Clinical Science

Interhospital transfer of blunt multiply injured patients to a level 1 trauma center does not adversely affect outcome

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KEYWORDS: Interhospital transfer; Trauma; Head injuries; Referral; Traumatic brain injury; Imaging

Abstract

BACKGROUND: Stops at nontrauma centers for severely injured patients are thought to increase deaths and costs, potentially because of unnecessary imaging and indecisive/delayed care of traumatic brain injuries (TBIs).

METHODS: We studied 754 consecutive blunt trauma patients with an Injury Severity Score greater than 20 with an emphasis on 212 patients who received care at other sites en route to our level 1 trauma center.

RESULTS: Referred patients were older, more often women, and had more severe TBI (all $P < .05$). After correction for age, sex, and injury pattern, there was no difference in the type of TBI, Glasgow Coma Scale (GCS) upon arrival at the trauma center, or overall mortality between referred and directly admitted patients. GCS at the outside institution did not influence promptness of transfer.

CONCLUSIONS: Interhospital transfer does not affect the outcome of blunt trauma patients. However, the unnecessarily prolonged stay of low GCS patients in hospitals lacking neurosurgical care is inappropriate.

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Despite improvements in trauma care in the last decades, severe trauma remains the leading cause of death for persons between 1 and 45 years of age.\textsuperscript{1,2} The main reasons for the improved outcomes of trauma victims are (1) faster and professional prehospital care; (2) standardization of initial management and diagnostic studies according to widely accepted guidelines such as Advanced Trauma Life Support; and (3) progress in understanding and treatment of complications such as infections and multiple organ dysfunction.
syndrome. Advancements in trauma care occurred concomitantly with the formation of specialized trauma centers and trauma systems that provide highly specialized care around the clock for all possible injuries including advanced intensive care and surgical specialty coverage. It has been proposed that trauma center care results in better outcomes, and they are more cost-effective than nontrauma centers in the treatment of multiply injured patients who require complex treatment by several services such as trauma, neurosurgery, and orthopedics. Because these trauma centers have limited capacity, it is crucial that only patients who require the highest level of care are transported there. For this purpose, trauma systems have been developed, and their effectiveness has been shown in some countries. The purpose of a trauma system is to deliver the right care to the right patient in the right time. Consequently, trauma patients have to be triaged to an appropriate level of care either by paramedics at the accident scene or by physicians in a facility that is not a trauma center. Rapid decision making to transfer a patient is especially important in remote areas where transport times are prolonged. The Centers for Disease Control and Prevention has issued guidelines to assist paramedics to triage the patients to the right level of care. Recent studies indicate that adherence to these guidelines results in improved outcomes in trauma patients. If a patient is initially treated at a nontrauma hospital, there is an ongoing debate about which diagnostic and therapeutic interventions should be undertaken at the outside facility before transfer. Several studies tried to determine if trauma patients initially taken to a nontrauma hospital have a worse outcome than patients who were directly admitted to a trauma center. A recent systematic analysis was not able to determine a survival benefit of patients who were directly admitted to a trauma center.

The purpose of this study was to assess the outcomes of severely injured patients (Injury Severity Score [ISS] ≥20) with blunt injuries who were initially taken to nontrauma hospitals and then referred to a level 1 trauma center and compare them with patients taken directly to the level 1 trauma center to determine if transport to a nontrauma hospital influences outcome. We focused on patients with traumatic brain injuries (TBIs) and how these injuries influenced the referral to the trauma center.

Patients and Methods

This study was approved by the University of Louisville Institutional Review Board. We queried the University of Louisville Hospital Trauma Registry over 2 years from January 1, 2010, to December 31, 2011. This database is maintained by professional registrars who are trained in the acquisition of data related to trauma. The entered data were verified, and data integrity was monitored by a specially trained senior registrar who is certified by the certification program for the Abbreviated Injury Scale (AIS). The University of Louisville Hospital (ULH) Trauma Center is an American College of Surgeons–verified level 1 trauma center. It is the regional level 1 trauma center serving Louisville, Southwestern, and Central Kentucky as well as Southern Indiana and provides care for about 5 million people in a largely rural area.

