, a senior or chief resident (postgraduate year [PGY] 4 or 5), a junior resident (PGY 2 or 3), and an emergency medicine resident (PGY 1 or 3). The trauma senior or chief resident performed most of these procedures under the supervision of the attending trauma surgeon.

Indications for EDT adhered to the guidelines set forth by the American College of Surgeons Committee on Trauma.[22] Patients with penetrating injuries who arrived to the ED in extremis without prolonged "down time" underwent EDT. All patients with penetrating injuries who lost signs of life (SOL) either in route or in hospital underwent EDT. SOL were defined as any of the following: pupillary response, spontaneous ventilatory effort, palpable carotid pulse, measurable or palpable blood pressure, extremity movement, or cardiac electrical activity. Injury locations or penetrating wounding mechanisms were not taken into account in the decision to perform an EDT.

The initial incision was a left anterolateral thoracotomy in all cases. Patients with bilateral thoracic wounds underwent left anterolateral thoracotomy and simultaneous placement of a right thoracostomy tube. If no significant injury was discovered in the left hemithorax, the incision was extended transversely across the sternum to create bilateral thoracotomies. In each patient, the pericardium was opened and open cardiac massage instituted after inspection of the heart. The aorta was then cross-clamped at the level of the distal descending thoracic aorta. Patients with perfusing rhythms were brought emergently to the operating room (OR) for definitive repair.

After institutional review board approval, a retrospective chart review revealed 180 patients with penetrating injuries who underwent EDT at Temple University Hospital between January 2000 and December 2005. "Urgent resuscitative" thoracotomies and OR thoracotomies were not included in the analysis. Because EMS personnel perform all procedures in our prehospital health care system, patients were divided into two groups on the basis of prehospital transportation and compared with respect to age, sex, year of injury, injury mechanism, injury classification (cardiac, noncardiac thoracic, abdominal, extremity), presence of SOL in the field and ED, initial cardiac rhythm, the presence of obtainable vital signs, the performance of prehospital cardiopulmonary resuscitation (CPR), initial Glasgow Coma Score, Injury Severity Score (ISS) (calculated using Abbreviated Injury Scores for head, face, chest, abdomen, extremities, and external; the 3 most severely injured body region scores were each squared [x^2] and then summed to yield the ISS), type of transport, number of prehospital procedures, survival to the operating room, and survival to discharge. The two study groups were defined solely by method of prehospital transportation—patients brought by ambulance (EMS) were compared with patients brought by police or private vehicle. All available EMS trip sheets were obtained from ambulance-transported patients. Elapsed prehospital times from police- or private-transported patients were either unreliable or unavailable and, therefore, not used in further study analysis. Descriptive statistics and post hoc analysis of all numeric variables were applied (χ^2 test, Mann–Whitney rank sum test) before a univariate and multivariate analysis was performed. Odds ratios (ORs) with 95% confidence intervals (CIs) for survival were calculated for each measured variable. A p value less than 0.05 was considered statistically significant.

RESULTS

Patients were compared on the basis of prehospital transport (Table 1). Eighty-eight (48.9%) patients were transported by EMS and 92 (51.1%) by either police (77) or private (15) transport. Patients brought by EMS were statistically similar to police- or private vehicle-transported patients with respect to age, sex, year of injury, mechanism, and injury class (primary injury location). Physiologic criteria were also assessed for both groups. Although the initial recorded cardiac rhythm, presence of vital signs, and Glasgow Coma Score were similar in both groups, EMS transported patients more often exhibited SOL in the field (EMS, 73 of 88 [83%] vs. police/private, 63 of 92 [69%], $p = 0.037$) and had a lower overall ISS (EMS, 34.56 $\pm$ 25.38 vs. police/private, 43.91 $\pm$ 27.60, $p = 0.039$). Moreover, EMS transported patients more often lost SOL between the field and arrival to the ED (EMS, 16 of 73 [21.9%] vs. police/private, 5 of 63 [7.9%], $p = 0.044$) despite more aggressive attempts at in-field CPR (EMS, 60 of 88 [68.2%] vs. police/private, 14 of 92 [15.2%], $p \leq 0.001$) and resuscitation (EMS, 137 prehospital procedures vs. police/private, 0 prehospital procedures) by paramedics. The mean prehospital time for EMS-transported patients was 19.0 $\pm$ 9.0 (range, 5–54) minutes. Overall, 17 cervical collars, 59 IV lines, and 61 endotracheal tubes were placed by paramedics in the prehospital setting.

