Published in final edited form as:

J Pediatr Surg. 2016 February ; 51(2): 323–325. doi:10.1016/j.jpedsurg.2015.10.055.

Pretransfer computed tomography delays arrival to definitive care without affecting pediatric trauma outcomes

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Abstract

Purpose—Children with thoracic or abdominal trauma, presenting to referring hospitals, may undergo CT imaging prior to transfer to a pediatric trauma center (PTC). We sought to determine if children who undergo pretransfer imaging experience a delay in definitive care and worse clinical outcomes.

Methods—Pediatric blunt trauma patients transferred to our level I PTC were identified in this IRB approved study. Those transferred with CT imaging of the chest or abdomen/pelvis prior to transfer were compared to those transferred without imaging.

Results—Of 246 patients with a mean age of 12.4 ± 5.3 years (64% male), 128 patients (52%) underwent chest ($n = 85$) and/or abdominal ($n = 115$) CT studies prior to transfer. Among those patients with pretransfer CT, 14% of CT scans were repeated. On multivariate analysis accounting for distance, time from injury to arrival at our PTC was significantly greater in children who underwent pretransfer CT (320 ± 216 vs. 208 ± 149 minutes, $p < 0.001$). Median length of stay (3 vs. 3 days) and mortality (3% vs. 3%) were similar between groups (all $p > 0.05$).

Conclusions—A substantial number of pediatric blunt trauma patients underwent CT scans prior to transfer, which is associated with a delay in transfer but not worse outcomes.

Keywords

Pediatric trauma; Computer tomography; Transfer; Injury

Trauma is the leading cause of death in children [1,2]. Definitive care at regional pediatric trauma centers (PTCs) has been shown to improve outcomes in injured children [3]; however, children often undergo initial assessment at nearby hospitals prior to transfer to PTCs [4]. Immediate care at local hospitals serves an important role for prevention of early

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deaths. However, the extent of diagnostic tests and interventions should be limited to those necessary to stabilize the patient [5,6].

The use of advanced imaging, including computed tomography (CT), is a major source of transfer delays to PTCs and is often not indicated [7]. Delayed transfer may significantly impact patient care by postponing potentially lifesaving interventions the referring center is not capable of providing. Often times, inaccessibility or poor quality of outside images necessitates repeated studies [8,9] which increases the associated risk of future malignancy [10,11]. The value added by outside imaging studies was recently questioned from a survey finding that physicians at rural trauma centers were more likely to obtain imaging prior to transfer because of liability concerns and perceived expectations of the receiving trauma center rather than a definite clinical indication [12,13].

While it is known that pretransfer imaging delays arrival to PTCs, the impact of this delay on overall time of arrival to definitive care or on clinical outcome remains unknown. As a rural PTC, our institution is the main referral center for pediatric trauma patients transferred from local access hospitals. In this study, we sought to examine the use of a pretransfer CT and the association with clinical outcomes among children transferred to our PTC. We hypothesized that pretransfer CT delays the arrival to PTCs and that this delay would result in increased mortality, intensive care unit (ICU) length of stay (LOS), and overall hospital LOS when compared to children who did not undergo CT prior to transfer.

1. Materials and methods

This was a retrospective observational study of pediatric patients (age 18 years old or less) with a diagnosis of a blunt thoracic and/or abdominal injury transferred to our institution during a 4-year time period (2009–2013). Patients greater than 18 years of age, with head trauma, and with contraindications to CT (i.e. pregnancy, severe contrast allergy) were excluded. Patients that underwent CT of the chest and/or abdomen/pelvis prior to transfer were compared to those without a pretransfer imaging study. The primary study outcome was the time interval between injury and time of arrival to the PTC. The secondary outcomes included the need for surgical intervention, ICU LOS, overall hospital LOS, and mortality rate.

1.1. Data collection

Patient medical records were reviewed to abstract data on demographics, mechanism of injury, injury severity score (ISS), interval time from time of injury to time of arrival at the level one trauma center, CT scans obtained at referring center or PTC, number of duplicate CT scans, ICU LOS, total hospital LOS, and mortality rate. This study was approved by the Mayo Clinic Institutional Review Board.

1.2. Statistical analysis

The data were analyzed to compare the difference in the interval time for transfer and secondary outcomes between those who underwent a CT scan before versus after arrival to the PTC. Data are presented as mean $\pm$ standard deviation for continuous variables and as percentages for categorical variables. Between group comparisons employed the Student's t-

test for continuous data and the chi-square test for categorical data. The nonparametric analog tests were used when appropriate (Wilcoxon rank-sum test and Fisher's exact test, respectively). The statistical significance was set at an alpha of 0.05 with a two-sided alternative hypothesis. Statistical analysis was performed using Stata statistical software, version 13.1 (StataCorp, College Station, TX).

