Is Total Out-of-hospital Time a Significant Predictor of Trauma Patient Mortality?

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Abstract

Objective: To determine if there is an association between total out-of-hospital time and trauma patient mortality. **Methods:** A retrospective review was performed of a convenience sample of consecutive medical records for all admitted patients transported by helicopter or ambulance from the scene of injury to the regional trauma center. Descriptive and univariate analyses were conducted to determine which variables were associated with patient mortality and total out-of-hospital time. Multiple predictors logistic regression was used to determine if total out-of-hospital time was associated with trauma patient outcome, while controlling for the variables associated with trauma patient mortality. **Results:** Of the 2,925 patients who were transported from the scene, 1,877 met the inclusion criteria. Six percent (116) did not survive. The multiple predictors model included CUPS (critical, unstable, potentially unstable, stable) status, patient age, Injury Severity Score, Revised Trauma Score, and total out-of-hospital time as predictors of mortality. Total out-of-hospital time (odds ratio 0.987; $p = 0.092$) was the only variable not found to be a significant predictor of mortality. **Conclusions:** Provider-assigned CUPS status, patient age, Injury Severity Score, and Revised Trauma Score all were significant predictors of trauma patient mortality. Total out-of-hospital time was not associated with mortality. **Key words:** wounds; trauma; injury; emergency medicine services; time; triage. ACADEMIC EMERGENCY MEDICINE 2003; 10:949–954.

Time has always been central to out-of-hospital emergency care. Today, it is recommended that trauma patients be transported using the most expedient and appropriate means.[1] Trauma patients have been considered to require expedient transport because they are thought to require a minimum of time between injury and surgical intervention. This principle has been taught to most out-of-hospital emergency care providers through emergency medical services (EMS) trauma care certification courses.[2] In these courses, the principle is taught as the "golden hour." Providers have been trained that patients have the best chance of survival if they reach a trauma center within one hour of injury.

The data to support the golden hour principle, that short total out-of-hospital time is the best treatment for trauma patients, have been based primarily on wartime findings.[3] These findings came mostly from the Vietnam War, in which the survival rate in medical facilities was increased 2% over previous wars to 97.5%, and the average time to definitive care was reduced from an average of five hours in the Korean War to only one hour.[4] Peacetime civilian literature has failed to support this generalization, however, and no research exists to support that definitive treatment must be obtained within the first hour of injury for optimal trauma patient outcomes.[5]

The objective of this study was to determine whether there was a significant association between trauma patients' total out-of-hospital time and mortality. Specifically, this study determined if trauma patient mortality was associated with the length of the time interval from injury to arrival at a trauma center (i.e., total out-of-hospital time). It was hypothesized that as this time interval increased, so would mortality. This study did not analyze the effect of time on trauma patient morbidity.

METHODS

Study Design. This was a retrospective review of medical records of admitted trauma patients. Multiple predictors logistic regression was used to determine if

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survival was related to out-of-hospital time. All patient information remained confidential, and the local institutional review board approved this study.

Study Setting and Population. Data for this study were obtained from records maintained at the only adult regional trauma center serving eight counties in western New York. The facility was a 389-bed tertiary care teaching facility with approximately 13,500 annual admissions, of which approximately 1,600 were trauma patients. Local trauma triage guidelines were similar to those recommended by the American College of Surgeons.[6] Regional helicopter use guidelines referenced these trauma triage guidelines and indicated that helicopter transport should be used when it would "significantly reduce the arrival time at the trauma center or reduce arrival time to less than 30 minutes."

All patient records from January 1993 through October 1996 were selected from the trauma center's trauma registry if the patient had been transported directly from the scene of injury by an ambulance or helicopter. Most data used for the analysis were gathered directly from the trauma registry. However, the out-of-hospital patient care report (PCR) and dispatch agency records were used to supplement the registry time data, because it was frequently incomplete.

The trauma registry included all patients who were admitted to the hospital or died while in the emergency department (ED). These patients were primarily adults because there was a separate pediatric trauma center in the region. However, there was no exclusion from the registry for age, so although youths treated at the adult trauma center were rare, they were included in the registry. In this analysis, 6% of the study population was younger than 18 years of age ($n = 110$).

Patients were entered into the registry if they had a documented E-code or were assigned a traumatic ICD-9 code (i.e., 800–959). Patients were excluded if they were discharged from the ED, had a medical condition that caused the injury (e.g., osteoporosis or cancer), or were poisoned, overdosed, suffocated, or drowned. Patients with a documented V code between 57.0 and 57.9 (i.e., rehabilitation or follow-up care) or E-codes 870.0 to 879.9 (i.e., injury caused by medical care), 929.0 to 929.9, 959, 969, 977, 989, or 999 (i.e., late effects of injury) were not included in the registry. Patients who were pronounced dead at the scene of the injury and were not transported were not included in the trauma registry.