Despite more frequent SOL in the field and lower overall ISS in EMS-transported patients, only 7 of 88 (8.0%) patients of this group survived until hospital discharge, and 16 of 92 (17.4%) survived after prehospital transportation by either police or private vehicle (Fig. 1). Of seven survivors after EMS transport, three underwent no prehospital procedures, three underwent one procedure, and one underwent three prehospital procedures. The single patient who survived until hospital discharge after EMS transport with three prehospital procedures was a multiple-gunshot-wound victim who presented hemodynamically normal and neurologically intact. However, a nonfunctioning thoracostomy tube and positive pressure ventilation after intubation caused a tension pneumothorax and hemodynamic collapse. An EDT was then performed and hemodynamic stability returned when the unrecognized pneumothorax was relieved by the thoracotomy incision.

Most patients transported by EMS underwent prehospital procedures (78 of 88 [88.6%]). No police- or private vehicle-transported patient underwent a field procedure. When the entire study population (n = 180) was analyzed on the basis of prehospital procedures, 78 patients (78 EMS, 0 police/private) underwent field procedures and 4 (5.1%) survived until hospital discharge, and 102 patients (10 EMS, 92 police/private) underwent no prehospital procedure and 19 (18.6%) survived (Fig. 2). When percent survival was plotted against the number of procedures per patient, an inverse relationship was noted (Fig. 3). Although prehospital procedures were common throughout the entire study period, a recent trend toward a greater number of field interventions is apparent. EMS performed 1.44 $\pm$ 0.98 (mean $\pm$ SD) procedures per patient during the 2000 to 2002 period but 2.08 $\pm$ 1.03 procedures during 2003 to 2005 ($p = 0.006$). Overall, EDT was also relatively more common later in the study period. Eighty-nine of the 180 patients (49.4%) underwent EDT during 2004 to 2005. This recent surge in EDT use, however,

Table 1 **Demographics and Clinical Characteristics: EMS vs. Police/Private Transport**

Characteristic	EMS Transport (n = 88)	Police/Private Transport (n = 92)	p
Age	31.17 ± 12.04	27.84 ± 8.33	0.224
Sex (male)	85	88	0.952
Year			
2000 vs. yrs 2001–2005	14	13	0.900
2001 vs. yrs 2000, 2002–2005	13	5	0.066
2002 vs. yrs 2000–2001, 2003–2005	9	13	0.568
2003 vs. yrs 2000–2002, 2004–2005	11	13	0.918
2004 vs. yrs 2000–2003, 2005	14	23	0.185
2005 vs. yrs 2001–2004	27	25	0.723
Mechanism			
Single gunshot wound vs. all others	31	31	0.908
Multiple GSWs vs. all others	47	53	0.627
Single stab wound vs. all others	6	4	0.677
Multiple stab wounds vs. all others	4	4	0.779
Injury class			
Cardiac	28	42	0.080
Noncardiac thoracic	36	28	0.190
Abdominal	19	18	0.879
Extremity	5	4	0.945
Field signs of life (SOL)	73	63	0.037*
ED SOL	57	58	0.931
Loss of SOL (field to ED)	16	5	0.044*
Initial cardiac rhythm			
Asystole	31	32	0.925
Agonal	5	8	0.764
PEA	36	28	0.190
Sinus tachycardia	11	15	0.607
Sinus bradycardia	0	3	0.260
Sinus	5	6	0.939
Obtainable vital signs	24	31	0.439
CPR in field	60	14	<0.001*
GCS	4.35 ± 3.54	4.41 ± 3.36	0.865
Injury Severity Score	34.56 ± 25.38	43.91 ± 27.60	0.039*
Method of transportation			
EMS	88	0	
Police	0	77	
Private vehicle	0	15	
Prehospital procedures			
Cervical collar	17	0	
IV line placements	59	0	
Endotracheal tubes	61	0	
Total	137	0	
Survival to OR	20	32	0.105
Survival to D/C	7	16	0.094

Patients were compared on the basis of prehospital transportation and were similar with respect to age, sex, year of injury, mechanism, injury class, initial recorded cardiac rhythm, presence of vital signs, and GCS. Despite less often exhibiting SOL in the field and greater ISS, 16 patients from the police/private transport group survived until hospital discharge. Prehospital CPR was used primarily by EMS personnel.

