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Review of Interventions and Radiation Exposure from Chest Computed Tomography in Children with Blunt Trauma

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Objective To determine the radiation risk to a child undergoing trauma evaluation with chest computed tomography (CCT) for every clinically actionable injury identified.

Study design This observational, cross-sectional study included all blunt trauma patients under 18 years of age undergoing CCT in a single urban emergency department. Via a retrospective chart review, therapeutic interventions done exclusively for chest injuries identified on CCT scan were identified. Effective radiation from each CCT was calculated and averaged and the dose required to diagnose 1 management-changing chest injury was determined.

Results Of 209 children undergoing CCT over a 19-month period, 168 were victims of blunt trauma. Ten required an intervention specifically for a chest injury identified on CCT (suggesting development of 1 malignancy per 37 actionable injures identified). None required an intervention for an injury exclusively noted on CCT, as all 10 actionable injuries were apparent via other modalities (radiograph, ultrasound examination, clinical examination).

Conclusion Although 10 uniquely actionable injuries were identified on CCT, none were found only on CCT. Because CCTs rarely modified management, the amount of radiation administered per management change was sufficiently high to recommend reconsideration of current imaging practice in this single-center study. *(J Pediatr 2018;■■:■■-■■).*

The necessity of chest computed tomography (CCT) scanning for children after blunt trauma is poorly studied, and primarily focuses on the presence of injury, not clinical significance. However, often injuries such as pulmonary contusions and pneumothoraces are unlikely to require an intervention unless clinically overt or noted on ultrasound imaging or chest radiography (CXR).[1-3] In a prospective trial, the NEXUS Chest CT group identified nearly all patients with clinically major injuries while avoiding CCT scans for patients without an abnormal chest radiograph, distracting injury, chest wall tenderness, sternal tenderness, thoracic spine tenderness, or scapular tenderness.[4] Although a useful decision-making aid, it is designed for use and studied in patients over the age of 14 years. The pediatric literature is mainly composed of smaller case series. There is no question that performance of CCT scans will identify thoracic injuries.[5] However, traumatic aortic injury is rare in children,[6] and several studies have found that the CCT scan added little additional information over and above the CXR in the identification of other injuries.[7-10] These studies reported variable rates of abnormal findings on CT (20%-89%), only one addressed management changes based directly on CT abnormalities, and none quantified the endpoint of radiation risk. Additionally, 82% of patients with chest injuries are impacted by multisystem injury,[11] with mortality as high as 25%, primarily from intracranial injuries.[12] Therefore, many chest injuries are inadvertently treated by interventions performed for an unrelated injury (eg, intubation for head injury) and resolve without unique intervention.

Despite the equipoise as to the clinical usefulness of the CCT scan in pediatric patients with blunt trauma, chest and spine CT use increased 50% and 4- to 9-fold, respectively, from 1996 to 2010.[13] Protocols vary among institutions, and in extreme cases, some centers report delivering as much as 20 mSv of radiation in 3%-8% of their pediatric CCT scans.[13] Even conservative radiation protocols for CCT scans can lead to a 0.31% increased lifetime cancer risk in an infant girl.[14] The goal of this study was to determine the rate at which positive CCT scans in pediatric blunt trauma victims predicted major unique chest-related interventions and the amount of radiation delivered to the pediatric population with blunt trauma per actionable injury identified.

ACT	Acute chest trauma
BEIR	Biological Effects of Ionizing Radiations
CCT	Chest computed tomography
CT	Computed tomography
CXR	Chest radiography
ED	Emergency department

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Methods

The primary outcome measure calculated was milligray of effective dose delivered per major chest-related intervention required.

This study was performed at a level 1 trauma center (level 2 pediatric trauma) with a dedicated trauma surgery service and pediatric emergency department (ED). Although there is no standard trauma bay protocol, with ideal staffing, the traumas are run by a senior resident with attending oversight. The trauma team is immediately present for any trauma meeting county prehospital trauma team activation criteria. Radiographs are taken at the discretion of the treating physician. The number of pediatric traumas under 18 years of age ranged from 612 to 748 per year from 2015 to 2016 per trauma registry criteria, with a 46% overall admission rate. Institutional review board approval was obtained.

