Direct Transport Within An Organized State Trauma System Reduces Mortality in Patients With Severe Traumatic Brain Injury

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Background: Prehospital management of traumatic brain injury (TBI) and trauma system development and organization are aspects of TBI care that have the potential to significantly impact patient outcome. This multi-center study was conducted to explore the effect of prehospital management decisions on early mortality after severe TBI.

Methods: This report is based on 1449 patients with severe TBI (GCS <9) treated at 22 trauma centers enrolled in a New York State quality improvement (QI) program between 2000 and 2004. The prehospital data collected on these patients include time of injury, time of arrival to the trauma center, mode of transport, type of EMS provider, direct or indirect transport, blood pressure and pulse oximetry values, GCS score, pupillary assessment, and airway management procedures.

Results: After exclusion criteria were applied, a total of 1,123 patients were eligible for analysis. The majority of patients were male (75%) with a mean age of 36 years. After controlling for arterial hypotension, age, pupillary status, and initial GCS score, direct transport was found to result in significantly lower mortality than indirect transport. Transport mode, time to admission, and prehospital intubation were not found to be related to 2-week mortality.

Conclusions: The present study provides class II evidence that demonstrates a 50% increase in mortality associated with indirect transfer of TBI patients. Patients with severe TBI should be transported directly to a Level I or Level II trauma center with capabilities as delineated in the *Guidelines for the Prehospital Management of Traumatic Brain Injury*, even if this center may not be the closest hospital.

Key Words: Traumatic brain injury, Transport, Mortality, Prehospital.

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With approximately 50,000 patients dying each year of severe traumatic brain injury (TBI), neurotrauma remains a serious public health crisis requiring continuous improvement in prehospital and in-hospital care.[1] Although the incidence of TBI has decreased over the years, a recent survey shows that TBI patients tend to be older with more severe injuries than before.[2] Pharmaceutical trials have failed to demonstrate any beneficial effect on patients with TBI; therefore the challenge of improving outcome rests on advances in prehospital management, critical care and rehabilitation.

Trauma system development and organization appears to reduce the incidence of death and disability from injury.[3–7] In TBI patients, prehospital hypoxemia and hypotension are important contributors to poor outcome and appropriate and rapid transport of TBI patients to dedicated trauma centers should reduce mortality and improve outcome.[8,9] The *Guidelines for the Management of Severe Traumatic Brain Injury* and the *Guidelines for Prehospital Management of Traumatic Brain Injury* are the first evidence-based guidelines for TBI management.[10,11] The prehospital guidelines are accepted as the standard by prehospital and emergency department clinicians and many medical organizations. However, there is insufficient Class I data to support any standard recommendations for transport decisions.

This multi-center study was conducted to explore the impact of prehospital management decisions and care on early mortality after severe TBI. Within this study Level I and Level II Trauma Centers in New York State have been prospectively tracking their compliance with *Prehospital* and *In-Hospital Guidelines* for the treatment of severe TBI patients since 2000. Using these data we analyzed the effect of prehospital transport decisions, transport times, transport mode, and prehospital intubation on early outcome.

We prospectively hypothesized that indirect transport to a Level I or Level II trauma center via a nontrauma center and greater time to admission would be associated with increased mortality at 2 weeks after injury whereas prehospital intubation would be associated with decreased mortality in patients with severe TBI.

MATERIALS AND METHODS

To track prehospital care and trauma center compliance with the *In-Hospital Guidelines*, the Brain Trauma Foundation (BTF) designed and implemented a quality improvement (QI) program in New York State as part of a cooperative consortium of trauma centers dedicated to improving severe TBI care in the

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acute care setting. The program is funded by the New York State Department of Health, Division of Healthcare Financing and Acute, and Primary Care Reimbursement.