GSW, gunshot wound; GCS, Glasgow Coma Score; PEA, pulseless electrical activity; D/C, hospital discharge.

* $p < 0.05$ denotes statistical significance.

has mirrored a recent growth in penetrating injuries seen in our trauma center (Fig. 4).

Univariate (Table 2) and multivariate (Table 3) logistic regression analyses were performed to identify all independent predictors of survival until definitive operation and hospital discharge. Overall prehospital procedures (OR = 0.59, 95% CI = 0.38–0.92, p = 0.019), in field cervical collar placement (OR = 0.007, 95% CI <0.001–0.44, p = 0.019), endotracheal intubation (OR <0.001, 95% CI <0.001–0.05, p = 0.0005), increase in ISS (OR = 0.97, 95% CI = 0.95–0.99, p = 0.040), and year of injury (OR = 0.63, 95% CI = 0.47–0.84, p = 0.0016) each, independently, had a negative impact on survival until definitive operation, whereas sinus tachycardia (OR = 5.17, 95% CI = 1.04–25.60, p = 0.044) was predictive of survival until operation. Although both mode of transportation and prehospital time were included in the univariate model, neither was found to significantly impact survival. However, the performance of prehospital pro-

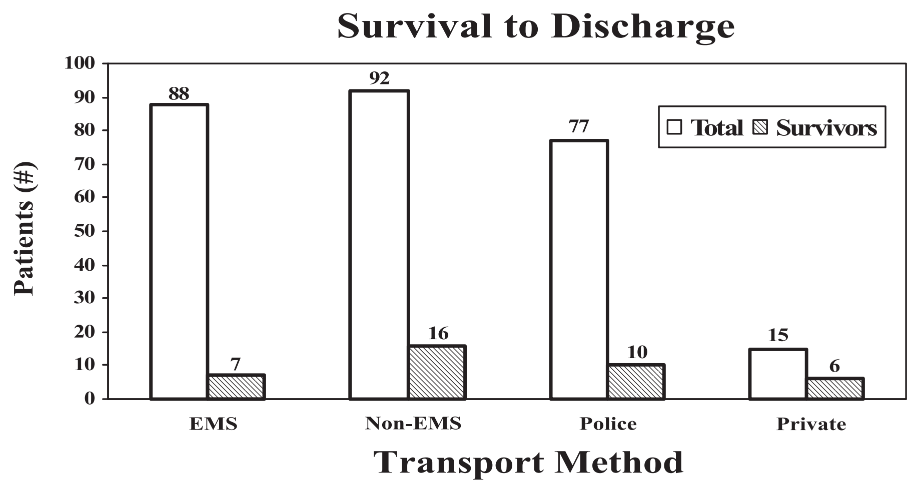

Fig. 1. *Eighty-eight patients were transported by EMS and 92 by non-EMS personnel (77 by police and 15 by private vehicle). Seven (8%) and 16 (17%) patients survived until time of hospital discharge, respectively.*

