Working Face-to-Face for Pediatric CT Dose Reduction: A Community Toolkit

Although children are especially vulnerable to the health risks of ionizing radiation, approximately 8 million CTs are performed on children in the USA. Widespread dose variation is common, particularly in non-pediatric focused facilities. In this article we present our rationale and hands-on approach in developing and refining a toolkit aimed at helping a community hospital with pediatric CT dose reduction.

INTRODUCTION

"Is this a private fight or can anyone join in?"
— Unknown Irish man who saw a fight and inquired [1]

In the USA concerns about potential radiation-induced cancer from CT scans continue to intensify in the public domain, as evidenced by recent articles in the New York Times [2] and Washington Post [3]. Over the past three decades the number of CT scans has increased dramatically, with current estimates at almost 5 million scan per year in the UK and about 85 million per year in the US [4]. U.S. population doses are at a historic high, with radiation exposure from medical sources having increased 600% since the 1980s [5,6]. The greatest contributor to the striking increase in population exposure in the US is the CT scan [7]. Dose levels for CT of the body in the USA remain substantially higher than those in Europe [8]. In the US, the average person has a CT every four and a half years and receives an annual dose from medical exposure of 3.2 mSv, in comparison with the UK where the average citizen has a CT every 17-18 years and the average annual dose from medical exposure is 0.4 mSv [8]. Dose variations between countries may be secondary to normative differences and cultural contexts. For example, in the USA, the practice of defensive medicine to reduce the threat of litigation [9] promotes high levels of image quality which may exceed diagnostic requirements. Coupled with this constraint is the absence of formal consideration of radiation dose in the justification process for each patient. In Europe, radiation dose is enshrined in medical exposure legislation and "requires optimization to be undertaken using diagnostic reference levels (DRLs)
The practice of using the same radiation exposure factors for CT examinations as those for adults is not uncommon, resulting in much higher doses of radiation than are necessary for an adequate level of image quality [17,18]. A recent study canvassing a large research network of health maintenance organizations in the USA found that many children received high radiation doses from CT scans [19]. This finding was attributed to both the greater use of higher-dose CT examinations, such as scans of the abdomen and pelvis, and to substantial variability in radiation doses [5]. The investigators projected that if radiation doses nationwide reflect the doses they observed for CT scans of the head, abdomen/pelvis, chest, and spine for children, then the scans performed in one year in the United States might cause 4,870 future cancers [5]. The investigators suggested that if the highest 25% of doses can be reduced to the median dose, then 43% of those cancers might be prevented [5]. Of the estimated 8 million CTs performed on children in the USA, up to 6.8 million are performed at sites outside the auspices of a dedicated pediatric facility [20,21]. Studies continue to show that CT dose optimization for children is particularly challenging at these non-pediatric focused sites [20,22,23].

**OUR WORK**

In our pilot study [24] we conducted a retrospective analysis of de-identified CT dose estimates from 20 community hospitals (CH) and radiology practices during a 6-month period in 2012. Based on this analysis, we identified 12 sites with pediatric dose estimates 2-10 times higher than corresponding age-based protocols at our academic medical center (AMC), a public, tertiary care Level I adult and pediatric trauma center. [See Figure 1 for graphical representation].

Following this analysis, we partnered with a general, non-pediatric community CH, to develop a toolkit for pediatric dose reduction, *The ABCs of Childcare in CT: Awareness, Belief, Change* [24]. [See Figures 2 for a sample of information provided within the toolkit.] The toolkit contained selected examples of AMC pediatric protocols with as low as reasonably achievable (ALARA) doses; medical literature regarding practical strategies; interactive Image Gently [25] pediatric CT dose calculation charts; a glossary of definitions and terms; selected educational links; tips, contacts and links provided by the Imaging 3.0 program[26]; and a list of direct contacts at AMC. The novelty of our approach existed in the collaborative effort of physicists, physicians, public health researchers, and CH imaging stakeholders. During this process, we used surveys and semi-structured interviews to develop, evaluate, and refine our toolkit for generalizability over different manufacturers and platforms, and tailoring to meet the individual needs of small CHs.

In addition to developing a physical toolkit, we also conducted an educational session with various members of the imaging
team. We used questionnaires to explore staff opinions and familiarity with CT risks and best practice guidelines in pediatric CT dose reduction. We also used semi-structured interviews to evaluate the content of the educational intervention and toolkit. These interviews were transcribed and reviewed for insights [24]. Finally, to establish baseline data for a future intervention, we collected dose data from CH pediatric CT scans for comparison to benchmarks, including the vendor and scanning parameters from the DICOM dose reports [24].

**WHAT WE FOUND**

“We all know that dose reduction is important, and in a small hospital that may be where it ends.”

— Interviewee from CH

**Educational Session Evaluation**

One of the benefits of our educational session was the facility-specific information that we presented. Baseline data from CH revealed approximately 2 to 3 times higher doses than matched patients at AMC. [See Table 1 for a comparison of CH and AMC pediatric CT doses and Figure 3 for the introductory slide to our presentation]. By presenting this information and describing our own struggles with dose reduction, the need for dose reduction became less of an abstract idea and more of a practical example with room for incremental improvement. “Just because we’re small is not an excuse not to implement good dose reduction strategies,” stated one interviewee. Following the session, we found an increase in knowledge and opinions towards CT risks, a strong willingness and readiness to implement change, and a positive utility of the session [24].