The QI TBI program tracks prehospital and in-hospital severe TBI patient data through an online database called TBI-trac. The database consists of clinical information from the prehospital environment, emergency department (ED), the first 10 days of intensive care unit (ICU) care and 2-week mortality. There are 46 designated trauma centers in New York State, of which two are exclusively pediatric trauma centers. When the study began in 2000 enrollment was limited to five Level I trauma centers. As of December 31, 2004, there were 22 Level I and two Level II participating trauma centers representing 54% of the total trauma centers in the state. This report is based on 1,449 patients treated at these trauma centers between June 6, 2000 and December 31, 2004.

TBI-trac includes all patients with severe TBI who meet the following criteria: arrival at a participating Level I or Level II trauma center within 24 hours of injury and a Glasgow Coma Scale (GCS) score of less than nine for at least 6 hours after injury and after resuscitation efforts including airway management, ventilatory support, and circulatory support. Also, the mechanism of injury must be consistent with trauma. Patients with subarachnoid hemorrhage secondary to aneurysm or stroke are not included. Patients with severe TBI who expired in the ED, or admitted with the diagnosis of brain death, or were transferred to the study hospital more than 24 hours after injury are not eligible for data collection. In addition, nonparalyzed patients with a GCS of three to four and fixed and dilated pupils were excluded from data analysis. These patients were excluded because they would not be expected to benefit from *Guidelines*-compliant care.

The prehospital section of the database includes information on time of injury, time of arrival to the trauma center, mode of transport, type of EMS provider, direct or indirect transport, blood pressure and pulse oximetry values, GCS score, pupillary assessment, and airway management procedures.

The research protocol was approved or deemed exempt from review by the institutional review board at each participating trauma center. To comply with HIPAA regulations, the database contains no patient identifiers and confidentiality is maintained for each center's data.

HOSPITAL TRANSPORT DECISIONS

The *Guidelines for Prehospital Management of Traumatic Brain Injury* recommend that patients with severe TBI (GCS score <9) be transported directly to a facility identified as having the following capabilities: immediately available computed tomography (CT) scanning, prompt neurosurgical care, and the ability to monitor intracranial pressure (ICP) and treat intracranial hypertension.[10] To further characterize transport decisions and their impact on outcome, we differentiated between direct versus indirect transport, time to admission, transport mode, trauma center geography (urban vs. nonurban) and basic life support (BLS) versus advanced life support (ALS) provider.

Direct Versus Indirect Transport

Indirect transport is defined as the transport of a patient from the scene of injury to a nontrauma center first, and then to one of the study trauma centers. Direct transport is defined as the transport of a patient directly from the scene of the injury to one of the study trauma centers.

Time to Admission

Time to admission is defined as the time from injury, based on the time of dispatch, to the time of admission to the study trauma center. Although not specified in the *Guidelines*, a shorter transport time is expected to lead to sooner and more effective treatment of severe TBI patients. We analyzed time to admission as a continuous variable.

Transport Mode

The best mode of transport is not specified in the *Guidelines*. In this study we differentiated between a ground ambulance or private vehicle and air (helicopter or emergency airlift).

Urban Versus Nonurban

An urban center is defined as a trauma center located within the five boroughs of New York City (Manhattan, Queens, Brooklyn, Bronx, and Staten Island). A nonurban center is defined as a trauma center located outside the five boroughs.

BLS Versus ALS

BLS management involves noninvasive treatments such as spinal immobilization, basic airway protection, automated external defibrillators, and medication administration limited to oxygen, albuterol sulfate inhalation, epi-pens, sublingual nitroglycerine, and assisting patients with their own medication under certain conditions. ALS management covers all BLS therapies in addition to a wide range of invasive skills including endotracheal intubation, intravenous cannulation, and medication administration.

