Emergency Medical Services (EMS) vs Non-EMS Transport of Critically Injured Patients

A Prospective Evaluation

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Background: A previous report of 5782 trauma patients demonstrated higher mortality among those transported by emergency medical services (EMS) than among their non–EMS-transported counterparts.

Hypothesis: Trauma patients who are transported by EMS and those who are not differ in the injury-to-hospital arrival time interval.

Design: Prospective cohort-matched observation study.

Setting: Level I trauma center, multidisciplinary study group.

Patients: All non-EMS patients were matched with the next appropriate EMS patient by an investigator who was unaware of the outcome and mode of transport. Every 10th EMS patient with an Injury Severity Score (ISS) of 13 or greater was also randomly enrolled. Matching characteristics included age, ISS, mechanism of injury, head Abbreviated Injury Score, and presence of hypotension. An interview protocol was developed to determine the time of injury. Interview responses from patients, witnesses, and friends were combined with data obtained from police, sheriff, and medical examiner reports.

Main Outcome Measures: Time to the hospital, mortality, morbidity, and length of stay.

Results: A total of 103 patients were enrolled (38 non-EMS, 38 EMS matched, 27 random EMS). Injury time was estimated using all available data made on 100 patients (97%). Independent raters agreed in 81% of cases. Deaths, complications, and length of hospital stay were similar between the EMS- and non–EMS-transported groups. Although time intervals were similar among the groups overall, more critically injured non-EMS patients (ISS $\geq$13) got themselves to the trauma center in less time than their EMS counterparts (15 minutes vs 28 minutes; $P<.05$).

Conclusions: A multidisciplinary approach can be utilized, and an interview protocol created to determine actual time of injury. Critically injured non–EMS-transported patients (ISS $\geq$13) arrived at the hospital earlier after their injuries.

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REPRODUCIBLE study on the worthiness of specific interventions in the prehospital phase of trauma care in a given region is difficult to accomplish. Although the numbers of interventions in the prehospital arena are finite, variations in the circumstance of injury make it difficult to ascertain when procedures justify the time required to perform them.

See Invited Critique at end of article

A retrospective study involving 5782 patients admitted to the Los Angeles County + University of Southern California Medical Center (LAC + USC) over a 2-year period found that trauma patients transported by the emergency medical services (EMS) experienced a higher mortality rate than their counterparts transported by civilian means (non-EMS).[1] Subgroup analysis of mortality found that outcome differences were not explained by demographics, patterns of injury, or severity of injury. The findings in this study led to the formation of a multidisciplinary EMS study group to pursue the hypothesis that there is a time element difference (injury to hospital arrival) between EMS- and non–EMS-transported patients, and to prospectively study whether there were outcome differences between these groups.

PATIENTS AND METHODS

To prospectively test the hypothesis, an interview protocol, a method for combining time estimates, and a screening method to identify a sample of carefully matched patients, were developed. To accomplish these tasks, the EMS study group, consisting of members of the Division of Trauma/Critical Care, trauma registry personnel, and members of the Social Science Research Institute of USC, was formed. An interview protocol was developed to determine the time of injury and the factors affecting decisions to access the EMS system. Graduate students in the social sciences were trained to apply this tool to patients, witnesses, and friends, and to use it in conjunction with data obtained from police and sheriff reports with cooperation from the Los Angeles Police Department and the Los Angeles County Sheriff's office. Medical examiner reports for nonsurviving patients were also used.

In constructing time estimates from the interviews and records, all data revealing that EMS was involved with a case was temporarily removed from each patient's file. Two independent raters (a clinician [H.B.] and a social scientist [K.H.]) reviewed all of the available information on time of injury for each case and gave estimates for the time of injury. The hospital arrival time was recorded by emergency department personnel who are specifically assigned the task of documenting such information for all patients. With this method, the injury-to-hospital arrival time interval was estimated by investigators who were unaware of the mode of transport or patient outcome. Each rater was free to devise his or her own system for arriving at the best estimate of the time of injury and avoided discussing any system of weighting of the available information before the reviews. These raters agreed in 81% of cases. A third rater (E.E.C.) reviewed the information (including the independent ratings) in each case where there was a discrepancy and made a final determination.