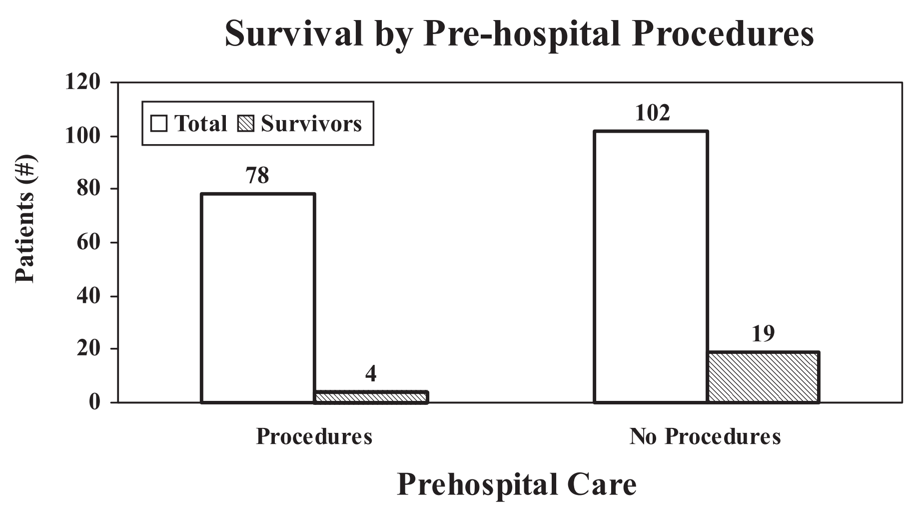

Fig. 2. *Of the 180 patients in this study, 78 underwent prehospital procedures and 102 received none. Respective survival was 4 (5.1%) and 19 (18.6%) patients.*

cedures that often accompanied EMS transport did affect survival. Of all measured clinical characteristics, the only independent risk factor found to adversely influence survival before hospital discharge was the performance of prehospital procedures. For each prehospital procedure performed, patients were 2.63 times less likely to survive until hospital discharge (OR = 0.38, 95% CI = 0.18–0.79, $p = 0.0096$). When cervical collar placement was not considered a prehospital procedure, results remained equivalent. For each IV line or endotracheal intubation in the field, patients were 2.71 times less likely to survive (OR = 0.37, 95% CI = 0.17–0.82, $p = 0.014$). Sinus tachycardia was the only independent predictor of survival until hospital discharge (OR = 7.71, 95% CI = 1.60–37.12, $p = 0.011$).

DISCUSSION

The role of the paramedic has expanded since the 1980s to include both Basic Life Support and Advanced Life Support.[2,5,12–14,23] Although this development has been advantageous in certain settings, our results suggest that the performance of prehospital procedures in critically injured patients with penetrating trauma requiring EDT negatively impacts survival. Our data indicate that, today, EMS personnel are more aggressive to perform prehospital procedures than they were previously. By assessing mode of transportation and prehospital procedures, we have shown that the performance of in-field procedures, including the placement of IV lines, cervical collars, or endotracheal tubes, provides no survival benefit to the critically injured penetrating trauma patient.

The need for EMS personnel to perform endotracheal intubations, place IV lines, and administer medications to injured patients resulted from early data extrapolated from cardiac arrest victims. Several reports[6,7,9] documented in-field endotracheal intubation success rates at 90% to 96% with few complications. Further support for these practices came from literature in rural, blunt, and head-injured