TREATMENT: AIRWAY, VENTILATION, AND OXYGENATION

The *Prehospital Guidelines* further recommend that patients with a severe TBI, who demonstrate hypoxia not corrected by supplemental oxygen and those who lack the ability to maintain their own airway have advanced airway management.[9] Advanced airway management is defined as the use of a device (endotracheal tube, laryngeal mask airway, or esophageal tracheal tube) not including oropharyngeal or nasopharyngeal airways to ensure a patent airway. Endotracheal intubation, if available, is the most effective procedure to maintain the airway.[9]

Treatment: Systolic Blood Pressure

The *Prehospital* and *In-Hospital Guidelines* define hypotension as a systolic blood pressure less than 90 mm Hg and recommend that hypotension be avoided or limited to the shortest duration possible. Because of the large amount of missing prehospital blood pressure data, systolic blood pressure values from day one of the in-hospital records were used to control for hypotension in the analysis.

Assessment of outcome patient outcome was assessed through data from the patient record and entered into TBI-trac by the Trauma Program Manager at each of the study trauma centers. Mortality was defined as death within the first two weeks after TBI. Two- week mortality was used because death in the first two weeks is predominately because of the severity of the TBI, whereas 30-day mortality could be related to complications of ICU stay, associated injuries (e.g. pneumonia, pulmonary embolus, sepsis, multiple organ dysfunction syndrome) and co-morbidities perhaps leading to mistaken conclusions about the association between *Guidelines* compliance and mortality. In addition, 2-week mortality data are easily obtained from hospital records, whereas 30-day mortality requires patient follow-up which is burdensome for trauma centers with limited resources.

Statistical Methods

The χ^2 test was used to evaluate the association between prehospital characteristics and direct versus indirect transport status. The Student t test was used for comparing means of continuous variables across groups. Where small sample sizes did not permit the use of the t test, the nonparametric Mann-Whitney (Wilcoxon rank-sum) test was used. Logistic regression analyses predicting two-week mortality were used to estimate the odds ratios, 95% confidence intervals, and p values of the predictor variables, derived from the *Guidelines for the Management and Prognosis of Severe Traumatic Brain Injury*, controlling for age, pupillary status on day 1, hypotension status on day 1 and GCS score on day 1.[10] All statistical tests are two-sided and $p < 0.05$ was considered statistically significant. Analyses were performed in SAS Version 9.1 (SAS Institute, Inc., Cary, N.C.).

RESULTS

Data for 1,449 patients were entered in the database from June 6, 2000 through December 31, 2004. Patients were excluded if they had a GCS score greater than or equal to nine on day one (71 patients), a GCS motor score of six on any day (14 patients). These patients were excluded from the analysis because they do not meet the definition of severe TBI. Patients were also excluded if they had a GCS score of three with pupils bilaterally fixed and dilated and not paralyzed (126 patients), a daily or outcome GCS score greater than or equal to four with pupils bilaterally fixed and dilated or missing pupil information (79 patients), a recorded time to study hospital greater than 24 hours (13 patients), a transport time to study hospital less than 10 minutes (17 patients) or were missing outcome assessment (six patients). After exclusion criteria were applied, a total of 1,123 patients were eligible for analysis. The majority of patients were male (75%) with a mean age of 36 years. The patient demographic and prehospitalization characteristics are shown in Table 1. Direct transport to a Level I or Level II trauma center was more frequent (77%) than indirect, while ground transport occurred in 64% of cases. Transport time was shorter for direct versus indirect transport.

We attempted to determine whether emergency medical services provider (ALS or BLS) influenced 2-week mortality, but 300 (26.5%) patients were missing provider-type information. Among the 829 patients who had provider data, 86.4% were transported by an ALS provider, while 13.6% were by a BLS provider. Although 2-week mortality was not significantly different between the two groups (21.8% and 24.1%, ALS and BLS, respectively) the proportion of patients