In addition to the data obtained from the aforementioned interviews and reports, patient demographics, patterns of injury, mechanism and severity of injury, physiologic criteria (vital signs, Glasgow Coma Scale score), need for surgical intervention and intensive care, and clinical course including survival and complications were studied for patients with major trauma (as defined by the Los Angeles County EMS Authority). All patients were treated according to standard trauma care principles by a dedicated team led by an in-house trauma attending physician.

PATIENT ENTRY

This was a cohort-matched observation study. The period of patient entry was January through October 1997. All patients admitted to the trauma center directly from the injury scene during the previous 24 hours were evaluated each morning by one of the clinician investigators for appropriateness of enrollment. The clinicians made an initial estimate of the Injury Severity Score (ISS) and considered patients with an ISS of 13 or greater, or with shock on admission (systolic blood pressure $\leq$90 mm Hg) as eligible for inclusion. These patients were recorded in order of hospital arrival times. Patients were entered without regard to sex or ethnicity. The general population of trauma patients (during the study period) includes approximately 15% females, and is approximately 80% Hispanic and 10% African American. Complete information regarding severity of injury and arrival to the hospital was immediately gathered for each seriously injured patient. Non-EMS patients were enrolled and the next EMS patient to arrive who met the matching criteria described below was enrolled in the study as well. Every 10th seriously injured EMS patient (not including those who were used as matches) was enrolled in a control group. Matching was accomplished with no knowledge of outcomes.

MATCHING CHARACTERISTICS

Patients transported by non-EMS means were matched with their EMS-transported counterparts according to age, ISS, head Abbreviated Injury Score (AIS), and mechanism of injury.

Patients were matched with cohorts who were either within a 5-year umbrella or within the same age category, as follows: 14 to 17 years, 18 to 29 years, 30 to 44 years, and 45 to 55 years. For example, a 42-year-old could be matched with a 46-year-old.

Patients were originally considered on the basis of clinician-estimated ISS on admission. Ultimate matching was on the basis of final (discharge) ISS. Patients were matched by ISS 13 to 24 vs ISS 25 to 75, so that patients with an AIS of 5 in any body region were automatically classified in the higher group(as $5^2 = 25$). If a non–EMS-transported patient with an ISS less than13 was included by virtue of a blood pressure of 90 mm Hg or less, the patient was matched with an EMS-transported patient who was likewise included on the basis of a blood pressure of 90 mm Hg or less with an ISS less than 13.

Patients with a head AIS of 3 or greater were likewise matched with similarly head-injured patients.

The categories for matching mechanism of injury were blunt injury vs penetrating injury.

EXCLUSION CRITERIA

Patients who did not have a theoretical choice of transport (age <14 years, patients taken into legal custody, patients transported directly from prison) were excluded from consideration.

To improve enrollment (discussed below), non–EMS-transported patients with lower ISSs were subsequently included (May through October 1997). Therefore, patients were entered in the study by 3 possible means: (1) all non–EMS-transported patients were entered and were matched with (2) an EMS-transported counterpart matched on the basis of age, ISS, head AIS, mechanism of injury, and presence or absence of hypotension on admission; (3) every 10th EMS-transported patient experiencing sufficient severity of injury to have potential for morbidity or mortality (ISS >12 or hypotension on admission) was also included.

