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Cervical spine computed tomography utilization in pediatric trauma patients

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ABSTRACT

Background: Guidelines for evaluating the cervical spine in pediatric trauma patients recommend cervical spine CT (CSCT) when plain radiographs suggest an injury. Our objective was to compare usage of CSCT between a pediatric trauma center (PTC) and referral general emergency departments (GEDs).
Methods: Patient data from a pediatric trauma registry from 2002 to 2011 were analyzed. Rates of CSI and CSCT of patients presenting to the PTC and GED were compared. Factors associated with use of CSCT were assessed using multivariate logistic regression.
Results: 5148 patients were evaluated, 2142 (41.6%) at the PTC and 3006 (58.4%) at the GED. Groups were similar with regard to age, gender, GCS, and triage category. GED patients had a higher median ISS (14 vs. 9, $p < 0.05$) and more frequent ICU admissions (44.3% vs. 26.1% $p < 0.05$). CSI rate was 2.1% (107/5148) and remained stable. CSCT use increased from 3.5% to 16.1% over time at the PTC (mean 9.6% 95% CI = 8.3, 10.9) and increased from 6.8% to 42.0% (mean 26.9%, CI = 25.4, 28.4) at the GED. Initial care at a GED remained strongly associated with CSCT.
Conclusions: Despite a stable rate of CSI, rate of CSCT increased significantly over time, especially among patients initially evaluated at a GED.

Trauma is one of the most common causes of morbidity and mortality in the pediatric population. Differences exist in the frequency of injury and type of injuries between pediatric and adult blunt trauma patients. The largest prospective study of cervical spine injury (CSI) performed in the United States found a rate of 1% among patients less than 18 years of age compared to 2.4% among patients 19 years and older [1–3]. Though CSI rates are lower in pediatric patients, they have higher rates of ligamentous injury due to increased ligamentous laxity [4]. For these reasons, differences may exist in the evaluation of CSI in pediatric and adult patients.

Due to significant morbidity and mortality from CSI, care must be taken in the evaluation of patients with potential CSI. Several studies have attempted to determine which patients require radiographic evaluation of the cervical spine. The largest of these, The National Emergency X-Radiography Utilization Study (NEXUS), developed a set of criteria to define patients at low risk for CSI, however, the study investigators recommended caution when using these criteria with children given the lower numbers of enrolled patients < 18 years [5].

Several studies suggest that cervical spine CT (CSCT) is a more efficient and effective screen for CSI in the adult patient [6–8]. These studies have led to changes in the recommendations of the American College of Surgeons Committee on Trauma on the evaluation of the cervical spine for injury to include routine use of CSCT for adult blunt trauma patients [9]. These are in contrast to current published guidelines recommending that pediatric blunt trauma patients be screened initially using plain radiography with adjunctive CT of select areas if concern for injury exists [10–12]. These guidelines are based on a published sensitivity of plain radiography for CSI in pediatric blunt trauma patients between 89% and 95% [13–15].

As the use of CT in evaluating the adult blunt trauma patient has increased, there is also evidence that the use of CT in the evaluation of children is on the rise [16,17]. CSCT results in a significant increase in the dose of ionizing radiation to the thyroid compared to that seen with cervical spine radiography CSXR [18,19]. This higher dose along with increased usage could lead to a significant overall exposure of ionizing radiation to the pediatric population [20,21].

The objective of our study was to compare the utilization of CSCT and plain radiography between a pediatric trauma center (PTC) and referral general emergency departments (GEDs) in a pediatric trauma

Abbreviations: CSI, Cervical Spine Injury; CSCT, Cervical Spine Computed Tomography; CSXR, Cervical Spine Radiographs; GED, General Emergency Departments; PTC, Pediatric Trauma Center; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; AIS, Abbreviated Injury Scale.

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population. We hypothesized that referral GEDs utilize CT more often to screen the cervical spine for injury among their pediatric trauma patients compared to the PTC.

1. Methods

This study was a retrospective review of patient medical records and radiographic studies of trauma patients evaluated at Primary Children's Medical Center (PCMC), an American College of Surgeons Level 1 pediatric trauma center (PTC) between January 1, 2002 and December 31, 2011. This study was approved by the University of Utah Institutional Review Board.

2. Data source

The PCMC trauma registry is a database containing patient information, physiologic data and clinical outcomes including survival status at hospital discharge and duration of hospital stay. Patient data from medical charts are abstracted and entered directly into the trauma registry by registrars who have completed the Abbreviated Injury Scale (AIS) Course through the Association of the Advancement of Automotive Medicine. For the purposes of this study, all patients with a level-1 or -2 trauma activation were enrolled. PCMC employs commonly used criteria to define trauma activation levels: Trauma 1: shock, significant penetrating injury, acute intracranial hematoma with mass effect, obvious severe open cranial injury, intubation, GCS <10, traumatic paralysis, proximal extremity amputation, or traumatic arrest. Trauma 2 activations include GCS 11 to 14, severe hypothermia, stable with multiple injuries or high-energy mechanism of injury [22]. Trauma 3 patients are stable, without the above criteria and were not included in our study. We obtained and analyzed data from the registry including demographics; year of enrollment, measures of injury severity including Injury Severity Scores (ISS), AIS for head and neck injury; mechanism of injury; emergency department disposition; hospital of initial presentation; use of CSXR and CSCT; presence and type of CSI; operative management of CSI. CSI was defined as any fracture, ligamentous injury with and without subluxation, spinal cord injury, spinal cord injury without radiographic association (SCIWORA), or a combination of these. Cervical spine strain was not considered a CSI for the purposes of this study.