Patients' out-of-hospital and hospital courses of treatment as well as final disposition were recorded in the registry. A single registrar abstracted data from the medical records after the patients were discharged from the hospital. The data were entered into a commercial database (Trauma 1; *Lancet*, Boston, MA).

Measures. The data used in this study included final outcome, out-of-hospital course of treatment, and a subset of the hospital course of treatment. Final outcome was the patient's vital status at discharge (i.e., alive or dead). Variables were selected for the study if they were related to the outcome (mortality), were related to the exposure (total out-of-hospital time), or were thought potentially to be confounders (measures of injury severity, transport mode, patient demographics).

Out-of-hospital variables included transport mode, total out-of-hospital time, and patient's CUPS (critical, unstable, potentially unstable, stable) status. Transport mode was whether an ambulance or helicopter transported the patient. Total out-of-hospital time was calculated by subtracting the earliest documented 911 call received time from the time the final transporting agency arrived at the trauma center ED. CUPS status is the out-of-hospital care provider's subjective designation of whether the patient was critical, unstable, potentially unstable, or stable. There were no precise definitions for which patients should receive which rating.

Hospital variables included Revised Trauma Score (RTS), Injury Severity Score (ISS), E-code, admission date, age, sex, and type of injury. RTS was calculated when the patient arrived in the ED. The trauma registry software used the standard formula (RTS = (GCS score coded $\times$ 0.9368) + (SBP coded $\times$ 0.7326) + (RR coded $\times$ 0.2908)) to calculate the RTS score, where GCS = Glasgow Coma Scale, SBP = Systolic blood pressure, and RR = respiratory rate.[7] RTS ranged from 0.00 to 7.84. ISS was calculated in the standard manner by summing the square of the three highest abbreviated injury scores (AIS) for injuries to different body regions.[8] The AIS scores were calculated by the registry computer software based on the patient's ICD-9 discharge codes.[9,10] Type of injury differentiated between patients who had sustained a blunt injury from patients with a penetrating injury.

Patients were excluded from the analysis if complete data could not be obtained from the registry, PCR, or dispatch agency records. Patients whose date of injury was more than one day different from their date of admission were excluded because they did not come immediately to the trauma center after their injury. Patients also were excluded if cardiopulmonary resuscitation (CPR) was initiated in the field because these patients, who were more likely to die, by protocol were transported to the nearest treatment facility, artificially shortening their total out-of-hospital time compared with the rest of the study population. Lastly, patients who were transported from correctional facilities were excluded because the security requirements involved with transporting these patients artificially increased their total out-of-hospital times compared with the rest of the study population.

Data Analysis. Descriptive statistics were used to describe the study sample, including means, standard deviations (SDs), and percentages. Bivariate analysis was conducted to determine which variables were associated with mortality. Continuous dependent variables were compared using t-test. Categorical and nominal dependent variables were compared using chi-square and Fisher's exact test. Stratified analyses were conducted to determine if total out-of-hospital time had a different effect on mortality for patients with different injury types and severity.

Multiple predictors logistic regression was used to determine if total out-of-hospital time was a significant predictor of trauma patient mortality. Variables that were found in the univariate analyses to have a statistically significant ($p < 0.05$) effect on mortality were included in the multiple predictors logistic regression to identify the independent effect of time on trauma patient outcome. All tests were two-sided with a p-value < 0.05 considered statistically significant.

The continuous variables total out-of-hospital time, ISS, RTS, and age were analyzed to determine if they were normally distributed before conducting the multiple predictors analysis. RTS was not normally distributed and could not be transformed to take on a normal distribution. This variable was dichotomized at the median value of 7.84. ISS also was not normally distributed. Because the medical literature considers ISS greater than 16 to be associated with increased mortality, and the relationship between ISS score and mortality has been shown to be nonlinear,[8] ISS was dichotomized at 16. Age and total out-of-hospital time were normally distributed. Lastly, the categorical variable CUPS score was dichotomized. This was accomplished by combining the *C* (critical) and *U* (unstable) categories and the *P* (potentially unstable) and *S* (stable) categories.