RESULTS

Three hundred fifty-nine patients were screened for enrollment. After cohort matching of non-EMS patients, and random sampling of EMS patients with an ISS of 13 or greater, 105 patients were ultimately enrolled in the study. Hospital arrival time was not documented for 2 patients, leaving 103 for analysis. There were 38 non-EMS patients, 38 EMS-matched patients, and a separate group of 27 random EMS patients who met the inclusion cri-

Table 1. Comparison of Groups by Demographic and Injury Characteristics*

Characteristic	All Non-EMS Patients (n = 38)	All EMS-Matched Patients (n = 38)	EMS Random Patients (ISS >12) (n = 27)
Age, mean, y	22	24	29†
Male, No. (%)	37 (97)	34 (89)	23 (85)
Hispanic, No. (%)	29 (76)	29 (76)	22 (81)
Penetrating injury, No. (%)	34 (89)	34 (89)	18 (67)†
ISS, mean	13	11	21†
Head AIS ≥3, No. (%)	4 (11)	4 (11)	5 (19)

*EMS indicates emergency medical services; ISS, Injury Severity Score; and AIS, Abbreviated Injury Score.
†$P < .05$.

Table 2. Consensus Time Estimate (Injury to Hospital) Among Investigators*

Group	No. of Patients	Mean ISS	Mean Time, min
Non-EMS (all)	37	13	26
EMS matched (all)	37	11	30
Non-EMS (ISS <13)	18	3	39†
EMS matched (ISS <13)	19	2	33
Non-EMS (ISS ≥13)	19	19	15†‡
EMS matched (ISS ≥13)	18	23	28‡
EMS random (ISS ≥13)	26	21	37

*ISS indicates Injury Severity Score; EMS, emergency medical services.
†$P < .05$, non-EMS ISS ≥13 group vs non-EMS ISS <13 group.
‡$P < .05$, non-EMS ISS ≥13 group vs EMS-matched ISS ≥13 group.

teria (ISS ≥13, etc) (**Table 1**). The 3 groups were similar in terms of sex and ethnicity. The random EMS group was more likely to have sustained blunt trauma and to be older and more severely injured, indicating that the non-EMS population was skewed toward young persons with penetrating trauma.

TIME

From all available sources, a consensus time estimate was available on 100 (97%) of 103 patients: 37 non-EMS, 37 EMS-matched, and 26 EMS random. There was no time difference among the entire sample of matched non-EMS and EMS patients. However, among patients with an ISS of 13 or greater, the non-EMS patients arrived at the hospital in significantly less time than the EMS-matched group (**Table 2**; 15 minutes vs 28 minutes; $P < .05$). Indeed, critically injured non-EMS patients had the shortest time interval among all subgroups studied, whereas the time interval was relatively consistent among EMS-transported patients, regardless of injury severity. Time estimates constructed from each single source of data (ie, interview only or official records only) showed the same pattern of results. From interviews alone, the mean non-EMS injury-to-hospital time was 11 minutes vs 26 minutes for EMS patients and from records only, the mean non-EMS time was 10 minutes vs 31 minutes for EMS patients.

OUTCOMES

No significant differences were observed between the seriously injured matched EMS and non-EMS groups regarding mortality, length of hospital stay, days in the intensive care unit (ICU), complications, or infections.

A composite outcome variable was constructed by combining 3 key outcomes: length of hospital stay, days in the ICU, and mortality. The ordinal-level variable formed was defined as follows: 1 = short hospital stay (<4 days), no days in the ICU, lived; 2 = long hospital stay (≥4 days) or some days in the ICU, lived; 3 = long hospital stay and some days in the ICU, lived; and 4 = died.

To test whether more rapid transport among matched critically injured patients was associated with better outcomes, 3 variables—ISS, time (in minutes) between injury and hospital arrival, and distance (in miles) between injury and hospital arrival—were entered into a regression analysis predicting this composite outcome variable.

The adjusted R^2 for this analysis was 0.640; ISS scores were strongly related to outcomes ($\beta = .84$, $P < .001$), and while time failed to reach statistical significance, there was a trend in the predicted direction (shorter time interval indicated better outcome; $\beta = .12$, $P < .13$).