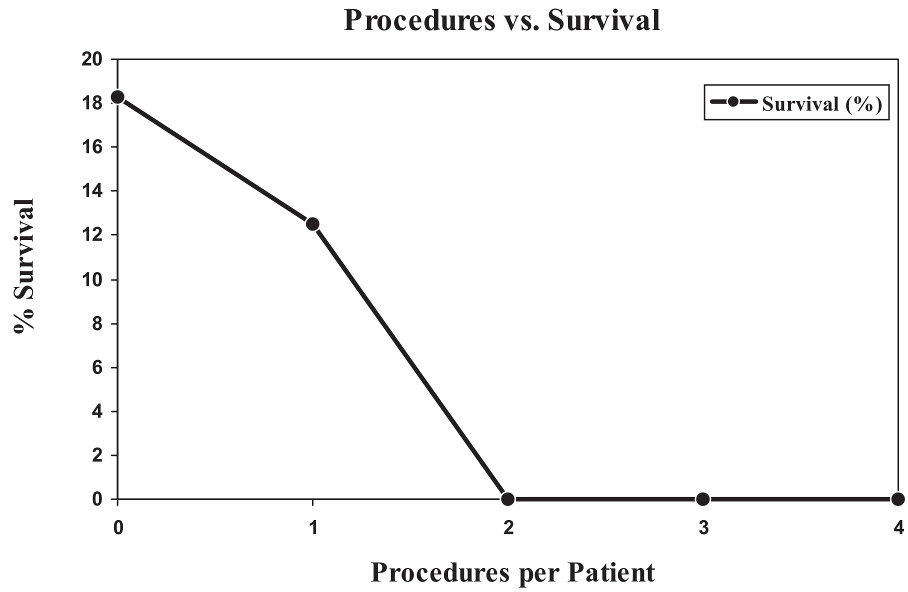

Fig. 3. *The sole independent risk factor for mortality before hospital discharge was performance of prehospital procedures. This graph demonstrates an inverse relationship when the number of in-field procedures per patient is plotted against percent survival. Data from the single patient who underwent EDT when an errant thoracostomy tube caused a tension pneumothorax and hemodynamic collapse was not included in this figure.*

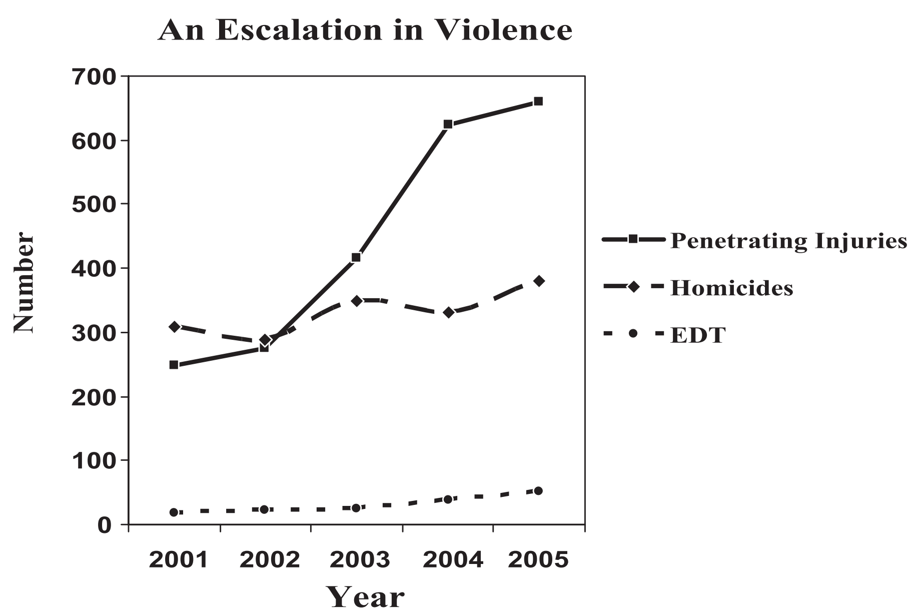

Fig. 4. *EDTs were performed more frequently during recent years. Although the incidence of EDT has been steadily increasing since 2001 (18 EDT in 2001 vs. 52 EDT in 2005), use of this salvage technique has paralleled a troubling trend of an escalating number of penetrating injuries presenting to our urban trauma center and a rising homicide rate in the city of Philadelphia.*

patients.[2–5,8–10,12–13] Although this evidence seems to justify the performance of prehospital procedures in rural patients with blunt head injuries with prolonged transport times,[1–14] the practice has not been substantiated in the urban penetrating trauma population with accessible and rapid transportation to Level I trauma centers.[15–21]

Although paramedics are highly effective in the performance of prehospital procedures, these procedures do not represent definitive care of the hypovolemic trauma patient with penetrating injuries requiring emergent transport to the hospital. Several reports have illustrated these points. In 1982, Gervin and Fischer[19] reported 13 patients with penetrating cardiac injuries and obtainable vital signs. Six of the 13 received "minimal" prehospital intervention. After a 9-minute transport time, five of these six survived. In the "maximal" intervention group, zero of seven survived after a