**Toolkit Evaluation**

Interviewees uniformly reported that our toolkit is a very useful resource. However, there were still opportunities for improvement. For example, because of the low volume of pediatric patients, interviewees suggested that the toolkit contains some information and sample protocols that they may not use.

**Risk Communication**

Patients, caregivers and providers alike are not fully aware of the risks that CTs present to patients [10]. Thus, we asked about the discussion of the risks and benefits of CT scans with patients before ordering or performing a study. One interviewee reported, “We try to, yes, but my opinion is most people come in the hospital and [a CT is] what they want.”

**Making an Impact**

Though some may wish to use lower doses, this implementation relies heavily on commitment from radiologists since they will have to read lower quality images. “I have to make sure that the radiologists understand where we are going and I have their buy-in,” stated one interviewee. Because many CHs are small, equipment maintenance and updates that include better dose optimization methods are other important barriers. The relatively low volume of CT scans in CHs, particularly for pediatric patients, provides CH staff with limited experience in practicing dose reduction technique and was a topic broached by all interviewees.

**DISCUSSION**

**The Big Picture**

“There are no small problems. Problems that appear small are large problems that are not understood.”

— Santiago Ramón y Cajal

There is a worldwide, critical need for continuing pediatric CT quality improvement, including assessment and reduction of unnecessary dose variation which does not contribute to positive patient outcomes and may jeopardize children’s health and safety [25, 27]. A most recent review of US healthcare quality measurement cited several issues which have limited improvement, including the lack of alignment in the use of measures and improvement strategies, and the lack of centralized national electronic systems for measurement, reporting, benchmarking, and improvement [28]. Radiation protection is a priority for the American College of Radiology (ACR), and systematic improvements in CT utilization, dose optimization, and patient safety are being realized through the power of national pooled data in the ACR’s Dose Index Registry, and up-to-date educational resources for radiologists and referring clinicians through the Image Wisely initiative [29, 30].

**The Smaller Picture**

“Enjoy the little things, for some day you may look back and realize they were the big things.”

— Robert Brault

Our motivation for the present research project was threefold, namely: 1) our long, personal, trial-and-error, ongoing experience in a large academic medical center for pediatric CT dose reduction, 2) the recognition that small hospitals in our own neighborhood may struggle with high radiation doses in children’s CT, and 3) the belief that we can help them to reduce these doses. Our rationale was that changing practice patterns related to pediatric CT dose reduction is complex, requiring a hands-on, evidence-based approach to dissemination and implementation [31, 32]. By closely interacting with CH imaging staff we learned that operational barriers to dose reduction include: 1) limited resources such as software and equipment upgrades, 2) the complex and counter-intuitive nature of dose-reduction techniques on scanners, 3) lack of educational support for pediatric protocol oversight and quality management, 4) the possibility that
CH radiologists who do not routinely interpret children’s CT scans may order images acquired at higher doses in order to increase diagnostic confidence and to offset the increased noise that accompanies lower dose scans, and 5) the relatively small number of pediatric patients [21,22,33]. We experienced CH leadership-in-action through their open mindedness regarding the need for dose reduction measures, their responsiveness involving our CT toolkit booklet, and their eagerness for dose reduction implementation and ongoing consultative support from a larger academic institution. A plan to present our research findings to a statewide healthcare imaging consortium to seek administrative support for implementation is in process.

CONCLUSION

Our research partnership revealed that one of the most challenging aspects for CHs to overcome when attempting to optimize pediatric CT doses is the limited number of pediatric patients. The small number of pediatric patients creates a need for educational interventions to raise awareness of radiation risks and to formalize pediatric CT protocols.

Acknowledgements

We wish to acknowledge financial support from the NC TraCS Institute. This project was supported by the National Center for Advancing Translational Sciences (NCATS), National Institutes of Health, through Grant Award Number 1UL1TR001111. The authors offer our sincere thanks to Timothy S. Carey MD, MPH; Marija Ivanovic, PhD; and Neela Kumar for their insights and assistance with this project. We greatly appreciate the recognition and support of Blue Cross Blue Shield North Carolina and the ACR Imaging 3.0 http://www.acr.org/Advocacy/Economics-Health-Policy/Imaging-3/Case-Studies/Quality-and-Safety/A-Community-Toolkit.

Table 1. Tabular comparison of mean pediatric size specific dose estimate (SSDE) and CTDI with 95% confidence interval between Academic Medical Center (AMC) and Community Hospital (CH). Reprinted from The Journal of the American College of Radiology, Armao D, Hartman T, Sheu CM, et al., A Toolkit for Pediatric CT Dose Reduction in Community Hospitals, 2016, with permission from Elsevier.

<table>
<thead>
<tr>
<th>Age Category</th>
<th>Facility</th>
<th>Mean CTDI (SD)</th>
<th>p Value</th>
<th>Significant</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 3</td>
<td>AMC</td>
<td>14.0 (11.0 - 17.0)</td>
<td>0.002</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>CH</td>
<td>54.3 (20.0 - 88.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 - 6</td>
<td>AMC</td>
<td>12.0 (7.6 - 18.4)</td>
<td>0.003</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>CH</td>
<td>44.3 (27.0 - 61.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 - 10</td>
<td>AMC</td>
<td>16.7 (11.5 - 21.8)</td>
<td>0.001</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>CH</td>
<td>21.4 (15.2 - 27.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 - 17</td>
<td>AMC</td>
<td>22.5 (18.0 - 29.0)</td>
<td>0.001</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>CH</td>
<td>44.3 (31.4 - 57.1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

REFERENCES