The electronic radiology system (Synapse) was queried for all CCT scans performed on patients under 18 years of age from October 2015 through April 2017 (19 months), based on the data available in the current electronic medical record system and the radiology system. The indication was confirmed using the radiology order and the medical notes, and penetrating trauma or nontrauma patients were excluded. Patients less than 18 years of age undergoing CCT scans for an acute blunt trauma were included in the final analysis. Only the first CCT scan was included for any patient.

A data dictionary was created and data were collected from the electronic medical record by 2 medical students and 2 attending physicians from the pediatric ED. The primary investigator performed training for the medical students and the second physician and was present for much of the data collection.

ED, inpatient, and radiology records were reviewed. Details regarding the accident type, mental status of the patient, initial signs and symptoms, involvement of the surgical service, and CXR and CT scan with radiation dose were recorded. Complaints of thoracic pain or difficulty breathing were considered symptoms and thoracic skin findings (bruising, laceration, abrasion), tenderness, and crepitus were considered signs. Obtunded and preverbal patients were not considered capable of reporting symptoms, but signs were still reported to the extent possible. Missing data were rare, because the electronic medical record has a trauma template driving documentation. Interventions performed on the patient, including surgery, intubation, blood transfusion, oxygen administration, chest tube placement, and thoracotomy, were also recorded. Patients were followed through their ED and hospital stay; no further follow-up was performed.

CT Scans and Radiation Dose

Scans were obtained on a Toshiba 64-slice scanner (Canon Medical Systems, Tochigi, Japan) with injection of Omnipaque (GE Healthcare, Chicago, Illinois). Volume computed dose index and dose length product were reported in points milligray and milligray per centimeter. The effective radiation dose was calculated using the dose length product multiplied by an age-based effective thoracic diameter and a conversion factor based on a 16 cm phantom for less than 15 kg and 32 cm for greater than 15 kg,[15] consistent with the programming on the scanner used. Therefore, the "effective dose" of radiation reported is the actual dose of radiation administered to the patient based on the computer-reported dose manually adjusted for size. Typically, but not always, both the cumulative radiation from the CT scan of the chest/abdomen/pelvis, as well as the contribution of the individual components are reported by the computer. In the cases in which the only the cumulative radiation was reported, individual components required estimation. A priori, the plan had been to calculate the average of the ratio of radiation from chest to abdomen/pelvis on the cases in which it was reported, then to apply that to the balance of the patient sample to extrapolate the amount of total radiation from the CCT scan versus abdomen/pelvis CT scans. When this was discovered to be much higher than anticipated owing to institution-specific protocols (49%), a more conservative estimate of one-third was used instead to prevent overestimation of the amount of radiation from a CCT scan.[16]

Definitions and Risk Estimates

The CT scan was determined to be positive if any finding was noted; however, it was considered to be acute chest trauma (ACT) positive only if pulmonary contusions; pulmonary lacerations; mediastinal and vascular injury; sternal, scapular, thoracic spine or rib fractures; or larger than trace pneumothoraces, hemothoraces, or diaphragm injuries were noted. Incidental findings and injuries not typically diagnosed with CT scan (eg, clavicle injuries) were not considered ACT positive. Findings at or above T9 were attributed to the CCT scan, rather than the abdomen/pelvis CT scan.

Surgery, intubation, blood transfusion, oxygen administration, chest tube placement, and thoracotomy were determined a priori to constitute major interventions. Because the institutional admission rate is nearly 50% for pediatric trauma, admission was not considered a major intervention. It was determined from the chart if these were due to a chest abnormality or another reason primarily using the indication on the procedure/operative notes (eg, intubation for poor neurologic status). Only interventions performed primarily for chest-related reasons were counted. For example, if a patient with a pulmonary contusion was intubated for a Glasgow coma scale of 3, and required no additional pulmonary intervention, this was not considered a chest-related intervention. Oxygen was considered an intervention only if in response to hypoxemia or respiratory symptoms, not if started empirically or was given during or immediately after sedation.

Patients were considered to have achieved the primary outcome measure if an ACT-positive scan was associated with delivery of a major chest-related intervention. However, other diagnostic modalities were also recorded, including identification of the actionable injury by CXR, ultrasound imaging, or clinical examination.

Biological Effects of Ionizing Radiations (BEIR) VII provides a method to calculate the cancer risk above baseline for a single exposure. Lifetime cancer risk estimates over baseline for a 10-year-old boy and a 10-year-old girl from the BEIR

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