Kentucky has an organized but not formally legislated and unfunded trauma system. The primary decision to which hospital a trauma patient is transported is made by the ambulance personnel at the accident scene. Patients who are transported with an air ambulance from the accident scene are usually directly flown to a level 1 trauma center. The decision to transfer a patient from a community hospital to the level 1 center is made by the responsible physician in the hospital’s emergency room depending on the patients’ injuries and comorbid conditions. Among the referring hospitals, there is 1 American College of Surgeons–verified level 3 trauma center. The majority of the referring hospitals are medium-sized community hospitals. In addition, there are at least 10 critical access hospitals (<25 beds) in the referral area. Depending on the injuries and comorbid conditions of the patient as well as staff availability in the local hospitals, some hospitals treat trauma patients. All community hospitals except the critical access hospitals have general surgeons on call, and the larger community hospitals are staffed with surgical specialists. Depending on the complexity of the injuries and the availability of intensive care unit (ICU) beds, some community hospitals treat trauma patients.

The database includes demographic data such as age, sex, injury severity, data on mechanisms and cause of accident, means of transportation to the trauma center (air ambulance vs ground transport), temporal information on the time before admission to ULH such as the time of arrival, discharge at the referring hospital, and arrival at ULH. Time at the outside hospital and transportation time were calculated from these data. Furthermore, the registry contains data on initial imaging at ULH, type and time of operations, other interventions such as transfusion of blood products or radiologic interventions (ie angiography), vital signs and Glasgow Coma Scale (GCS) at the accident scene, referring hospital, and ULH. Data on the length of mechanical ventilation, length of treatment in the surgical ICU, and length of hospital stay are recorded. Outcome and the discharge site are also available.

Anatomic injury severity was assessed with the ISS, which is calculated from the 3 most severely injured body regions. Injuries to each body region were assessed with the Abbreviated Injury Scale according to the AIS version 2005 (AAAM, Barrington, IL). The AIS 2008 added additional, more specific descriptions of injuries to allow the assessment and evaluation of long-term effects of each injury but also reassessed the severity of some injuries based on improvements of treatment in recent years resulting in better prediction of mortality. Mainly the severity of some head injuries were reassessed. This reassessment of injury severity results in lower ISS scores compared with previous
years in the database but also with previously published studies with which this study may be compared.

Inclusion and exclusion criteria

Only patients with an ISS greater than 20 were included in this study. We chose to exclude patients with an ISS less than or equal to 20 because we wished to investigate severely injured patients with multisystem trauma or severe single system trauma. Severe trauma was defined by the AIS to each of the 6 body systems (head/neck, face, chest, abdomen, extremities, and skin) with an AIS greater than or equal to 3. Therefore, to achieve an ISS greater than 20, a patient requires at least 1 system with an AIS greater than or equal to 4 plus the second body region with an AIS greater than or equal to 2 or 1 body region with an AIS greater than or equal to 5, which is a severe injury to this particular body region. Penetrating injuries and burns were excluded. Transfers from the referring hospital longer than 12 hours after the initial admission were also excluded. Patients who died on arrival or before arrival at ULH were also excluded because of the lack of accurate information on injuries and patient information.

Hospital charges

Data on claims for reimbursement were available from 1 large insurance provider. Of main interest were the overall charges and to which degree computed tomographic (CT) imaging at the outside facility contributed to the overall charges.

Statistical analysis

In an initial analysis, referred and directly admitted patients were compared directly. In a second analysis, we matched the referred patients 1:1 with directly admitted patients to adjust for differences in injury pattern, age, and sex. Matching criteria were AIS head, chest, and abdomen as well as mechanism of injury, age, and sex. Data are presented as mean ± standard deviation or as indicated. For comparison of 2 groups, the Mann-Whitney U test was used; for multiple comparisons, the Kruskal-Wallis test was applied. To identify significant correlations between 2 parameters, a linear regression analysis was conducted. Independent predictors of death were identified with a stepwise logistic regression. SigmaPlot 11.0 (SyStat Software Inc, San Jose, CA) was used to create the graphs. IBM SPSS 18.0 Statistic Software Package was used for statistical analysis (IBM, Armonk, NY).