Table 1 Demographic and Prehospitalization Characteristics of Study Population

Characteristic	
No.	1123
Age (yr)	
Mean	36.0
SD	20.6
Range	(0.1, 93.7)
	N (%)
Male gender	839 (74.8%)
Race	
White	883 (79.1%)
Black	155 (13.9%)
Other	79 (7.0%)
GCS score	
3–5	541 (53.7%)
6–8	335 (33.3%)
>9	131 (13.0%)
Pupillary abnormalities	184 (20.7%)
Location of center	
Urban	316 (28.1%)
Nonurban	807 (71.9%)
Transport to level I trauma center	
Direct	864 (77.3%)
Indirect	254 (22.7%)
Transport mode	
Air	338 (35.7%)
Ground	608 (64.3%)
Transport time: Direct (hr)	
Mean	1.1
SD	1.5
Range	(0.2, 20.1)
Transport time: Indirect (hr)	
Mean	4.5
SD	3.3
Range	(0.3, 22.7)
Ambulance intubation	441 (42.3%)
No. (%) of those directly transported	346 (41.8%)
No. (%) of those indirectly transported	95 (44.2%)

Table 2 Admission Time to Trauma Center by Transport Mode and Transport Status

	Time (in hrs) to Trauma Center				
	n	Mean*	SD	Median	Range
Direct transport by air†,‡	242	1.3	0.6	1.2	(0.2, 6.2)
Direct transport by ground†,§	464	0.9	1.9	0.6	(0.2,20.1)
Indirect transport by air‡	88	4.0	2.8	3.5	(0.7,22.7)
Indirect transport by ground§	117	4.9	3.7	4.1	(0.3,20.8)

* Difference in means is tested by *t* test: † Air versus ground by direct transport status is significant at $p < 0.001$; ‡ direct versus indirect transport status by air is significant at $p < 0.001$; § direct versus indirect transport status by ground is significant at $p < 0.001$.

transported directly (76.8% and 92.0%, ALS and BLS, respectively; $p < 0.001$) was greater among the BLS group.

Table 2 represents admission time to the trauma center by transport mode and transfer status. Direct transport resulted in significantly shorter mean times to the trauma center when compared with indirect transport, whether transport was by air or by ground (2.7 hours shorter by air versus 4.0 hours shorter by ground, $p < 0.001$ for both modes). Direct transport by ground was also significantly shorter than by air ($p < 0.001$).

Admission time to hospital was shorter by direct transport whether trauma centers were in urban or in nonurban areas ($p < 0.0001$ for both locations). Mean and median times were at least 2.5 hours shorter for direct versus indirect transport (Table 3).

Two-week mortality by transport status to trauma center before adjustment for severity of injury was marginally higher ($p = 0.10$) among patients who arrived at trauma centers by indirect transport (Fig. 1). Except for shorter mean times from injury to admission to the study hospital, patient characteristics were similar among patients transported directly to a study trauma center and those transported indirectly (Table 4). After controlling for arterial hypotension, age, pupillary status, and initial GCS score on day 1, direct transport was found to result in significantly lower mortality than indirect transport (Table 5). Comparison between groups on hypotension status was assessed using systolic blood pressure on day one since 47% of patients were missing prehospital data. The number of patients missing data on prehospital hypotension was greater in those with indirect transport. The difference between the number of patients missing data in the direct and indirect categories was highly

Table 3 Admission Time to Trauma Center by Location and Transport Status

Transport to Trauma Center	n	Time (in hrs) to Trauma Center			
		Mean ± SD	Median	95% CI	*p* Value
Urban center					
Indirect	23	6.4 ± 4.2	6.7	(4.6,8.2)	<0.0001*
Direct	274	0.9 ± 1.8	0.5	(0.7,0.9)	
Nonurban center					
Indirect	224	4.3 ± 3.1	3.6	(3.9,4.7)	<0.0001†
Direct	559	1.1 ± 1.3	1.0	(1.0,1.3)	

* Mann-Whitney Wilcoxon test; comparison of time to study hospital by direct versus indirect transport status for urban centers.
† *t* test; comparison of time to study hospital by direct versus indirect transport status for non-urban centers.