3. Data analysis

Our primary outcome was the percentage of patients with a CSCT on initial evaluation at the PTC or GED and the change in that percentage over time. For the purposes of this study, patients who presented to the PTC after an evaluation at a GED without a CSCT were classified as no CSCT. Secondary outcomes included use of CSXR to evaluate the cervical spine, incidence of patients with CSI and operative management for CSI.

Descriptive statistics, including medians, interquartile range, and percentages were initially calculated for gender, age, GCS, mechanism of injury, ISS, Head injury AIS, emergency department disposition, and trauma level categorization as a function of initial site of care (i.e., PTC vs. GED). Preliminary analyses to test for group differences between PTC and GED patients were also conducted. These included Mann Whitney U test for age, a chi-square test for gender, and contingency tables for GCS, mechanism of injury, CSI, ISS, Head Injury AIS, disposition, and trauma level categorization.

To test whether certain factors were associated with use of CSCT, we calculated odds ratios (ORs) and corresponding 95% confidence intervals (CIs) for the predictor variables using multivariate logistic regression modeling. In the model, we dichotomized age into two categories: less than 8 years and equal to or greater than 8 years as this is the age when children become anthropomorphically similar to adults with the cervical spine fulcrum located at the C3–C4 level [23]. Similarly we dichotomized GCS into <12 and 13 or above, a cutoff frequently used to distinguish patients with more mild traumatic brain injury from those with more moderate to severe injury. ISS and Head Injury AIS were also dichotomized for the purposes of the multivariate regression. Factors tested in the model included age, gender, initial site of care, year, presence of CSI, GCS, ISS, Head Injury AIS, and trauma triage category. Reference categories were age < 8 - years, male, PTC, year 2011, no CSI, GCS ≥ 13, ISS <15, Head Injury AIS <3, and Trauma Level 2. All statistical analyses were performed using SPSS (SPSS, Inc., Chicago, IL, Version 20.0).

4. Results

During the study period, a total of 5148 Trauma I and II patients were evaluated at the PTC. Of those patients, 2142 (41.6%) presented directly to the PTC and 3006 (58.4%) were evaluated initially at a GED. The patient characteristics of the two groups are presented in Table 1. The groups were similar with regard to age, gender, and initial GCS upon presentation. Patients evaluated at a GED had a higher median ISS (14 vs. 9, $p < 0.05$) and median AIS for head and neck injury (3 vs. 2, $p < 0.05$). They were more likely to be admitted to the ICU (44.3% vs. 26.1%, $p = 0.001$) and have non-accidental trauma as their mechanism of injury (5.3% vs. 1.4%, $p < 0.001$). Over the study period, ISS for both PTC and GED patients remained stable.

4.1. Use of radiographic imaging

Over the study period, a total of 15.2% (CI = 14, 16) of patients had CSR at the GED compared to 76.2% (CI = 74, 78) at the PTC. The proportion of patients with CSCT at the PTC increased from 3.5% to 16.1% (mean 9.6% 95% CI = 8, 11) compared to the GED where utilization increased from 6.8% to a maximum of 42.0% (mean 22.6%, CI = 25, 28) over the study period. Fig. 1 shows the trend of utilization of CSCT during the study period. A comparison of PTC and GED patients who underwent CSCT is shown in Table 2. The two groups were similar with regard to percent with CSI, median Head AIS, and percent admitted to the ICU. Patients undergoing CSCT who presented to the PTC tended to be older (median years 11 vs. 8), and had a lower median ISS (14 vs.16) than those presenting to the GED.

4.2. Rate of CSI

Overall, 120 (2.3%) patients had a cervical spine injury. Total percentage of patients with CSI over the study period presenting to the PTC was 1.4% compared to 2.6% of patients presenting to the referral GED ($p < 0.05$). Despite mild fluctuations, overall the

Table 1
Comparison of Patient Characteristics between PTC and GED.

Hospital	PTC (n = 2142)	GED (n = 3006)
Patient Characteristics		
Age, median years (IQR)	8 (3, 12)	6 (2, 11)
Male % (95% CI)	63.1% (60, 65)	64.9% (63, 67)
C-spine Injury % (95% CI)[a]	1.4 (1, 2)	2.6 (2, 3)
GCS, median (IQR)	15 (14, 15)	15 (14, 15)
Injury Severity Score, median (IQR)[a]	9 (5, 17)	16 (9, 21)
Head Injury AIS, median (IQR)	2 (2, 3)	3 (3, 4)
Admission to ICU % (95% CI)[a]	26.1 (23, 28)	44.3 (41, 45)
Admitted directly to OR % (95% CI)[a]	9.1% (2, 4)	11.6.% (6, 8)
Trauma 1 Activation % (95% CI)[a]	18.0 (34, 39)	24.1 (17, 21)
Mechanism of Injury		
MVC % (n)	27.3 (585)	27.2 (610)
Fall % (n)	19.1 (410)	25.1 (756)
Pedestrian % (n)	13.6 (293)	8.2 (247)
Sports Injury % (n)	13.8 (296)	7.3 (220)
Non-Accidental Trauma % (n)[a]	1.4 (36)	5.3 (160)

[a] $p < 0.05$.