Results

A total of 754 patients with an ISS greater than 20 were included in this study. Of these, 212 were transferred from outside facilities within less than 12 hours, and the remaining 542 were directly admitted. Table 1 provides an overview of the included patients. Including all patients, the mean ISS was 28.1 ± 7.6 with a mean age of 47.6 ± 20.7 years. The overall mortality was 22.2%. Referred patients were older and slightly less severely injured but had more severe TBI as measured by the mean head AIS. Directly admitted patients had more frequent and more severe chest, abdominal, and pelvic injuries. Despite these differences in TBI, the GCS at admission at the trauma center was similar (10 ± 5) between patients referred from another hospital and those directly admitted from the scene. The cause of injury in referred patients was falls in 41.5%, whereas falls were the cause of injury in direct admits in less than 15%. Motor vehicle collisions were the leading cause of injury in directly admitted patients. Directly admitted patients

<table>
<thead>
<tr>
<th>Table 1 An overview of the included patients</th>
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<tr>
<td>Referred patients (n = 212)</td>
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<tr>
<td>Age</td>
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<tr>
<td>ISS</td>
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<tr>
<td>Sex (% male)</td>
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<tr>
<td>Head injuries (AIS) (% SD)</td>
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<td>Chest injuries (AIS) (% SD)</td>
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<td>Abdominal injuries (AIS) (% SD)</td>
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<td>Pelvic injuries (AIS) (% SD)</td>
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<td>GCS ULH arrival</td>
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<td>GCS outside facility</td>
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<td>Motor vehicle collision (%)</td>
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<td>Motor cycle accidents (%)</td>
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<tr>
<td>Falls (%)</td>
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<tr>
<td>Other (%)</td>
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Data are stated as mean ± SD or as indicated.

AIS = Abbreviated Injury Scale; GCS = Glasgow Coma Score; ISS = Injury Severity Score; NS = not significant; SD = standard deviation; ULH = University of Louisville Hospital.
were transported with air ambulance in 64.8% compared with 56.1% of the referred patients (\( P = .036 \)). Over half of the referred patients were transferred from hospitals less than 50 miles away from the level 1 trauma center.

**Time at the outside hospital and factors influencing referral time**

Table 2 provides an overview of the time referred patients spent at the outside facility and on transportation. Referred patients spent an average of 157 ± 91 minutes at the outside facility with a wide variation ranging from 12 to 520 minutes. There was no difference of time spent at the outside’s facility emergency room between survivors and nonsurvivors. Analyzing the total time from arrival at the outside hospital to arrival at the trauma center (includes transportation time), nonsurvivors had a shorter pretrauma center treatment time that was statistically significant.

To identify factors that are associated with promptness of referral, we investigated overall injury severity and especially TBI further. Injury severity was not associated with a more rapid transfer (Fig. 1). Patients with low GCS (\( \leq 7 \)) were more rapidly transferred than patients with a GCS of 8 or higher (121 ± 74 minutes vs 164 ± 90 minutes, \( P = .014 \); Fig. 2). However, 37% of the patients with low GCS stayed in facilities without neurosurgical capabilities for greater than 2 hour. Patients with an AIS head of 4 or higher stayed an average of 146 ± 89 minutes compared with 177 ± 92 minutes in patients with an AIS head less than or equal to 3 (\( P = .036 \)). Analyzing the different subtypes of TBIs such as subdural or epidural hematomas, only patients with diffuse severe brain injuries such as axonal injuries or brainstem injuries were significantly more rapidly referred (Fig. 3). There was no difference in the time to referral between subdural, epidural, or intracerebral hematomas. Therapeutic interventions for TBI were not influenced by a prolonged stay at the outside facility with a craniotomy rate for directly admitted patients of 45.9% compared with 54.1% for referred patients. There was no difference between the length of stay at the referring institution in patients who subsequently underwent a craniotomy or intracranial pressure monitoring at the trauma center compared with patients without any intervention for TBI (Fig. 4).

Age was strongly associated with how long a patient stayed at the outside facility (Fig. 5). There was a significant linear correlation between increasing age and time at the referring hospital (\( P < .001 \), slope = .284). Patients older than 65 years stayed an average of 48 minutes longer at the outside hospital (135 vs 183 minutes, \( P = .006 \)).

