Reduction of Radiation Exposure in Pediatric CT – A Shared Responsibility

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Purpose
- To describe an ongoing quality improvement program to reduce radiation dose to pediatric patients. In this program, radiologists, technologists, and medical physicists worked together to standardize and implement new protocols, follow compliance, and ensure diagnostic content of the new protocols.
- This Quality Improvement Program used even more aggressive dose reduction for pediatric patients than proposed by Image Gently Campaign by adjusting kVp and Quality Reference mAs by weight as well as using tube current modulation (TCM, e.g., CareDose4D from Siemens). This required more input from team members to ensure that protocols were correctly implemented and that acceptable image quality was obtained for all studies.

Methods
- New weight based pediatric chest and abdomen/pelvis CT scan protocols adapted from Kim et al. (below) were implemented for use in inpatient and outpatient practices.
- Weekly scan data was then analyzed for protocol adherence to established weight based parameters and feedback provided to technologists to improve compliance.
- To ensure adequate diagnostic content of new protocols, 27 cases were selected at random and each was independently reviewed by two pediatric radiologists, who were blinded to both the scan parameters and each other’s ratings.
- The radiologists only evaluated the image noise and either identified the case as acceptable or noisy.
- The physicists investigated the cases that were rated as noisy and gave feedback to the group.

Results
- Furthermore it was observed that in 93% of all the collected data the average effective mAs was greater than the quality reference mAs.
- When new protocols were compared to the old ones, it was observed that just by reducing the kVp form 120 to 100, the CTDIvol reduced by almost a factor of 2.

Discussion and Conclusions
- Reducing radiation dose to pediatric patients while maintaining image quality is a challenging task most effectively handled as a shared responsibility of radiologists, technologists, and medical physicists. This is especially true when using technical features such as the tube current modulation which must be well understood to implement appropriately.
- Radiologist training and quick feedback, resulted in rapid compliance by all shifts.
- Pediatric radiologists determined that techniques provided diagnostic image quality.
- Medical physicists assisted in implementation and evaluation of techniques.
- When properly used (correct patient size reference, patient placement), Tube Current Modulation schema like CareDose4D, is a form of automatic exposure control that tailors the mAs to patient size to maintain a desired image quality; therefore, an increase in mAs is to be expected in patients larger than the reference size.
- An institution wishing to reduce dose via TCM should instead focus on selection of Quality Reference mAs; adjusting downward to reduce actual patient dose while balancing the need for appropriate diagnostic image quality.

### Weight

<table>
<thead>
<tr>
<th>Weight</th>
<th>Chest</th>
<th>Abdomen / Pelvis</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 5 kg</td>
<td>kVp</td>
<td>Qual. Ref. mAs</td>
</tr>
<tr>
<td>80</td>
<td>45</td>
<td>80</td>
</tr>
<tr>
<td>6-15 kg</td>
<td>80</td>
<td>55</td>
</tr>
<tr>
<td>16-60 kg</td>
<td>100</td>
<td>55</td>
</tr>
<tr>
<td>&gt; 61 kg</td>
<td>120</td>
<td>55</td>
</tr>
</tbody>
</table>

**Quality reference mAs:** A parameter defined by Siemens to represent the image quality that would have been achieved if a fixed tube current had been performed at that specific mAs level on an average sized patient. It is set by the user to select the desired image quality for a tube current modulated exam.

**These protocols were approved by the radiologists and implemented into the scanners.**

**Technologists were educated to use the appropriate kVp and quality reference mAs based on the patients’ weight.**

**Patients’ protocol and raw data (projection data collected by the detectors) were collected at the end of each week by the physicists to generate a spreadsheet with scan information such as scan date, date of birth, scan type, kVp, quality reference mAs, average effective mAs, collimation, rotation time, and weight for further analysis.**

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*Figure 1:* A thoracic scan performed to evaluate interstitial lung disease in a pediatric patient which was rated as noisy by a radiologist. The correct pediatric chest protocol (100 kVp and 55 mAs) was used but the adult size reference (70 kg) was inadvertently chosen for this scan. As a result the scanner compensated for the small size of the patient and so decreased the tube current. The average effective mAs in this scan was 32 (lower than quality reference mAs).

*Figure 2:* Patient protocols of a patient captured at two different time points. The upper protocol shows the resulting CTDIvol value of 5.66 from 120 kVp and 55 mAs (quality reference mAs) and the lower protocol shows a CTDIvol of 3.10 from 100 kVp and 55 mAs.

*Figure 3:* Two chest scans of the same patient at two different time points. The image on the left was acquired using an older pediatric chest protocol, the image on the right was obtained using the newly implemented pediatric chest protocol (quality reference mAs of 55, 100 kVp and tube current modulation, CareDose4D from Siemens).