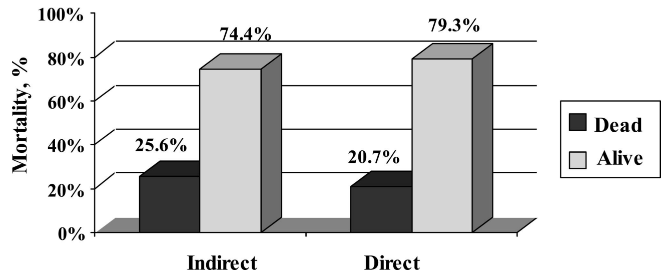

Fig. 1. *2-Week mortality by transport status to trauma center.*

Table 4 Comparison of Patients Transported Directly Versus Indirectly to the Trauma Center

	Direct Transport (%)	Indirect Transport (%)	*p* Value
Number of patients	864 (77.3)	254 (22.7)	
GCS day 1			
3–5	435 (52.0)	118 (47.4)	
6–8	402 (48.0)	131 (52.6)	0.20
Age (yr)	36.5	34.4	0.21
Mean time from injury (hr)	1.1	4.5	<0.0001
Hypotension day 1 (%)	131 (15.3)	28 (11.1)	0.10
Pupillary abnormalities day 1 (%)	185 (21.5)	50 (19.8)	0.56

Table 5 Regression Analyses Predicting Two-Week Mortality

Predictor Variable*	Odds Ratio	95% CI	*p* Value
Direct vs. indirect transport†	1.48	(1.03,2.12)	0.04
Air vs. ground transport‡	1.18	(0.82,1.71)	0.38
Admission time to trauma center§	1.00	(1.00,1.00)	0.25
Prehospital intubation (yes vs. no)‖	0.82	(0.59,1.14)	0.24

* All four models are adjusted for hypotension status on day 1, < or >60 year of age, abnormal or normal pupil status on day 1, and initial GCS in a logistic regression model predicting mortality.
† Reference is direct transport.
‡ Reference is air transport.
§ Odds ratio for each 1-minute increase of admission time to trauma center.
‖ Reference is having prehospital intubation.

significant (44.2% vs. 56.7%, $p < 0.001$). Indirect transport via a secondary hospital was associated with an almost 50% increase in mortality ($p = 0.04$). Transport mode, time to admission, and prehospital intubation were not found to be related to 2-week mortality. We also examined admission time as a categorical variable and found no relation to mortality. Additionally, there was no significant admission time by transport status interaction.

DISCUSSION

The purpose of this study was to prospectively analyze the effect of prehospital transport decisions, transport times, transport mode, and prehospital intubation on early outcome after severe TBI. The New York State TBI database is currently the largest database of its kind and data collection is ongoing. The majority of centers that participated were Level I trauma centers and only two hospitals were Level II centers The demographics of the head-injured population described in this report are representative of other studies with the majority being male and in the younger age group (Table 1). Seventy-seven percent of patients were admitted directly to the trauma center and 23% came from other hospitals that were not part of the study. Transport time was significantly shorter in the direct versus the indirect group (1.1 hours vs. 4.5 hours, respectively; Table 1). The crude mortality was similar between the direct and indirect groups, but after adjusting for confounders that are known to affect outcome from severe TBI, such as age, GCS, arterial hypotension and pupillary abnormalities, direct and indirect transport emerged as being significantly related to mortality.

These results demonstrate that transport decisions in the field are among the most important decisions affecting outcome in patients with severe TBI. The current *Guidelines for Prehospital Management of Traumatic Brain Injury* recommend direct transport of TBI patients to a facility that offers CT scanning, neurosurgical care, ICP monitoring and treatment capabilities.[9] These recommendations were derived mainly through extrapolation from the general trauma literature.[5,11,12] This is to our knowledge the only study that links indirect transport to increased mortality in patients with head injuries.

