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Limiting thoracic CT: a rule for use during initial pediatric trauma evaluation☆,☆☆

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ABSTRACT

Background: Despite increases in imaging guidelines for other body-regions during initial trauma assessment and the demonstrated utility of chest radiographs (CXR), guidelines for use of thoracic computed-tomography (TCT) are lacking. We hypothesized that TCT utilization had not decreased relative to other protocolized CTs, and mechanism and CXR could together predict significant injury independent of TCT.

Methods: We performed a retrospective review of blunt trauma patients ≤18 y.o. (2007–2015) at two level-1 trauma centers who received chest imaging. Baseline characteristics and incidences of body region-specific CT were compared. Injury mechanism, intrathoracic pathology, and interventions among other data were examined (significance: $p < 0.05$).

Results: Although other body-region CT incidence decreased ($p < 0.05$), TCT incidence did not change ($p = 0.65$). Of the 2951 patients, 567 had both CXR and TCT, 933 received TCT-only, and 1451 had CXR-only. TCT altered management in 17 patients: 2 operations, 1 stent-placement, 1 medical management, 9 thoracostomy tube placements, and 4 negative diagnostic workups. All clinically significant changes were predicted by vehicle-related mechanism and abnormal CXR findings.

Conclusions: TCT utilization has not decreased over time. All meaningful interventions were predicted by CXR and mechanism of injury. We propose a rule, for prospective validation, reserving TCT for patients with abnormal CXR findings and severe vehicle-related trauma.

Level of evidence: Diagnostic study, Level III.

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Despite its low incidence in children (5–12%), significant blunt thoracic injury has been reported to have a high mortality [1–4]. As thoracic computed tomography (TCT) is a sensitive screening tool for occult injury [5], there has been a notable trend toward increasing use of TCTs and decreasing use of chest radiographs (CXRs) for initial trauma evaluation. [6] Pediatric trauma, however, differs from that of the adult as a result of the unique mediastinal, vascular, and chest wall characteristics of children that lower frequency of severe thoracic injury [7,8]. Recently, the known risk of ionizing radiation exposure [9], and the fundamentally different injury pattern in children have called into question frequent utilization of TCT for pediatric trauma. Although these factors would suggest limiting the use of TCT, many institutions have not implemented imaging guidelines for thoracic trauma as has been the case with many other body region modalities. Additionally, some have shown that implementation of a body-region specific protocol can indirectly decrease utilization of CT in pediatric trauma evaluations [10], however it is not certain whether this effect has extended to TCT.

Recently, several studies have demonstrated relatively minimal added value from TCT use in initial pediatric trauma evaluations and have instead advocated for the restriction of TCT to only those patients found to have mediastinal widening on CXR, as this can be a harbinger of great vessel injury [7,11,12]. However, given the low incidence of aortic injury in pediatrics and the demonstrated association of blunt aortic injury with normal screening CXRs [13], it may be necessary to identify other factors associated with severe thoracic injury before restricting TCT use to only those with mediastinal widening on CXR. While previous evidence has demonstrated that vehicle-related trauma is the

Abbreviations: CT, Computed tomography; TCT, Thoracic computed tomography; CXR, Chest radiograph; ISS, Injury Severity Score; MVC, Motor vehicle collision; PvA, Pedestrian vs. automobile; ATLS, Advanced trauma life support.

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most common mechanism associated with severe pediatric thoracic injury such as aortic dissection [14–19], mechanism itself has not been explicitly studied as a potential factor to consider when determining whether a TCT is likely to change clinical care.

Our objectives were to 1) assess the potential value of developing a TCT protocol at our institution by determining if TCT utilization had already decreased in the setting of targeted reductions in other imaging modalities, and 2) to examine the benefit of using mechanism of injury along with screening CXR to develop guidelines for thoracic CT. Overall, we hypothesized that mechanism of injury and abnormal chest radiograph findings together could predict the need for TCT in the initial trauma evaluation.

1. Materials and methods

We conducted our study at two Level-1 trauma centers in Portland, Oregon (Center 1 = Doernbecher Childrens' Hospital/Oregon Health and Science University; Center 2 = Randall Childrens' Hospital/Legacy Emanuel Medical Center). IRB approval was obtained at both institutions (Center 1: STUDY00015150; Center 2: 1348–2016). All pediatric trauma patients, defined as patients ≤18, were identified through each center's trauma registry.

To assess our first objective, determining whether targeted reductions in CT use were associated with any changes in TCT utilization, Center 1 alone was analyzed. Center 1 began standardizing region-specific CT other than chest, such as CT of the cervical spine, in 2010. Therefore, imaging incidences of body region-specific CT were compared at Center 1 across the study period to determine the impact of these protocols. Center 2 was not included in this analysis because it did not begin using guidelines for body-region specific CT use until after the study period ended. Data on CT-scan utilization was pulled directly from the trauma registry, as the type of imaging obtained was recorded for each entry. The proportion of patients who received each type of imaging was calculated and the Cochran-Armitage test of trend was used to determine if there were significant trends in the rate of imaging use over the study period.

