Injured Children Receive Twice the Radiation Dose at Nonpediatric Trauma Centers Compared With Pediatric Trauma Centers

SA-CME

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Abstract

Background: Use of cranial CT scans in children has been increasing, in part due to increased awareness of sports-related concussions. CT is the largest contributor to medical radiation exposure, a risk factor for cancer. Long-term cancer risks of CT scans can be two to three times higher for children than for adults because children are more radiosensitive and have a longer lifetime in which to accumulate exposure from multiple scans.

Study Aim: To compare the radiation exposure injured children receive when imaged at nonpediatric hospitals (NPHs) versus pediatric hospitals.

Methods: Injured children younger than 18 years who received a CT scan at a referring hospital during calendar years (CYs) 2010 and 2013 were included. Patient-level factors included demographics, mode of transportation, and Injury Severity Score, and hospital-level factors included region of state, radiology services, and hospital type and size. Our primary outcome of interest was the effective radiation dose.

Results: Four hundred eighty-seven children were transferred to the pediatric trauma center during CYs 2010 and 2013, with a median age of 7.2 years (interquartile range 5-13). The median effective radiation dose received at NPHs was twice that received at the pediatric trauma center (3.8 versus 1.6 mSv, $P < .001$). Results were confirmed in independent and paired analyses, after controlling for mode of transportation, emergency department disposition, level of injury severity, and at the NPH trauma center level, hospital type, size, region, and radiology services location.

Conclusion: NPHs have the potential to substantially reduce the medical radiation received by injured children. Pediatric CT protocols should be considered.

Key Words: Effective radiation dose, nonpediatric hospitals, CT scan

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BACKGROUND

CT use in children has increased, due in part to increasing concussion concerns, paralleled by emergency department (ED) visits [1-3]. During 2009 to 2010, traumatic brain injury was evaluated in 4.8 million ED visits, and 82% of these evaluations included a CT scan [4]. Among injured children, head CT utilization is greater at hospitals with lower pediatric volumes, at

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community hospitals, and by providers without pediatric residency training [5]. Ionizing radiation from medical imaging now accounts for nearly half of the radiation exposure experienced by the US population [6,7]. CT scans are the greatest contributor to medical radiation exposure, which can increase cancer risk. Long-term cancer risks for children can be two to three times higher than for adults [8] because children are more sensitive to radiation and have a longer lifetime in which to accumulate exposure from multiple CT scans [6,9,10].

The ACR and American Association of Physicists for Medicine support the "as low as reasonably achievable" (ALARA) principle, which urges providers to use the minimum level of radiation needed in imaging examinations while maintaining diagnostic quality [11]. The use of optimized technical parameters focused on lowering tube current and tube voltage have demonstrated the reduction of radiation exposure in children by up to 65% [12-14].

Adoption of dose reduction imaging protocols has been variable with most success at pediatric hospitals and trauma centers [15]. The majority of pediatric trauma patients are managed at nonpediatric hospitals (NPHs), usually the nearest hospital after a traumatic event where children are transported for stabilization and evaluation. More seriously injured children are often transported to pediatric trauma centers (PTCs) for definitive care. It therefore follows that the majority of CT scans are performed at NPHs. In addition, results from our preliminary study demonstrated that a statewide image repository reduced the rate of CT scans repeated at a PTC by half [16].

Few studies have compared the radiation exposure between children imaged at NPHs and children imaged at pediatric facilities [5,10,16]. Most studies have used estimates for radiation dose [5,10]. We sought to use clinical radiology matrices, a more precise set of exposure metrics, to evaluate variability in CT scan exposure and to compare the CT scan radiation exposure of children imaged at NPHs and children imaged at a pediatric hospital using an optimal scanning protocol (OSP). We hypothesized that CT scans performed at NPHs would have higher radiation doses compared with CT scans performed at the children's hospital.

METHODS

Data Sources

We conducted a cross-sectional study using administrative data from the pediatric trauma registry and clinical data from the PACS. All children who met the state trauma system's definition of a traumatic injury (trauma team activation, penetrating injuries, and ED deaths) were included in the registry. The trauma registry is housed at the only level I PTC in the state, which receives injured children from 64 accredited trauma system facilities. A dedicated trauma team manages the pediatric trauma registry to ensure the timeliness, accuracy, and completeness of the registry.

Patient and Variable Selection

Our state trauma system comprises 64 trauma centers; these include 6 level I, 5 level II, 18 level III, and 35 level IV hospitals [12] served by 62 EDs. Among these are two PTCs and one burn center [17]. The second PTC is located in a neighboring state.

All injured children under 18 years of age who met the trauma criteria, underwent CT imaging, and were transferred to the PTC from an outlying hospital during calendar year (CY) 2010 and CY 2013 were included. The image repository was created in July 2011, and we allowed for a year of full implementation across the state. All children transferred to the PTC arrived in the ED, where additional imaging, if required, is typically performed before the child is discharged to the intensive care unit, operating room, admitting floor, or home.

Independent patient-level factors studied as potential covariates included age, race, gender, mode of transportation, Injury Severity Score (ISS), and ED disposition. ISS was categorized as mild (1-8), moderate (9-16), severe (17-25), and life-threatening (>26). Hospital-level factors studied included the region of the state, hospital type (urban, rural, critical care access, or community), hospital size (large, medium, and small), and location of radiology services (in-house or outsourced). Hospital size was based on the Healthcare Cost and Utilization Project definition and was nested in location and teaching status [18]. Our primary outcome of interest was the effective radiation dose (ERD).

Optimal Scanning Protocols (OSPs)

The CT scan protocols (referred to as OSPs) used at the PTC are institution-specific and partly based on the ACR protocols. Radiology clinicians in collaboration with equipment manufacturers developed the protocols through a quality improvement process. The protocols use dose modulation and iterative reconstruction. Additionally, the protocols require the following: (1) Radiologists' approval is obtained for repeat scans if warranted