Little information is available on how transport times and early transport decisions affect the outcome from severe TBI. Young et al. compared trauma patients with Injury Severity Scores less than 15 who were sent directly to a Level I trauma center with patients transferred to the trauma center from another hospital.[11] Excluding patients who died in the first 24 hours, the hospital and ICU stay was shorter in patients who were sent directly to the trauma center. There was no difference in overall mortality but in the group of patients who died within 24 hours there were more unexpected deaths (i.e. patients who die despite the fact that their chance of survival was estimated to be >0.50) in the "transfer" group when compared with the "direct" group. The authors attributed this finding to delays in transfer and concluded that severely injured trauma patients should be transferred directly to a trauma center.

Nathens et al. studied the difference in mortality, length of stay and hospital costs between trauma patients in Washington State admitted directly to a Level I trauma center versus patients transferred to a Level I center from a Level III or IV center.[12] The groups were poorly matched with only 281 patients in the "transfer" group versus 4,439 patients in the "direct" group. Patients in the "direct" group had more severe injuries. After adjusting for confounders in a multivariate analysis, no difference in mortality or length of stay were found, but significantly higher hospital costs were observed in transferred patients.

Sampalis et al. compared outcome of severely injured patients brought directly to a Level I trauma center (n = 2,756) with those transferred from a lower level center (n = 1,608).[5] Although both groups were well-matched, there was a higher rate of head and neck injuries in the "transfer" group as compared with the "direct" group (56% vs. 28%, respectively). Patients with severe head injuries in the "transfer" group were more likely to die than those patients in the "direct" group. Overall, after adjusting for confounders, ICU and hospital length of stay was significantly higher in the "transfer" group; however, there was no difference in mortality.

This study is the first report of prospectively collected data in a database designed to follow head-injured patients. Our findings strongly support that patients with severe TBI should be transported directly to a Level I or Level II trauma center. The increased transport time of 4.5 hours in the "indirect" group may place patients at risk for secondary ischemic events and delays in prompt surgical care that could explain the higher odds ratio for mortality. However, our findings on "time to admission" do not support this conclusion. Against our initial hypothesis time to admission was not related to early mortality. To interpret these results it is important to consider that time to admission in the transfer group includes the time spent at the initial hospital; in the direct group it only includes time from the scene of the injury to the trauma center. Thus, it may be better for a severe TBI patient to spend more time in the ambulance or helicopter to a Level I or II trauma center than it is to spend the same length of time in transfer to a lower level center first. This would identify the transfer via a lower level hospital as an independent risk factor for mortality. Further investigation is also needed to determine the reasons for transport to nontrauma centers.

It is possible that blood pressure, specifically prehospital hypotension is a contributing factor to mortality and further studies should focus on obtaining these data for a more complete evaluation. Does this mean that after severe TBI a closer hospital should be bypassed to bring a patient to a Level I trauma center despite the added time in transport? Based on our findings on the relationship between transport decisions, time to admission and early mortality this seems justified.

In an attempt to explain the decrease in survival associated with indirect admission, we explored the effect of delay in neurosurgical intervention on outcome. Our results demonstrated a similar proportion of patients had ICP monitoring, whether transported directly (40%) or indirectly (39%, $p = 0.80$) to a trauma center. In contrast, of those patients who underwent subdural hematoma evacuation, a significantly greater proportion of patients transported indirectly underwent neurosurgical intervention more than 4 hours after injury when compared with those transported directly (70% vs. 35%, respectively, $p < 0.001$). This increase in time to surgery did not result in a significantly increased risk for mortality ($p = 0.29$) among the patients transported indirectly to the trauma center, although the confidence interval around the odds ratio of 2.2 (0.51–9.5) may be compatible with an increased risk. However, clearly the width of the confidence interval indicates the limited power available for this sub-analysis.

