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CT Scan Effective Radiation Dose Reduction in Pediatric Trauma Patients

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☒ By checking this box, I indicate that my mentor has read and reviewed my draft proposal prior to submission

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ABSTRACT

This project attempts to address the problem of excessive radiation exposure via CT imaging for pediatric patients presenting at adult regional trauma centers.

To answer this question, we utilized the pediatric trauma registry to conduct a retrospective chart review of consisting of all patients under 14 years of age that received trauma related CT imaging and that were transferred from an adult trauma center to Dayton Children's Hospital in the time period of January 2019 to December 2019. Cases of unnecessary imaging will be determined by subject matter expert review, based on ACS and Image Gently guidelines. Cases of overexposure to radiation were determined via DLP and effective radiation dose, in conjunction with subject matter expert review.

Results showed that 48 pediatrics patients were transferred to Dayton Children's Hospital from 12 different adult trauma, from January to December 2019. In total, 118 scans were performed on these 48 patients. Of these, 41 scans were identified as an opportunity for improvement. The most common opportunity for improvement was a reduction in unnecessary cervical spine scans.

From a patient safety perspective, this project emphasizes the need for increased knowledge of pediatric imaging guidelines at adult trauma centers. Such knowledge includes knowing when a scan can be reformatted from an existing image, as well as an understanding of weight-based pediatric imaging. A follow up project could be to assess for change after implementation of guidelines at the adult trauma centers.

Key Words: Pediatric, Trauma, CT Scan, Effective Radiation Dose

STATEMENT OF PURPOSE

The QI project, CT Scan Effective Radiation Dose Reduction in Pediatric Trauma Patients, was completed in conjunction with Dayton Children's Hospital and the Southwest Ohio Regional Trauma System (SORTS) Committee. The project attempted to address the problem of excessive radiation exposure via CT imaging for pediatric patients presenting at adult regional trauma centers.

This project aimed to propose pediatric CT imaging guidelines based on the American College of Surgeons and Image Gently guidelines. Specifically, this project offered evidence for adoption of weight-based pediatric imaging CT protocols, as well as, offered pediatric imaging guidelines based on the combination of American College of Surgeons and Image Gently guidelines. This project will also suggest educational training opportunities for trauma centers to recommend to CT technicians.

INTRODUCTION & LITERATURE REVIEW

As the frequency of imaging continues to increase in the United States, the health risk of radiation also continues to increase.[1] Exposure to radiation is especially concerning in pediatric populations as their long lifespan creates an increased risk for the accumulation of genetic mutations and oncogenic effects.[2] These mutations can result in cancer later in life – the estimated risk of radiation-induced fatal cancer for pediatric CT scans is 10 times higher than that of adult scans.[3] Studies have also found differences in scanning guidelines between adult and child facilities, potentially posing even greater risks for pediatric patients being seen at an adult facility.[4] That is, adult facilities may not be aware of proper pediatric scanning guidelines due to low pediatric patient volume. Finally, physicians in the emergency and trauma setting are subject to both the chaos and fatigue of their environment with can contribute to clinical

decisions that are not evidence-based, such as excessive ordering of pediatric CT imaging.[5,6] A study conducted by medical students at the Boonshoft School of Medicine, in conjunction with Dayton Children's Hospital, found the above concerns hold true in the Dayton region as well.[7]

While there are many approaches to the problem of high effective radiation dose in children, the largest area of opportunity is to simply eliminate unnecessary radiation exposure through evidence-based clinical decision-making guidelines from entities such as the Image Gently Campaign and the American College of Surgeons.[8,9] This project synthesized guidelines from both the Image Gently Campaign and the American College of Surgeons for distribution to the regional trauma centers whom are participating. The purpose of distributing these guidelines is an attempt to fill a possible knowledge gap among adult trauma center providers.[10] Another method of reducing effective radiation dose is via weight-based pediatric imaging protocols. Weight-based imaging is the practices of adjusting the amount of radiation used during a CT scan for that patient's mass.[9] That is, weight-based pediatric imaging would require CT software that allows for changes in radiation dose, based on a patient's size. These changes can readily be recorded and validated using dose-length product. Weight-based pediatric imaging protocols are suggested as a fundamental improvement that can be made at adult medical facilities, if not already in place.[9] The significance of this project lies in the benefit of future patients who may be exposed to less radiation following education on weight-based protocols for CT scans and utilization of scanning guidelines in the pediatric population at adult medical facilities.