COMMENT

The prehospital phase of care immediately following injury (resuscitation, immobilization, transport) is a particularly challenging arena in which to offer policy changes that may affect outcome. The American College of Surgeons requires that level I trauma centers be actively involved in the prehospital phase of care.[2] Although therapeutic interventions by paramedics have been shown to reduce mortality in the care of persons with cardiac arrest, there are conflicting opinions as to the value of advanced-level interventions vs strict rapid transport in the treatment of trauma patients.[3-5] There are authors who have advocated prehospital stabilization with life support maneuvers,[6-9] and those that promote a "scoop and run" technique that emphasizes minimal intervention and strict rapid transport.[10-12]

Variations in the setting of trauma care may partly explain the different recommendations in the literature, and present a hazard when interpreting reports regarding the debate over the degree of prehospital intervention. While rapid effective evacuation of injured soldiers by helicopters was credited with helping reduce the mortality of wartime injuries in Vietnam, the applicability of these lessons to care in the civilian setting is unclear.[13-15] Grossman et al[16] found important differences in prehospital care and response times between the urban and rural settings in a prospective cohort study of the EMS in the state of Washington. Most recently, studies from Montreal (Quebec), San Diego (Calif), Houston (Tex), and Hartford (Conn) have raised the question as to whether intravenous fluid resuscitation justifies the time required to accomplish the task.[11,12,17,18] An interesting parallel is seen in a report from South Africa[19] and the previously described study from LAC + USC.[1] Lerer and Knottenbelt[19] demonstrated in a study from South

Table 3. Prolonged Scene Times for Patients With Penetrating Trauma Transported to LAC + USC*

Year	No. of Penetrating Trauma Patients	No. (%) of Fallouts†
1993	1361	207 (15.2)
1994	1314	250 (19.0)
1995	1396	85 (6.1)
1996	1005	37 (3.7)

*LAC + USC indicates Los Angeles County + University of Southern California Medical Center.
†A fallout is a case with a paramedic scene time of more than 20 minutes.

Africa that the survival rate following penetrating chest injuries was better in patients from poorer socioeconomic areas. An intriguing analogy is seen in that the hospital in South Africa also treats large numbers of patients with poor access to health care. The authors of that study speculated that the outcome difference may have been due to the increased use of more readily available private transportation to reach the hospital among poorer patients. There was a Latino predominance among the non-EMS group in the LAC + USC study that may reflect the ethnicity of the east Los Angeles neighborhood surrounding the hospital.

That actual interval between time of injury and the beginning of in-hospital acute care is not generally known. This is because although detailed records are available from the time the EMS is notified, information from the injured or from witnesses is generally not obtained regarding the actual time of injury. Very little is known regarding any component of the time interval in the non-EMS population. Although many trauma centers receive patients transported by non-EMS means (4% to 15% of all patients among 6 urban trauma centers surveyed and as high as 16% in a hospital in Northern Ireland),[20] this circumstance had not been sufficiently analyzed. A multidisciplinary research team, formed to focus on these issues, has developed procedures to access previously neglected factors necessary for illuminating these gaps in knowledge.

Two major developments occurred that may well have affected patient enrollment and the time interval being analyzed in this study. First, there has been a well-documented decrease in violent assault, and therefore penetrating trauma in Los Angeles County in the 4 years since the previously mentioned findings were reported.[21] At the same time, the non–EMS-transported patients were more likely to have penetrating trauma.

With non-EMS transport becoming less common, we decided to enroll, interview, and analyze all non–EMS-transported patients meeting major trauma criteria, even those with a final ISS less than 13. This created 2 additional subsets to be considered in the data analysis phase of the project: non-EMS patients with ISSs less than 13 and their EMS-matched counterparts with ISSs less than 13.

Another development that may have affected the results of our study was our immediate response to the observation of different outcomes by transport mode, made in our initial retrospective review. As a major trauma center that has some involvement in the oversight of the prehospital phase of acute care following injury, we felt compelled to intervene where possible to decrease the paramedic scene times for critically injured patients. This intervention took the form of a focused quality improvement program that included extensive written reviews of all scene times greater than 20 minutes. The liaison overseeing this review was the medical director of the LA City Fire Department (the EMS entity that transports the largest proportion of trauma patients to LAC + USC). This quality improvement program has resulted in a progressive decrease in the proportion of patients with penetrating trauma experiencing prolonged scene times (**Table 3**). In summary, the decrease in the number of penetrating trauma admissions, combined with the implementation of a quality improvement program to decrease scene times (and hopefully preventable deaths), has the effect of requiring a longer study period to enter the number of patients necessary to identify outcome differences, if they exist. The time differences identified in Table 2 may well have been even more dramatic, but for the concurrent intervention designed to reduce EMS scene times.