**Imaging studies at the trauma center and operative interventions**

In this group of severely injured trauma patients, CT imaging was very frequently used. Ninety-three percent of all patients received CT imaging of at least 1 body region at admission at the trauma center; 75% of these initial CT scans were whole-body CT scans. There was no difference for CT scans for any particular body region between referred (91.0%) and all directly admitted patients (93.7%). However, referred patients received more targeted imaging; 84.4% of directly admitted patients received a whole-body CT scan, whereas only 49.2% of referred patients were fully scanned (\( P < .001 \)).

Directly admitted patients were more often operated on within 12 hours after admission (40.4%) than referred

![Influence of Injury Severity on Time at Outside Facility](image-url)

**Figure 1** The time at the referring hospital is correlated with injury severity as assessed by the ISS. A high ISS did not result in faster referral. Data are stated as mean ± standard deviation.
patients (27.8%). Because there is a significant difference in age, sex, and especially injury patterns between referred and directly admitted patients, we matched the 212 referred patients with 212 directly admitted patients. Matching criteria were age, sex, body region of injury, and severity of injury of the involved body region. After this correction, directly admitted patients did not undergo emergency operations more often than referred patients (35.7% vs 27.8%).

Outcome measures

Table 3 shows the average length of mechanical ventilation, length of ICU, and hospital stay in referred and directly admitted patients. There was no difference between the 2 groups for these outcome parameters. The in-hospital mortality was also not different between referred and directly admitted patients (25.9% vs 20.7%, \( P = .12 \)). To address the influence of the different injury patterns and patient characteristics outlined previously between referred and directly admitted patients.

Figure 2 The time at the referring hospital is related to the GCS at the outside hospital. Patients with a GCS less than or equal to 8 stayed an average of 121 ± 74 minutes compared with 164 ± 90 minutes in patients with a GCS greater than 8 \( (P = .014) \).

Figure 3 The duration of stay at the outside facility depending on the type of traumatic head injury. Diffuse brain injuries include diffuse axonal injuries and brainstem injuries. There was no difference in the length of stay at the outside hospital between subdural hematoma (SDH), epidural hematoma (EDH), and intracerebral hematomas. SAH = subarachnoid hematoma.

Figure 4 The duration of stay at the outside facility is related to treatment at the trauma center. There was no difference in the length of stay at the outside facility between patients who subsequently underwent a craniotomy versus patients who did not.

Figure 5 The time at the referring hospital is correlated with the age of the patient. There is a linear correlation of the age of the patient with a prolonged stay at the outside hospital (slope = .284, \( P < .001 \)).
admitted patients, we compared the matched directly admitted patients with the referral group. There was also no difference in the length of mechanical ventilation, ICU stay, and hospital stay between the referred and the matched directly admitted patients. Furthermore, the trend for a lower mortality in the directly admitted patients disappeared completely with 26.8% deaths in directly admitted matched patients compared with 25.9% in referred patients.

**Influence of referral on costs**

The claims for hospital charges of the referring hospital were provided by one large insurance provider. There was a wide distribution of charges from the various referring hospitals. In average, $7,376 ± $6,076 was charged for initial evaluation of these severely injured patients. Of these, CT-imaging at the outside facility accounted for $3,445 ± 3,433, or almost half of the total charges. There was a considerable variation of charges between the institutions ranging from $1,305 to $24,135. The charges did not correlate with injury severity, time spent at the outside facility or distance from the referring institution to the trauma center. Of note, transportation costs were not included in these charges.

**Independent predictors of mortality**

The strongest predictor of mortality was AIS head (odds ratio [OR] = 1.4; 95% confidence interval [CI], 1.2 to 1.5). Other independent predictors for death were AIS abdomen (OR = 1.3; 95% CI, 1.1 to 1.5), ISS (OR = 1.1; 95% CI, 1 to 1.1), and age (OR = 1.03; 95% CI, 1.02 to 1.04). Referral status was not a predictor of mortality.

**Comments**

Trauma care provides any health care system with several challenges. The time from accident to treatment is often a decisive factor in outcomes of trauma victims. Therefore, the initial assessment and triage are pivotal for good outcomes. The goal of triage is to provide a particular patient with the necessary level of care. Severely injured patients should be treated at a trauma center, whereas less severely injured patients can be treated at a lower level of care. We aimed to identify if interhospital transfer results in adverse outcomes and what the associated charges of treatment are before arrival at the trauma center. Furthermore, we sought to identify processes during the referral process that offer opportunities for improvement.