METHODS

Context

This project utilized a trauma registry dataset consisting of all patients under 14 years of age that received trauma related CT imaging of the head, neck, chest, and abdomen/pelvis in the time period of January 2019 to December 2019. 14 years of age was selected to minimize

individuals with adult-size body habitus.[10] The dataset was the result of retrospective chart review assessment completed using EPIC charting and the Pediatric Trauma Registry on Dayton Children's Hospital computers. All data was deidentified. The dose length product (DLP) that measures radiation energy transfer to a plastic cylinder in the CT scanner was used to compare radiation exposure to patients at all facilities. The effective radiation exposure calculation was a product of research previously conducted at Dayton Children's Hospital.[7] The resulting trauma registry data set was used to identify instances of unnecessary scanning and/or instances overexposure to radiation.

Cases of unnecessary imaging were determined by subject matter expert review, based on ACS and Image Gently guidelines. The subject matter expert for this project was Elizabeth Ey, MD, Chief of the Division of Pediatric Radiology at Dayton Children's Hospital. Cases of overexposure to radiation were determined via DLP and effective radiation dose, in conjunction with subject matter expert review. Cases of both unnecessary imaging and overexposure to radiation were circulated to each participating trauma center.

Once instances of unnecessary scanning/overexposure were identified we explored recent literature for possible causes of the identified trends. Finally, recommendations on areas of opportunity were made based on American College of Surgeons/Image Gently campaign guidelines. Recommendations were made in the form of a pediatric imagining guidelines to decrease unnecessary scanning, as well as, specific changes for each participating trauma center.

Planned Interventions

Development of evidence-based pediatric CT imaging guidelines to decrease instances pediatric radiation overexposure. Specifically, this project offered pediatric imaging guidelines based on the combination of American College of Surgeons and Image Gently guidelines, as

well as, evidence for adoption of weight-based pediatric imaging CT protocols. This project also suggested educational training opportunities for trauma centers to recommend to CT technicians.

Study of the Interventions

The study of the interventions proposed in this project will be conducted as a secondary research project. The reason for this includes time to implement interventions, time for data to accumulate after interventions have been put in place, and time to analyze the new data post-intervention. This future study will include a measure of unnecessary imaging to evaluate the usage of pediatric imaging guidelines, a measure of overexposure to radiation to evaluate the effectiveness of weight-based pediatric imaging protocols, and a measure of implementation of pediatric imaging guidelines.

Measures

Measures chosen for studying processes and outcomes of the intervention (rational, operational definitions, validity and reliability)

- Dose length product (DLP)
    - Rational Definition: measures radiation energy
    - Operational Definition: measures radiation energy transfer to a plastic cylinder in the CT scanner was used to compare radiation exposure to patients at all facilities
    - Used to calculate effective radiation dosage

- Effective radiation dosage
    - Rational: The amount of radiation a patient receives.
    - Operational: Radiation dosage corrected for with the DLP.
    - Used to determine cases of overexposure to radiation, per subject matter expert review

Content validity was established through subject matter expert review by Elizabeth Ey, MD, Chief of the Division of Pediatric Radiology at Dayton Children's Hospital. All patients pulled from the pediatric trauma registry query were validated against the EHR.

Analysis

Excel was utilized to visualize and analyze data. We produced counts of CTs performed by each individual trauma centers. Excel was used to calculate effective radiation dose using dose length product and an equation developed by a previous medical student project.[7] Finally, this equation and individual patient chart review in the EHR were used to analyze and identify instances of unnecessary imaging or excessive radiation exposure.

RESULTS

Utilizing Microsoft Excel to analyze our data, our results showed 48 pediatrics patients were transferred to Dayton Children's Hospital from 12 different adult trauma, from January to December 2019. A total of 118 scans were performed on these 48 patients. Of these, 41scans were identified as an opportunity for improvement per radiologist review. The most common opportunity for improvement was a reduction in unnecessary cervical spine scans. These opportunities for improvement are discussed in the "Discussion" section. From January 1, 2019 to December 31, 2019 the most common scan performed on pediatric patients transferred to Dayton Children's hospital were head CTs (44), cervical spine CTs (23), and abdominal CTs (13). These were followed by pelvis CTs (12), face CTs (12), and chest CTs (9). All other CT scan types had few observations. The complete individual results for each participating regional adult trauma center can be found in Table 1.

Table 1. Total Number of Pediatric CT Scans Completed for Patients Transferred to Dayton Children's Hospital, January – December 2019

Trauma Center	CT Head	CT Abd.	CT Pelvis	CT Chest	CT Face	CT C. Spine	CT T. Spine	CT L. Spine	CT Orbit	CT Neck	Total
Hospital A	4	3	3	3	3	6	1	0	0	0	23
Hospital B	1	0	0	0	0	0	0	0	1	0	2
Hospital C	1	0	0	0	0	1	0	0	0	0	2
Hospital D	7	1	1	1	1	3	0	0	0	0	14
Hospital E	2	1	0	0	1	1	0	0	0	1	6