Table 2 Univariate Analysis

Parameter	Survival to OR			Survival to D/C		
	Odds Ratio	95% Confidence Intervals	p	Odds Ratio	95% Confidence Intervals	p
Age	0.99	0.96–1.02	0.531	1.01	0.97–1.05	0.666
Sex	1.90	0.41–8.79	0.413	2.90	0.53–15.88	0.221
Year	0.74	0.62–0.89	0.0015*	0.80	0.63–1.01	0.063
Mechanism	0.81	0.59–1.12	0.210	1.06	0.68–1.65	0.805
Class	1.57	1.09–2.25	0.015*	1.27	0.79–2.05	0.326
Field SOL	4.12	1.52–11.15	0.005*	8.29	1.09–63.40	0.042*
ED SOL	4.42	1.93–10.12	0.0005*	4.35	1.24–15.26	0.022*
Asystole	0.24	0.11–0.55	0.0008*	0.24	0.07–0.85	0.027*
Agonal	0.43	0.09–1.99	0.278	1.26	0.26–6.10	0.770
PEA	0.50	0.25–1.04	0.062	0.34	0.11–1.05	0.061
Sinus bradycardia	5.08	0.45–57.28	0.189	<0.001	<0.001–>999.99	0.986
Sinus tachycardia	12.71	4.71–34.26	<0.0001*	6.78	2.56–17.94	0.0001*
Sinus rhythm	4.82	1.35–17.26	0.016*	4.51	1.21–16.85	0.025*
Obtainable vitals	9.62	4.60–20.14	<0.0001*	5.48	2.16–13.90	0.0003*
ISS	0.97	0.96–0.99	0.0003*	0.98	0.96–1.00	0.052
Transportation	0.55	0.29–1.07	0.076	0.41	0.16–1.05	0.064
No. procedures	0.61	0.43–0.86	0.005*	0.44	0.23–0.84	0.013*
Collar	0.30	0.07–1.37	0.120	0.40	0.05–3.17	0.386
IV line placements	0.89	0.56–1.42	0.629	0.50	0.21–1.18	0.115
ETT	0.89	0.56–1.42	<0.0001*	<0.001	<0.001–>999.99	0.933
Prehospital time	0.61	0.43–0.86	0.433	0.99	0.83–1.17	0.876

Univariate analysis, with survival until definitive operation and survival to hospital discharge as endpoints, was performed for each clinical parameter. Statistically significant predictors of survival until both OR and hospital discharge included the presence of SOL in the field and ED, stable cardiac rhythms, and measurable vital signs. Clinical characteristics which negatively influence survival both before operation and hospital discharge included asystole as the initial cardiac rhythm and the performance of prehospital procedures.

ETT, endotracheal tube.

* $p < 0.05$ denotes statistical significance.

Table 3 Multivariate Analysis

Parameter	Survival to OR			Survival to D/C		
	Odds Ratio	95% Confidence Intervals	p	Odds Ratio	95% Confidence Intervals	p
Year	0.63	0.47–0.84	0.0016*			
Class	1.13	0.58–2.20	0.728			
Field SOL	4.68	0.58–37.92	0.149	7.86	0.65–94.68	0.104
ED SOL	4.03	<0.001–>999.99	0.820	1.65	0.03–105.00	0.814
Asystole	4.53	<0.001–>999.99	0.805	2.58	0.04–162.48	0.654
Sinus tachycardia	5.17	1.04–25.60	0.044*	7.71	1.60–37.12	0.011*
Sinus rhythm	1.64	0.21–13.00	0.639	5.90	0.93–37.53	0.060
Obtainable vitals	2.39	0.55–10.37	0.244	0.92	0.19–4.48	0.916
ISS	0.97	0.95–0.99	0.040*			
No. procedures	0.59	0.38–0.92	0.019*	0.38	0.18–0.79	0.0096*
Collar	0.007	<0.001–0.44	0.019*			
ETT	<0.001	<0.001–0.05	0.0005*			

Multivariate analysis determined the sole predictor of survival until OR and hospital discharge was the presence of sinus tachycardia, whereas year of injury, increase in ISS, and number of prehospital procedures were all associated with increased mortality before operation. The performance of prehospital procedures was the only independently measured clinical variable found to have an adverse affect on survival until hospital discharge.

* p value <0.05 denotes statistical significance.