2. Results

2.1. Cohort characteristics

There were 246 blunt thoracic or abdominal trauma pediatric patients transferred to our institution during the study period (Table 1). CT scans were performed in 128 (52%) patients prior to transfer, while the remaining 118 (48%) patients underwent their first CT scan at the PTC. Outside CT scans were transferred from a cloud based server from linked outside hospitals or on CD files from unlinked hospitals. There was no difference in the mean age of patients with (12.1 ± 4.9) and without (12.7 ± 5.6) a pretransfer CT ($p = 0.4$). Patients with a pretransfer CT scan were more likely to be transferred from a facility a further distance from our PTC (96 ± 109 vs. 71 ± 43 miles, $p = 0.02$). Ninety patients were female (37%). The most common mechanisms of injury included motor vehicle crashes (37%), all-terrain vehicle crashes (12%), falls (8%), bike crashes (7%), motocross crashes (5%), recreational sports injuries (6%), and injuries from animals (4%). The average injury severity score was 13.4 ± 9.3 . The mode of patient transfer was predominantly ground (56%), with 44% transferred by helicopter. Overall patient mortality was 3%.

2.2. Pretransfer CT imaging studies

A pretransfer CT imaging study ($n = 128$) was performed in 35 patients (27%) that met level 1 activation criteria and in 41 patients (32%) that met level 2 activation criteria. Among the 128 patients with pretransfer imaging studies, 85 underwent a chest CT, and 115 underwent an abdomen/pelvis CT.

2.3. Outcomes

2.3.1. Time interval of transfer—Time spent at the initial facility prior to transfer (2.9 ± 1.7 vs. 1.6 ± 0.6 hours, $p < 0.05$) and total time from injury to arrival at the PTC (5.3 ± 3.6 vs. 3.5 ± 2.5 hours, $p < 0.001$) was greater in children who underwent pretransfer CT than those who did not. Patients who underwent pretransfer CT were more likely to require surgical intervention (7% versus 1%, $p = 0.04$) than those who did not (Table 2). There were no significant differences in ICU admissions, ICU or total hospital LOS, or mortality between those who underwent pretransfer CT and those who did not.

2.3.2. Repeat imaging and clinical outcomes—Repeat CT scans were obtained in the Emergency Department after arrival from the referring facility for 12 of 85 chest CTs (14%) and 16 of 115 abdominal/pelvic CTs (14%) (Table 3). Additional CT scans obtained in the ICU or general care floor for changes in clinical condition were not categorized as repeat scans. Median ICU LOS (1 vs. 1 day, $p = 0.52$), median hospital LOS (3 vs. 3 days, $p = 0.84$), and mortality (2.5% vs. 3.1%, $p = 0.41$) did not differ between the groups.

3. Discussion

Advanced Trauma Life Support (ATLS) guidelines recommend against advanced imaging prior to transfer of pediatric trauma patients unless it is required for stabilization. Despite the guidelines, our data demonstrate that a significant number of transferred pediatric blunt trauma victims continue to undergo pretransfer CT imaging at the referring center. Pretransfer imaging was associated with increased time spent at the referring facility and delayed transfer to our PTC. Many children underwent repeat CT at the PTC. However, pretransfer imaging was not associated with differences in mortality, ICU admissions, or hospital length of stay. Patients who underwent pretransfer CTs were more likely to undergo surgical intervention at the PTC.

In 2004, Fenton et al. [14] published their experience with CT examinations prior to transfer for definitive trauma care at Primary Children's Medical Center in Salt Lake City, Utah. They reported that 9% of the patients who were transferred after undergoing CT examinations required repeat scanning. However, the majority of these repeat scans were of the head. Patients who underwent CT imaging prior to transfer experienced a significantly delayed field time compared to those who were transferred without CT examination (5.21 vs. 4.14 hours).

Cook et al. [9] reported an even higher rate of repeat CT scans from their experience at the University of North Carolina at Chapel Hill. Of 199 patients who underwent abdominal CT scans prior to transfer, 36 (18%) required a repeat scan upon arrival to Chapel Hill. These additional scans resulted in an additional 180 mSv of cumulative radiation and more than \$110,000 in additional costs.

We report a comparable rate of repeat CT scans. Of the 128 patients who underwent imaging prior to transfer, 12 (14%) underwent repeat chest CT scans and 16 (14%) underwent repeat abdomen/pelvis CT scans. In the current study, head CTs, including repeat head CTs for evolution of intracranial bleeding, were not examined. While many hospitals in our regional trauma system are able to share digital imaging and clinical information, we still report a high number of repeat scans. The reason for the repeat scans was caused by delays uploading data or inadequate quality of outside films in contrast to new or progressive findings. We anticipate children treated in areas without regionalized trauma systems may have an even greater risk of duplicate imaging. Furthermore, if pediatric trained providers at PTCs are the ones to determine imaging decisions, the rate of initial CT scans would likely be lower. Unnecessary exposure to radiation is especially concerning in the pediatric population, given the increased risk for development of future malignancy [11].