RESULTS

The trauma registry contained 2,925 records for patients transported by ambulance or helicopter from the scene of injury to the trauma center from January 1993 to October 1996. Of those patients, 2,410 had complete time data and were not in cardiac arrest ($n = 57$). Twenty-six patients were excluded for having more than one day between injury and admission. Twenty-five patients were excluded due to being transported from a correctional facility. Additionally, 482 records had to be excluded for not containing key variables (i.e., RTS and CUPS score). A total of 1,877 records were available for inclusion in the analysis. Table 1 illustrates the descriptive statistics for each of the variables of interest and compares the 1,877 patients who had complete data with the 482 patients who had incomplete data. There were statistically significant differences in injury type, age, CUPS status, and total out-of-hospital time.

Mean total out-of-hospital time was compared for each of the variables of interest stratified by the patients' vital status at hospital discharge. Using descriptive statistics, it was found that mean total out-of-hospital time was always longer for survivors than nonsurvivors (data not shown) with one exception. Total out-of-hospital time was longer for the nonsurvivors when the out-of-hospital providers designated the patient as stable or potentially unstable (Table 2). However, this time difference was not statistically significant.

Patient survival rates were compared for each of the variables of interest (Table 3), and the odds ratio (OR) for mortality was calculated with 95% confidence interval (CI). It was determined that CUPS status (OR 10.18, 95% CI = 6.54 to 15.90), RTS (OR 15.33, 95% CI = 9.90 to 23.79), and ISS (OR 19.98; 95% CI = 12.67 to 31.52) all were significantly associated with patient outcome. Survivors also were found to have a significantly longer mean ± SD total out-of-hospital time (survivor, 35.3 ± 16.9 minutes, versus nonsurvivor, 31.6 ± 15.6 minutes; $p = 0.022$) and were significantly younger (survivor, 36.4 ± 16.5 years, versus nonsurvivor, 47.8 ± 24.4 years; $p = 0.000$). Injury type, transport mode, and gender were excluded from any additional analysis because they were not significantly associated with patient outcome.

Total out-of-hospital time was considered the main effect for the multiple predictors logistic regression. CUPS status, age, ISS, and RTS were considered confounders, and mortality was the outcome variable. Table 4 illustrates the multiple predictors logistic regression model for these variables entered together to predict mortality. The accuracy of prediction for this model was 94.3%. All variables were significant predictors of mortality except total out-of-hospital time. The relationships between the confounders and survival were all in the direction that was expected. That is, a *C* or *U* on the CUPS scale (OR 3.96), increasing age (OR 1.05), an RTS less than 7.84 (OR 5.34), and an ISS between 17 and 75 (OR 8.90) all were associated with an increased risk of mortality.

DISCUSSION

This study attempted to determine if an association existed between total out-of-hospital time and outcome for adult trauma patients. The hypothesis that increased total out-of-hospital time was associated with increased trauma patient mortality was not supported by this analysis. Survivors in this data set had longer average total out-of-hospital times than nonsurvivors. After controlling for injury severity, patient demographics, and treatment factors, total out-of-hospital time was not associated with survival.

Caution must be used when interpreting these results. Based on these findings, ambulance personnel should not discontinue the practice of rapid transport

TABLE 1. Descriptive Statistics for All Variables—Comparing Patients with Complete and Incomplete Data

Variable	Categories	All Patients N	All Patients %	Patients with Complete Data n	Patients with Complete Data %	Patients with Incomplete Data n	Patients with Incomplete Data %	Comparison of Patients with Complete and Incomplete Data: p-value
Vital status	Died	142	6%	116	6%	26	5%	
	Lived	2,242	94%	1,761	94%	456	95%	0.518
Transport mode	Helicopter	192	8%	150	8%	42	9%	
	Ambulance	2,218	92%	1,727	92%	440	91%	0.605
Injury type	Penetrating	511	21%	423	23%	71	15%	
	Blunt	1,873	79%	1,454	78%	411	85%	0.000
Gender	Male	1,723	72%	1,357	72%	341	71%	
	Female	661	28%	520	28%	141	29%	0.499
Age (mean)		2,384	38±18 (range: 11–97)	1,877	37±17 (range: 11–97)	482	42±20 (range: 14–92)	0.000
	11–20	354	15%	285	15%	68	14%	
	21–30	626	26%	512	27%	99	21%	
	31–40	569	24%	452	24%	112	23%	
	41–50	339	14%	271	14%	64	13%	
	51–60	183	8%	139	7%	44	9%	
	61–70	123	5%	89	5%	34	7%	
	71–97	190	8%	129	7%	61	13%	
CUPS score	C—Critical	46	2%	41	2%	5	4%	0.035 (C and U compared with P and S)
	U—Unstable	444	22%	404	22%	39	28%	
	P—Potentially unstable	1,061	52%	986	53%	63	45%	
	S—Stable	490	24%	446	24%	32	23%	
Revised Trauma Score	(mean)	2,229	7.5 ± 1.0	1,877	7.5 ± 1.1	327	7.6 ± 0.9	0.120
	7.84	1,879	79%	1,574	84%	280	86%	
	< 7.84	505	21%	303	16%	47	14%	0.419
Injury Severity Score	(mean)	2,384	10 ± 10	1,877	10 ± 9	482	10 ± 10	1.000
	0–16	1,930	81%	1,527	81%	380	79%	
	17–75	454	19%	350	19%	102	21%	0.211
Total out-of-hospital time	(mean)	2,384	37 ± 18	1,877	35 ± 17	482	40 ± 17	0.000
	0–30 min	1,111	46%	958	51%	153	32%	
	31–45 min	686	29%	496	26%	189	39%	
	46–124 min	587	25%	423	23%	140	29%	