The detrimental impact of hypoxia and hypotension on outcome from TBI in the prehospital phase has been clearly demonstrated in the literature.[7,8] Therefore, the lack of impact of prehospital intubation on mortality was quite striking. Our data showed that overall 42% of patients were intubated with similar proportions in those who were directly and indirectly transported (Table 1). Against our initial hypothesis prehospital intubation was not associated with reduced mortality. However, in the absence of data on oxygenation and intubation success this is difficult to interpret. Prehospital intubation has been discussed controversially in the literature. While some authors found an improvement in mortality with early intubation after severe TBI,[13] others did not confirm these findings.[14,15] Possible explanations include that endotracheal intubation, or the attempt of intubation, carries its own significant risks. In patients with severe TBI intubation may cause increased intracranial pressure.[16] Aspiration and hypoxia during intubation may be detrimental, as could be malpositioning of the endotracheal tube or dislodgement of the tube during transport. Interestingly, increased mortality from TBI after successful rapid sequence intubation in head-injured patients has been linked to more aggressive early hyperventilation and an increased rate in aspiration pneumonia.[17] Our study does not allow us to draw any definitive conclusions on the role of prehospital intubation after severe TBI.

There are a number of limitations to this study. The database was primarily designed to monitor compliance of trauma centers with the *Guidelines for the Management and Prognosis of Severe Traumatic Brain Injury* and the *Guidelines for Prehospital Management of Traumatic Brain Injury*.[9,10] Therefore, some desirable information was not recorded, such as time from injury to transfer to the initial hospital, reason for inter-hospital transfers, vital signs, and neurologic status, resuscitation interventions and time spent at the initial hospital Also, no information was recorded that would have allowed an assessment of the success rate of prehospital endotracheal intubation. Although the potential increases in hospital charges and costs associated with patient transfer has been suggested in the general trauma population,[5,12] we cannot make any statements regarding increases in hospital charges and costs associated with patient transfer. Finally, the amount and the quality of data that can be collected in the prehospital phase are limited because of the special environment of the ambulance and helicopter setting. However, the necessity of accurate and thorough prehospital data are critical to any future research.

CONCLUSION

The present study provides class II evidence that demonstrates a 50% increase in mortality associated with indirect transfer of TBI patients. Patients with severe TBI should be transported directly to a Level I or Level II trauma center with capabilities as delineated in the Prehospital Guidelines, even if this center may not be the closest hospital.

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EDITORIAL COMMENT

We continue to search for the best practice models for emergency medical services (EMS) systems and prehospital management of the injured patient. The study by Hartl and colleagues represents an effort to evaluate prehospital management of a particularly sensitive population; patients with severe traumatic brain injury (TBI).

The goal of the study was to evaluate prospectively the effect of prehospital care on early outcome in patients with severe TBI. The authors hypothesized that patients with severe TBI who were evaluated at a nontrauma center before being transferred to a Level I or II trauma center had an increased mortality at 2 weeks and that prehospital intubation would decrease mortality. The data were extracted from an online TBI database. The results suggest that patients with severe TBI have better outcomes when transferred directly to a Level I or II trauma center versus a nontrauma center.

While the methodology used to reach this conclusion was clear, I was left with several questions. Why were the patients with severe TBI transported to a nontrauma center? Was it unavailability of aeromedical support or a more clinically important factor such as hemodynamic instability or an unstable airway (factors that may affect outcome)? What caused the difference in mortality in the two groups of patients? Was it a time factor or a function of the treatment received at the two different types of facilities? This information may point out changes needed at nontrauma centers to improve the care of patients with TBI and decrease their mortality rate.

The authors stated that EMS personnel transporting patients with severe TBI should by-pass nontrauma centers. Their data support that position; however, I believe this study raises many important questions that should be answered before such a sweeping mandate can be made. I applaud the authors' efforts to show the potential benefits of an organized EMS system and how it may improve the care of severe TBI patients.

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