Children transferred to our rural PTC experienced similar delays secondary to unnecessary imaging as major urban centers [7,8,14]. We did not, however, find ISS to influence use of pretransfer CT as has been previously reported [7]. This may be caused by sample size as the pretransfer CT imaging group did have a higher ISS, but the difference did not reach statistical significance. Furthermore, patients who underwent pretransfer CT were more likely to undergo surgical intervention at our PTC, which may imply that these patients presented with more severe injuries. Despite the longer times to definitive care experienced

by patients who underwent pretransfer CT, there was not a significant difference in clinical outcomes between cohorts.

In 2014, Benedict et al. reported their experience out of Tufts Medical Center in Boston, Massachusetts, following the Department of Public Health's statewide trauma triage guidelines. The guidelines specify the anatomic, physiologic, and mechanistic criteria for stabilization and immediate transfer to a pediatric trauma center without pretransfer CT imaging. Of the patients who were scanned prior to transfer to Tufts, 66% met the criteria for immediate transfer but underwent CT imaging anyways.

Within our regional trauma system, we advise providers to immediately transfer patients to our facility, following stabilization, without advanced imaging if they meet criteria for level 1 or level 2 activation. In this retrospective review, approximately 60% of our patients who underwent CT examination prior to transfer had met criteria for immediate transfer after stabilization. These data suggest that more education is needed throughout our regional trauma system and across the country at large. Many providers at referring institutions feel that they are expected to obtain imaging prior to transfer so that the tertiary center can begin making preparations. Others use advanced imaging to rule out trauma in an attempt to avoid unnecessary transfers.

A significant limitation of this study is that we did not have access to regional data to determine how effective CT scans are for preventing unnecessary transfers. We were not able to review patients who underwent CTs at outside hospitals and were not transferred to our PTC because of the scan results. It is possible that a number of CTs prevented unnecessary transfers. Nonetheless, if a patient meets the criteria, they should be transferred to a PTC without imaging. Following this guideline will decrease time to definitive care, avoid unnecessary repeat CT scans, and likely decrease the number of scans in general.

In conclusion, a significant number of pediatric blunt abdominal and thoracic trauma patients undergo CT prior to transfer to definitive PTC care. Despite the delays in transfer associated with obtaining these scans, measured clinical outcomes were not significantly different between the two groups.

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Table 1

Demographics and comparison of time to arrival at pediatric trauma center of patients with and without pretransfer CT imaging.

	With CT prior to PTC (<i>N</i> = 128)	Without CT prior to PTC (<i>N</i> = 118)	<i>p</i> Value
Age (years)	12.1 ± 4.9	12.7 ± 5.6	<i>p</i> = 0.4
Female sex (%)	51 (40)	39 (33)	<i>p</i> = 0.3
ISS	14.5 ± 9.6	12.3 ± 8.9	<i>p</i> = 0.07
Time to arrival at PTC (hours)	5.3 ± 3.6	3.5 ± 2.5	<i>p</i> < 0.001
Time at outside facility (hours)	2.9 ± 1.7	1.6 ± 0.6	<i>p</i> < 0.001
Distance from outside facility (miles)	96 ± 109	71 ± 43	<i>p</i> = 0.02

Table 2

Outcomes for patients with and without pretransfer CT scans.

	With pretransfer CT (N = 128)	Without pretransfer CT (N = 118)	p Value
ICU Admission	66 (51%)	58 (49%)	$p = 0.7$
Surgical intervention	9 (7%)	2 (1%)	$p = 0.04$
Median ICU length of stay in days (range)	1 (0–50)	1 (0–12)	$p = 0.95$
Median hospital length of stay in days (range)	3 (1–62)	3 (1–62)	$p = 0.30$
Mortality	3 (2.5%)	4 (3.1%)	$p = 0.78$

Table 3

Incidence of duplicate imaging for patients who underwent CT scans prior to transfer to PTC.

	Patients who underwent prehospital CT (N = 128)	No prehospital CT (N = 118)	p Value
Received an initial chest CT scan at OSH <i>or</i> upon arrival at PTC	85	83	$p < 0.01$
Received an initial abdomen/pelvis CT scan at OSH <i>or</i> upon arrival at PTC	115	109	$p < 0.01$
Duplicate CT in the PTC ED			
Chest	12	NA	NA
Abdomen	16	NA	NA
Additional CT in the PTC ICU			
Chest	3	0	$p = 0.04$
Abdomen	9	1	$p < 0.01$
Additional CT on the PTC general care floor			
Chest	1	1	$p = 0.9$
Abdomen	5	2	$p = 0.2$