for adult trauma patients. The findings of this study indicate that perhaps time is not as important a factor for trauma patient mortality as has been believed. Additional studies are needed, however, to determine which types of trauma patients or traumatic injuries are the most time-dependent.

One possible explanation for these findings is bias caused by provider decision making. The possibility that providers more rapidly transported the patients they believed were the most severely injured limits the conclusions that could be drawn from this retrospective record review. It was found that when mean total out-of-hospital times were compared based on mortality and stratified by each of the variables of interest, total out-of-hospital time was always longer for survivors with one exception, CUPS score; however, this difference was not statistically significant. This is interesting becauce CUPS is a subjective measure of the provider's impression of patient status. Among patients classified by providers as stable or potentially unstable, nonsurvivors had a mean total out-of-hospital time that was longer than the survivors. However, for patients classified as critical or unstable, mean total out-of-hospital times were longer, for survivors than nonsurvivors.

This finding is similar to that of Petri et al.,[11] who found that shorter on-scene times resulted when patients were more severely injured and that patients with shorter on-scene times were more likely to die. Their study also found that within each stratum of ISS score, the patients who died had shorter total out-of-hospital times than the patients who survived. These authors suspected that somehow providers were identifying the patients who ultimately would die with more accuracy than the severity scores.

Findings related to CUPS score and total out-of-hospital time may indicate that a provider transport bias exists. This bias plays a role in total out-of-hospital time that is outside what can be controlled for using severity measures such as ISS and RTS. Providers may have a better sense of which patients will die than these scores and may expedite scene

TABLE 2. Mean Total Out-of-hospital Times Stratified by CUPS Status and Vital Status

	Survivor		Nonsurvivor		
	Minutes	*n*	Minutes	*n*	p-value
C or U	33 ± 16	361	29 ± 15	84	0.032 (diff 4 min 95% CI = 0.4 to 8)
P or S	36 ± 17	1,400	39 ± 15	32	0.274 (diff −3 min 95% CI = −9 to 3)

C = critical; U = unstable; P = potentially unstable; S = stable; CI = confidence interval.

treatment and transport for the patients they believe have the worst prognosis as is taught in their trauma life support courses.[2] This theory is supported by the findings of Emerman et al.,[12] who found that when emergency medical technicians predicted patient mortality on a visual analog scale, they were as accurate as RTS and two other measures of injury severity in predicting the patients' ultimate outcome. Simmons et al.[13] found that using a four-point scale similar to the CUPS score, paramedic perception was an important indicator of patients who truly needed the interventions provided at a trauma center.

Appropriate treatment for trauma patients is an important question for society because in 2000, unintentional injuries were the fifth leading cause of death for all Americans and the leading cause of death for persons aged 1 to 34.[14] It may seem intuitive that if decreased transport time benefits some patients, all patients should be transported as rapidly as possible. This type of approach may be beneficial to some patients but does not consider the adverse effects these transport methods have on provider and patient safety, and cost.

Using helicopter transport to decrease total out-of-hospital time is much more costly than ambulance transport and not without danger. The average helicopter EMS fatality rate for the past five years has exceeded all other aviation operations.[15] A disproportionate number of helicopter EMS crashes were found to occur at night and during scene transports.[15]

Ground ambulances traveling at increased speed with the use of lights and siren may not increase cost, but they do increase the risk associated with such transport. Clawson[16] estimated that 72,000 motor vehicle crashes occur each year in the United States and Canada as a result of ambulance lights and siren use. This includes collisions directly involving responding ambulances and collisions that result from the confusion and disruption of traffic created by an ambulance passing through traffic with lights and siren. A study of ambulance crashes in Tennessee found that 47% of all crashes involved those responding with lights and siren and were more likely to result in an injury than the remaining 40% of crashes that did not involve the use of lights and siren.[17] Ambulance use of lights and siren is not without risk and exposes out-of-hospital personnel and the general public to danger. These safety and cost concerns must be considered when deciding which patients to transport as quickly as possible to a trauma center.