The actual magnitude of the times in Table 2 gives the impression that critically injured non-EMS patients appreciated the urgency of their situation. Their time interval dropped significantly as their ISS rose above 13 (15 vs 39 minutes; $P<.05$). Among the protocol-driven EMS group, however, there was relative consistency in terms of how quickly they arrived at the hospital regardless of the severity of their injury (mean time, 28 minutes for patients with ISS <13 and 33 minutes for EMS-matched patients with ISS <13). Given the effort involved in determining the actual time of injury for each individual patient, it will require more time and a larger sample size to assess in a multivariate fashion the effect of time on outcome measures.

Non-EMS patients represent the purest form of "scoop and run." We believe that the combined findings of the 2 reports from LAC + USC have important policy implications in the prehospital arena, particularly regarding patients with penetrating trauma. Not one of the more than 3000 patients with penetrating injuries in these studies was even theoretically benefited by formal thoracolumbar immobilization (ie, a patient with an unstable vertebral column injury and a less than complete neurologic deficit).

The published doubts regarding the time invested pursuing intravenous fluid resuscitation have already been cited.[11,12,17,18] Accordingly, we believe that in an urban trauma setting, the prehospital care of persons with penetrating trauma who are spontaneously breathing and moving their legs should place the highest priority on rapid transport (as opposed to intravenous resuscitation, intubation, or spinal immobilization).

We conclude that in our urban setting, severely injured non–EMS-transported patients arrived at the hospital more quickly than their EMS-transported counterparts. Future study will be directed at more severely injured patients where time and distance differences are confirmed and a trend toward outcome differences identified. A longer study period is clearly required to enroll a sufficient number of patients with the more severe injury inclusion criteria.

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Invited Critique

Considerable controversy exists regarding the prehospital management of critically injured patients by EMS personnel. A "scoop and run" approach may neglect key issues, such as a compromised airway, while prolonged attempts at resuscitation in the field simply cannot stabilize a patient in need of operative intervention. Few prospective, randomized clinical trials exist that address those advanced life support (ALS) interventions performed in the prehospital setting that improve patient outcome.

The previous study by Demetriades et al (*Arch Surg.* 1996;131:133-138) documented a higher mortality rate in trauma patients cared for by EMS personnel compared with that of patients privately transported. That study was not so much an indictment of prehospital ALS for trauma patients as it was illustrative of a system lacking adequate medical supervision (ie, EMS scene times averaging more than 20 minutes). With the introduction of quality improvement measures, the EMS scene time decreased dramatically. This is probably the key reason why the present study no longer identifies a significant difference in mortality between the 2 modes of transport. But, it remains worrisome that this well-designed study failed to show a survival advantage attributable to ALS interventions by EMS personnel.

While a few, carefully selected management strategies may benefit the trauma patient, a point of diminishing return no doubt exists wherein further attempts at resuscitation are not beneficial in the face of ongoing, uncontrolled hemorrhage. Unfortunately, Cornwell and colleagues did not present data on which ALS interventions were performed on these critically injured patients prior to arrival at their level I trauma center.

These authors have refocused attention on a fundamental aspect of trauma care and their work serves to remind us of why surgeons must maintain involvement in the prehospital management of trauma patients. Resuscitative measures that fail to show benefit in an urban setting with a brief transport time to a trauma center with in-house surgeons could possibly improve outcome when utilized in an suburban or rural setting with longer transport to a community hospital. Further research will be necessary to clarify which actions, if any, justify the time investment required at the scene.

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