We then conducted a historic cohort study of all blunt trauma activations for patients ≤18 years that involved a TCT and/or a CXR. Both trauma registries (Center 1 and Center 2) were used to identify patients and a retrospective chart review was completed to allow for comparison of imaging findings and clinical interventions. Activations from 2007 to 2015 were identified from Center 1, and in order to ensure that the study was adequately powered to identify clinically relevant thoracic trauma, activations from 2009 to 2015 at Center 2 were also included. Center 2 trauma patients from 2007 to 2008 were not included, as their registry data was incomplete prior to 2009. All patients who experienced a penetrating injury, drowning or hanging were excluded. Blunt trauma was defined as motor vehicle crash, pedestrian struck, fall, crush injury, sports injury, non-penetrating animal injury, non-penetrating assault, and non-accidental trauma.

Patient characteristics including age, sex, Injury Severity Score (ISS), injury mechanism, intrathoracic pathology, transfer status, interventions, readmissions for intrathoracic complaints, and death were examined for all patients. Trauma history and physician exam notes were used to identify those patients who received imaging as part of their initial trauma evaluation. Only those patients who received CXRs and/or TCTs as part of their initial trauma evaluations were included in the study. The subjects were then divided into three cohorts according to the imaging obtained in the initial trauma evaluation: those who received CXR and TCT, those who received TCT-only, and those who received CXR-only. The time at which imaging occurred was examined for all patients. Interventions undertaken to manage thoracic trauma were defined as operation or procedure for intrathoracic injury, tube thoracostomy, targeted medical management (i.e. blood pressure control) or additional diagnostic study.

For the CXR and TCT group, subjects were only included if the CXR occurred prior to the TCT. These were further sub-divided according to the findings on both CXR and TCT: those that were concordant and those that were discordant (Fig. 1). These groupings were then separated according to the value added by the TCT. The concordant group was separated into *Both Negative* (TCT added no value) and *Both Positive* (TCT confirmed CXR findings). The discordant group was separated into *No change in management* (TCT provided new information without change in management), and *Change in management* (TCT provided new information that resulted in a change in clinical management). An intervention was classified as a change in clinical management resulting from TCT if pathologic imaging findings that led to intervention were not noted on prior CXR, or other imaging, and the intervention occurred after TCT to address discordant findings. Time stamps on imaging, notes and orders were used to establish a temporal chain of events. This definition was chosen because while it would rule patients who had physiologic changes into the *Change in management* sub-group thus potentially biasing the results toward CT utility, this would ensure no patients were inappropriately ruled-out of the *Change in management* subgroup.

Patients in the CXR-only and TCT-only groups were divided into those with negative and positive findings. Those subjects who received CXR without chest CT were evaluated for any missed intrathoracic injuries resulting in delayed procedures or operations, further diagnostic tests, or readmissions for intrathoracic injury. Those subjects who received TCT without prior CXR were examined to determine if their severity of injuries and interventions differed significantly from the other two cohorts, possibly explaining the decision to forgo the use of screening CXR.

All statistical analyses were performed with STATA 14. Trends were evaluated using the Cochran-Armitage test and the Mantel–Haenszel test of trend. Oneway ANOVA with Bonferroni pairwise comparisons, Kruskal-Wallis, χ^2, Fisher's exact test, z-test of proportions with Bonferroni correction, and Mann–Whitney tests were used where appropriate. Statistical significance was set at $p < 0.05$.

2. Results

2.1. Imaging trends

In Center 1, guidelines for CT-Cervical Spine use in trauma had been instituted early in the study period. This led to a significant decrease over the study period in CT-Cervical Spine ($p < 0.001$). However, although there was a similar downward trend of CT-Head ($p < 0.001$), CT-Abdomen ($p = 0.03$), and CT-Pelvis ($p = 0.02$) usage, we did not find a significant downward trend in thoracic CT use ($p = 0.65$) (Fig. 2). Of note, there was a significant decrease in the use of CXRs ($p < 0.001$), that may have been a result of an interim statewide teleradiology initiative [10]. Additionally, a comparison of the trends of those who received TCT and those who received CXR and TCT revealed the existence of a sub-group of patients who received thoracic CT without prior CXR, which was then included in our subsequent analysis.

2.2. Historic cohort study

2.2.1. Overall cohort characteristics

A total of 6861 pediatric patients, ≤18 years, presented to the two Level 1 trauma centers during the respective study periods. Of these, 2951 were evaluated with either or both TCT and/or CXR during their initial trauma evaluation, 1451 of which were evaluated with CXR-only, 933 with CT-only, and 567 with both CXR and TCT (Fig. 1).

Overall, the median age on presentation was 13 (IQR:6, 16), the majority were male (65.0%, n = 1919), 32.6% (n = 961) were transfer patients, and the median ISS was 9 (IQR:4, 17). Motor vehicle collision (MVC) was the most common mechanism of injury (34.3%, n = 1011), followed by falls (23.1%, n = 682), sports-related injuries (16.5%, n = 487), Pedestrian vs. Automobile (PvA) (15.6%, n = 459), and other, including assault, non-accidental trauma (NAT), crush, and

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