25-minute transport time. Smith et al.[15] divided his patients into three groups according to hemodynamic stability. Regardless of hemodynamic status, the time required to start an IV infusion in the prehospital setting (8.6–12.6 minutes) was longer than the transportation time in all groups. McSwain corroborated these findings. He reported the mean time to place an IV line in less than ideal field conditions was 11 minutes.[24] With a mean field time of 19 minutes in our EMS-transported patients, our prehospital times are similar to these documented reports.

In the setting of severe hemorrhagic shock, some trauma surgeons think that peripheral IV lines are inadequate to resuscitate patients—often the rate of fluid loss is greater than the rate of fluid administration through a peripheral IV line.[5,15] Severe penetrating injuries may incur blood loss at a rate of 50 to 100 mL/min. Because only one quarter of the replacement IV crystalloid solution remains intravascular, an infusion of 200 to 400 mL/min would be necessary to adequately replace the volume lost through hemorrhage. Although we did not have available data concerning blood loss, in our study, 59 IV lines were placed in EMS-transported patients, all of which were infusing crystalloid solutions before hospital arrival.

Many think that fluid resuscitation should be delayed until definitive repair is achieved in the operating room. In his 1994 report,[16] Bickell performed a randomized, prospective trial involving 598 patients with penetrating torso injuries and prehospital systolic blood pressures below 90 mm Hg. Patients were randomized into two groups: those that received immediate or standard resuscitation and those in whom resuscitation was delayed until the operating room. A statistically significant survival benefit was achieved in the delayed resuscitation group (62%) when compared with in the immediate resuscitation group (70%).

In our study population, CPR was performed primarily by EMS personnel and infrequently by police or private citizens. However, the role of in-field external cardiac massage in penetrating trauma victims in extremis has also been questioned. A substantial body of literature has described the mechanics of external cardiac compressions.[25–27] Forward blood flow is generated by an increase in intrathoracic pressure and the presence of one-way venous valves. External compressions provide approximately 25% of baseline cardiac output resulting in only 10% of normal cerebral and coronary flow. However, open cardiac massage after EDT is much more efficient, generating 60% to 70% of baseline cardiac output. Furthermore, EDT with aortic cross-clamping redistributes the limited blood volume to the brain and myocardium and may limit hemorrhage from subdiaphramatic injuries.[28]

The limitations and biases of our clinical study are inherent to those of a retrospective design. Data extracted from charts or EMS trip sheets were at times limited and incomplete. Because of the nature of these critical injuries, we were forced to rely on police or eyewitness accounts of clinical details from the scene. Elapsed prehospital times from police or private transported patients were either unreliable or unavailable and, therefore, not used in our analysis. However, data regarding method of transportation and the performance of prehospital procedures were consistently well described in the trauma admission records. For these reasons, prehospital transportation and resulting procedures were chosen as the primary study variables, not prehospital time. Although mode of transportation and field time did not independently affect hospital survival, the performance of each prehospital procedure did negatively impact survival. Because reported field times are notoriously unreliable, this study was designed to utilize concrete findings, such as endotracheal tubes or IV lines, as markers for a prehospital time delay. However, records often did not describe exactly when endotracheal tubes, IV lines, and cervical collars were placed. Occasionally, it was difficult to determine whether procedures were performed either at the scene or in route to the hospital. Regardless of where procedures were performed or if they did, in fact, delay arrival to the hospital, the most significant finding of this study remains—any procedure performed before arrival to the trauma bay is an independent risk factor for death before hospital discharge.

It is our intention to provide this review of the most severely injured penetrating trauma victims, not as a criticism of practice, rather as a refinement in care for the evolution toward optimal outcomes after injury. Although our results challenge some current practices of EMS personnel, we are indebted to their hard work and dedication to the delivery of effective trauma health care in the city of Philadelphia.

In conclusion, we think survival of critically injured penetrating trauma patients would be improved if field intervention was minimal and procedures were restricted until arrival to the trauma bay. Furthermore, we think that paramedics should adhere to a minimal or "scoop and run" approach to prehospital transportation in this setting, with procedures delayed until hospital arrival. These recommendations are suggested for those patients with penetrating trauma in close proximity to an urban Level I trauma center and are not meant to be extrapolated to other critically injured patients: namely rural patients with blunt head injuries with prolonged times.

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