Hospital F	1	0	0	0	0	0	0	0	0	0	1
Hospital G	1	0	0	0	0	0	0	0	0	0	1
Hospital H	1	0	0	0	0	0	0	0	0	0	1
Hospital I	14	5	5	2	3	6	0	0	0	0	35
Hospital J	3	1	1	1	2	2	0	0	0	0	10
Hospital K	2	1	1	1	1	2	0	0	0	0	8
Hospital L	7	1	1	1	1	2	1	1	0	0	15
Totals	44	13	12	9	12	23	2	1	1	1	118

DISCUSSION

Analysis of the CT scans revealed 41 opportunities for improvement between the 12 adult trauma centers. The two most common opportunities for improvement were related to spinal CT (24) and delayed scans (8). Spinal CTs were an opportunity for improvement for nearly every trauma center. Spinal CTs are an opportunity for improvement because it was an unnecessary scan for many patients, and hence unnecessary exposure to radiation. Spinal CTs are often considered unnecessary per the American College of Surgeons and the Image Gently campaign because they can often be reformatted from existing images.[11] For example, if a patient received a head CT, the cervical spine CT was also captured in many cases. A radiological image of just the cervical spine could be formatted from the head CT, in this scenario. Similar scenarios include abdominal scans for the thoracic spine and pelvis scans for the lumbar spine. Reformatting the spinal image from existing scans is a powerful way to reduce pediatric radiation exposure.

The second most common opportunity for the regional adult trauma centers to improve imaging of pediatric patients it to avoid delayed scans. Per the American College of Surgeons and the Image Gently Campaign guidelines, single phase scanning is the standard in pediatric imaging.[11]

There are other general causes of excessive effective radiation dose in the setting of an adult trauma center. One factor is the high pressure and fast-paced nature of the emergency and trauma departments.[6] Working in this environment can lead to decision-making fatigue and lower quality of care for patients. Another factor is the seemingly low priority on radiological training among resident emergency physicians.[12,13] Both Baloescu and Dym suggest that radiological training may not be a priority because resident physicians do not seem to improve their radiological decision making when comparing their CT offering practices at the beginning and the end of residency. Finally, the lack of pediatric weight-based protocols can contribute to a general increase in effective radiation dose among pediatric patients.[9]

The individual opportunities for improvement for each trauma center can be found in Table 2. These opportunities for improvement were circulated to each respective trauma center in the form of a letter. They synthesized guidelines and recommended educational materials were also circulated. The individual opportunities for improvement for each respective trauma center can be found in Table 2.

Limitations in this study include: Does not include all pediatric patients that presented at adult trauma centers, only those transferred to Dayton Children's Hospital; a limited number of patients transferred from some trauma centers; given different scanning machines and differing scanning protocols at each adult trauma center, effective radiation dose can only be estimated via calculation.

Moving forward, the next steps for this project include implementation of the synthesized guidelines to address the opportunities for improvement at each respective trauma center, data collection after implementation, and finally analysis of this data to evaluate the effectiveness of

the distributed guidelines. The effectiveness of the guidelines would be assessed in terms of number of inappropriate scans and in terms of scans with an excessive effective radiation dose.

Table 2. Opportunities to Improve Pediatric Scanning Practices at Participating Regional Trauma Centers, January – December 2019

Trauma Center	CT Head	CT Abd.	CT Pelvis	CT Chest	CT Face	CT C. Spine	CT T. Spine	CT L. Spine	CT Orbit	CT Neck	Total
Hospital A	0	3	3	3	1	5	0	0	0	0	15
Hospital B	0	0	0	0	0	0	0	0	0	0	0
Hospital C	0	0	0	0	0	1	0	0	0	0	1
Hospital D	0	0	0	0	0	3	0	0	0	0	3
Hospital E	0	0	0	0	0	1	0	0	0	0	1
Hospital F	0	0	0	0	0	0	0	0	0	0	0
Hospital G	0	0	0	0	0	0	0	0	0	0	0
Hospital H	0	0	0	0	0	0	0	0	0	0	0
Hospital I	0	1	1	2	0	6	0	0	0	0	10
Hospital J	0	0	0	1	0	1	0	0	0	0	2
Hospital K	0	0	0	1	0	2	0	0	0	0	3
Hospital L	0	0	0	1	0	3	1	1	0	0	6
Totals	0	4	4	8	1	22	1	1	0	0	41

CONCLUSION

This project has highlighted the need for increased knowledge of pediatric imaging guidelines in the region's adult trauma centers. These guidelines can educate providers and help them address areas of improvement such as reformatting spinal scan from existing scans, when possible, as well as generally opting for single-phase rather than delayed scanning in pediatric patients. Finally, these guidelines also introduce and provide education on pediatric weight-based imaging that may not already be in place at said regional trauma centers. Should these guidelines be successfully implemented, future pediatric patients will benefit by receiving a decreased effective radiation dose.

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