We found that referred patients are significantly older and were more likely to have severe TBI than directly admitted patients. Time at the outside facility correlated only with age of the patient; the older the patient, the longer the stay at the outside ER. Surprisingly, neither injury severity nor GCS was associated with time at the outside hospital. Despite this delay in definite care, mortality was not different between transferred and directly admitted patients. Also, there was no difference in the rate of craniotomies between the directly admitted and referred patients. Interhospital transfer did not adversely affect outcome and only increased costs slightly.

Our study supports recent findings that referred patients are not at an increased risk for mortality as summarized in a recent systematic review. In our study, there appears to be a trend for lower mortality in directly admitted patients, which may reach statistical significance in a larger cohort of patients. However, after correction for age, sex, and injury pattern of the referred patients, this trend disappeared. The fact that there is no survival difference may be caused by improved prehospital and referring hospital care or the high rate of severe TBI in the referred patients. Two recent studies were also not able to identify a benefit of direct admission to a level 1 trauma center in patients with severe TBI. In addition, referral status did not alter the treatment of TBI. Craniotomy was performed in about half of both the referred and directly admitted patients with TBI. Despite this encouraging result that mortality and treatment are not affected by a delay in transfer to a trauma center, there may be more beneficial long-term results with a better functional outcome in directly admitted trauma patients. However, we do not have data on functional outcome in our study. Despite no difference in mortality depending on referral status, the finding of such high mortality rates in patients with TBI is in strong contrast to recent outcomes in military trauma care. Injured soldiers now undergo more aggressive operative treatment for blunt and penetrating head injuries than closely matched civilian trauma patients. Most importantly,

<table>
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<th>Table 3</th>
<th>Outcome parameters of referred and directly admitted patients</th>
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<tbody>
<tr>
<td></td>
<td>Referred patients</td>
</tr>
<tr>
<td>Number of patients</td>
<td>212</td>
</tr>
<tr>
<td>Ventilation days</td>
<td>4.2 ± 8.1</td>
</tr>
<tr>
<td>ICU days</td>
<td>6.9 ± 9.4</td>
</tr>
<tr>
<td>Length of hospital stay</td>
<td>11.3 ± 12.6</td>
</tr>
<tr>
<td>Hospital mortality (%)</td>
<td>25.9</td>
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</table>

Data are stated as mean ± standard deviation or as indicated. ICU = intensive care unit; NS = not significant.
This more aggressive treatment resulted in 3-fold or more reduced mortality for military trauma victims, especially in patients with a high AIS head of 5.20

This study identified 2 potential areas for improvement in the care of severely injured patients: the early identification of patients with severe TBI must be enhanced, and the initial evaluation of elderly patients at outside institutions should be more prompt and decisive. Referred patients were older and suffered more frequently and from more severe TBI than directly admitted patients, suggesting that the clinical recognition of TBI is still a challenge, especially in elderly patients with low impact injury mechanisms such as falls. High-force injuries such as high-speed motor vehicle accidents often result in clinically more obvious injuries such as severe chest, abdominal, or orthopedic trauma with clear clinical signs such as hemodynamic lability and obvious deformities of the extremities. The challenge to identify patients with severe TBI extends into the initial evaluation phase at the referring institution. Only patients with severe TBI such as brainstem or diffuse axonal injuries were referred in less than 2 hours. These injuries usually have strong clinical indicators such as a GCS of 3 and fixed pupils without paralytics or sedating medications. Surgically amenable mass lesions such as epidural or subdural hematomas did not shorten the duration of stay at the outside facility (Fig. 3). Furthermore, a low GCS at the referring institution did only marginally prompt a faster transfer. Patients with a GCS less than 8 stayed an average of greater than 2 hours at the outside facility. The reasons for this delay are unclear. One factor may be decision making and clinical judgment. Mohan et al25 reported that undertriage the failure to triage patients to the appropriate level of care may be caused by failures in clinical judgment and decision making. Rapid evaluation of patients with a low GCS with head CT scans to identify patients with intracranial lesions may prompt a faster transfer of these patients. However, it is important to selectively scan the injured body region because unnecessary CT imaging may also contribute to a prolonged stay at the outside emergency room.2,25 We believe that improvements in prehospital triage and faster recognition and treatment of severe TBI after admission in nontrauma centers may result in improved outcomes.11,20 In addition, applying the concept of fast and more aggressive operative treatment, which has been developed in recent military experiences, in civilian patients with TBI may improve the mortality. Furthermore, DuBose et al20 pointed out that the compliance of civilian neurosurgical care does not often follow closely established guidelines of the Brain Trauma Foundation. Hence, a possible step to improve care of the civilian patients with head trauma may be to apply these guidelines more strictly.