LIMITATIONS

Total out-of-hospital time was calculated using times documented by out-of-hospital care providers on a patient care report. In many instances, multiple agencies and perhaps more than one dispatch center may have been involved in a patient's care. Timepieces at these dispatch centers may not have been synchronized, leading to some error in the calculated total out-of-hospital times.[18,19] This error would have been random, making it difficult to predict how any synchronization error would affect the study results. However, it is doubtful that the error would occur more often in the case or control group. The effect of synchronization error likely would have biased the results toward the null value.

TABLE 3. Patient Survival by Descriptive Variables Including Odds Ratio for Risk of Mortality

Variable Categories	Categories	Nonsurvivor	Survivor	p-value	OR	95% CI
Transport mode	Helicopter	10% (15)	90% (135)	0.065	1.79	0.97 to 3.26
	Ambulance	6% (101)	94% (1,626)			
Injury type	Penetrating	8% (32)	92% (391)	0.219	1.33	0.86 to 2.07
	Blunt	6% (84)	94% (1,370)			
Gender	Female	7% (36)	93% (484)	0.471	1.19	0.77 to 1.82
	Male	6% (80)	94% (1,277)			
CUPS score	C or U	19% (84)	81% (361)	< 0.001	10.18	6.54 to 15.90
	P or S	2% (32)	98% (1,400)			
RTS	< 7.84	26% (80)	74% (223)	< 0.001	15.33	9.90 to 23.79
	7.84	2% (36)	98% (1,538)			
ISS	17–75	26% (90)	74% (260)	< 0.001	19.98	12.67 to 31.52
	0–16	2% (26)	98% (1,501)			
					Difference	
Mean total out-of-hospital time (min)		31.58 ± 15.55	35.26 ± 16.90	0.022	3.69	0.52 to 6.85
Mean age (yr)		47.84 ± 24.35	36.42 ± 16.52	< 0.001	11.41	8.20 to 16.43

C = critical; U = unstable; P = potentially unstable; S = stable; RTS = Revised Trauma Score; ISS = Injury Severity Score; OR = odds ratio; CI = confidence interval.

TABLE 4. Multiple Predictors Logistic Regression Predicting Mortality Including All Patients (*N* = 1,877)*

	OR	p-value	95% CI
Total out-of-hospital time	0.987	0.023	0.97 to 1.00
Critical or unstable	3.958	0.000	2.26 to 6.94
Age	1.048	0.000	1.04 to 1.06
Injury Severity Score 17–75	8.898	0.000	5.34 to 14.82
Revised Trauma Score < 7.84	5.336	0.000	3.17 to 8.97

*Accuracy of prediction of the model 94.3%.
OR = odds ratio; CI = confidence interval.

The time interval beginning with notification of the dispatch center for the primary response agency and ending with arrival at the adult regional trauma center was used as an estimate of total out-of-hospital time. In reality, the total out-of-hospital time interval should begin with the actual time of injury. No information was available on the time interval from injury to placement of the 9-1-1 call. Some bias may have been introduced by estimating total out-of-hospital time without knowing the actual time of injury. Inability to measure time of injury is a limitation of most time-related EMS research. By excluding the patients whose date of admission was more than one day after their date of injury, however, we were able to exclude the patients who waited days before seeking medical attention.

Twenty percent of patients eligible for inclusion in this analysis could not be included due to missing data. There were some differences between patients who were included in the analysis and patients who were excluded. The statistically significant differences were probably a function of the study's large sample size and may not be considered clinically significant. The effect of these differences on the study outcome is difficult to determine.

Finally, survival is not the only outcome variable that should be considered. Patient morbidity is an important and more common trauma outcome. Most trauma patients transported by EMS sustain injuries that are not severe enough to result in mortality no matter how long care is delayed. This study of mortality was only a small first step in exploring the effect of time on trauma patient outcome. Additional studies should be conducted and must examine morbidity as an outcome.

CONCLUSIONS

Provider-assigned CUPS status, patient age, ISS, and RTS were found to be significant predictors of adult trauma patient mortality. Total out-of-hospital time was not associated with adult trauma patient mortality.

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