These difficulties in triage are accentuated in elderly trauma patients. These patients usually suffer from low impact injury mechanisms and therefore do not appear to meet criteria for a direct admission to a trauma center. This practice may result in an increased mortality of elderly patients.24,25 We found that referred patients were significantly older than directly admitted patients, indicating that the high injury severity of elderly patients is often not recognized during the initial assessment. These patients are at high risk for intracranial bleeding because of the widespread use of anticoagulation therapy including low-dose aspirin or warfarin.26,27 The correlation of the duration of care at the outside hospital and the increased age of the patients supports this hypothesis (Fig. 5). We believe that physicians should be aware of these challenges in the assessment of elderly trauma patients. Because of the increased life expectancy and more active lifestyle in the elderly population, these patients constitute an increasing group of patients for every trauma service.20 Accounting for these difficulties in the care of elderly trauma patients, it has been proposed that age alone should be an indication for trauma team activation.20 Early aggressive treatment can improve the outcomes of elderly patients.30 Hence, the prolonged stay of elderly patients in referring emergency rooms can be readily improved by increased awareness of the likelihood of severe trauma in these patients despite low impact injury mechanisms. A more aggressive initial evaluation, especially for TBI, and treatment may improve the outcome of these patients.

CT imaging has become the standard to evaluate multiple injured patients in recent years, and early full-body scans in trauma patients appear to improve outcome.31 There are concerns this practice may detrimentally alter the speed of transfer while increasing costs. About half of the imaging studies conducted in referring institutions are repeated at admission at the trauma center.22,23 In our cohort, referred patients had more targeted imaging. Although we lack information on the cause of imaging, a large proportion is likely because of follow-up studies to investigate the development of injuries, such as the progression of intracranial lesions or completion imaging. The charges associated with imaging at the outside institution were about half of the total charges of the referring facilities. Although charges for CT imaging are not high, a more selective use of CT imaging at outside facilities may increase the speed of referral, and direct electronic transfer of obtained images with a written report to the accepting institution may reduce repeat imaging and result in faster operative interventions.33 The reduction of repeat imaging is important because trauma patients are likely to have repeat imaging during their hospital stay for various reasons and the cumulative dose of radiation is likely to ultimately induce cancer in a significant portion of young trauma patients over their lifetime.34,35

Our study has several limitations. The data are gathered from a prospectively collected database maintained by certified coders. Detailed clinical information on the status of the patient at the outside facility and on the decision-making process during the initial evaluation is lacking. Furthermore, we do not have detailed information on diagnostic procedures and therapeutic interventions at the outside institution and how they improved the status of the patient or altered the clinical judgment of the treating physician. In addition, we lack information on patients who may have died before arrival at ULH. We believe that a
small number of patients die because of a delay in care in the outside hospital or en route. Also, because our hospital is based in broadly rural areas with relatively long distance transfers from the referring hospital, we do not know what influence the weather had on choice of mode of transportation. Lastly, we do not have data on the long-term outcome of these severely injured patients. Delays in transfer may not influence mortality, but may result in worse functional recovery.

Conclusion

Referred trauma patients are older and suffer from severe TBI. Faster recognition of these TBI, especially in elderly patients with low impact falls, and rapid transport after selective CT imaging at the outside hospital may improve the outcome of severely injured trauma patients. Future guidelines and recommendation should focus on establishing valid protocols for the initial evaluation including selective imaging studies and rapid transfer of injured patients. Optimally, all CT scans performed in a referring hospital should be forwarded to the trauma center electronically or brought with the patient.

References