Pediatric Chest Radiography Imaging Technique Variability in the Emergency Department

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Hypothesis

Subjective assessment of pediatric chest wall size when selecting an optimal chest radiograph acquisition technique lacks reliability and can be avoided by implementing a quantitative objective measurement tool.

Background

A large number of pediatric patients who present to the Emergency Department have respiratory complaints (Knapp, 2013 and Neff, 2012). For those patients, chest radiographs are a routinely performed, leading to frequent x-ray examinations during ER visits. While these tests are clinically indicated, their performance is frequently inconsistent, with variable radiation doses delivered to patients.

The wide dynamic range of computed and digital radiography (CR and DR) detectors allow for exposures over or under a target dose that result in a satisfactory images. In an effort to cater to radiologists’ view preferences and to avoid repeated exams, radiographers tend to err on the side of overexposure. Given the high frequency of pediatric chest radiographs, it is important to ensure that the radiation dose of an exam as low as reasonably achievable (ALARA).

Dose specification is better optimized according to patient size rather than age (Kleinman, 2010). Calipers have been suggested as an accurate measuring tool to be applied before exposing children to radiation to increase the consistency of the tests and to avoid inaccurate estimation of patients’ body thickness (Kleinman, 2010). However, calipers are not routinely used because they add an extra step to the exam workflow.

An alternative method of measurement that can achieve a comparable level of consistency and reliability of manual calipers is Microsoft Kinect™, an infrared sensor that is commercially used with video games and widely found in households. Using software developed by our coauthors, the infrared sensor and calipers were employed to estimate patient thickness. Exam acquisition parameters were then evaluated as a function of patient thickness.

Methods

This preliminary clinical investigation received approval from Children’s National Health System IRB committee. A sample of ED patients with clinically indicated and ordered two-view chest x-rays were interviewed and consented to enroll in the study (N=22). The patients’ anterioposterior (AP) and lateral width measurements were obtained first using calipers then with the infrared sensor. The measurements with both devices were taken at the level of the sternal notch.

Thickness measured using the Kinect™ were obtained by first detecting the wall bucky. The patient was then positioned against the wall bucky using standard protocols. The Kinect device then detected the patient to provide a thickness estimate. For each study, the tube potential and tube current-time product values were collected. The patient thickness information was not provided to the radiographers in order to avoid influencing the selection decision of image acquisition technique factors. Additionally,
the patients’ age and weight were recorded for the corresponding studies. Occasional smaller patients were examined on a pediatric positioning chair and our measurements were obtained in the same posture they were radiographed. Patients who were younger than one year old, critically ill or radiographed supine on the table bucky were excluded.

Results

The arithmetic mean age of the patient sample was 7.2 years. The average patient lateral thickness was $22 \pm 5$ cm and the average patient AP thickness was $16.4 \pm 3$ cm. The maximum difference in tube potential at a fixed patient thickness was 20 kV (Figure 1) at 16 cm. For a 20 cm patient, the maximum and minimum tube current-time product at a fixed tube potential (110 kV) differed by a factor of 6, ranging from 0.66 to 4 mAs (Figure 2).

Discussion

This work quantitatively demonstrates an inconsistency in the imaging technique leading to variability in the entrance exposure rates. The inconsistent technique factors observed in this study resulted in inconsistent image quality. In Figure 3, there are two AP radiographs of two patients with the same thickness (20 cm) and tube potential (110 kVp), but the left exam was performed at 0.66 mAs and the right exam was performed at 4 mAs. Although our Radiologist preferred the higher-exposure radiograph in terms of vascular and reticular markings conspicuity, the lower-exposure one would not need to be repeated. Considering the common indications among pediatrics population presenting to the ED, an acceptable chest radiograph quality can be potentially be produced with a six-fold reduction in entrance exposure rate. This is a substantial dose reduction in a frequently performed examination.
The variability in imaging technique points toward developing time-efficient and easily implementable means to standardize acquisition techniques based on patient thickness. One obstacle preventing the implementation of patient thickness measurements is the additional step in the exam workflow. The Kinect device is a measurement device that is completely noninvasive and could eventually provide fully automated patient thickness measurements. Initial experiences with the device were encouraging.

Ultimately, we hope to achieve stream-lined personalized care for a vulnerable population (Don, 2004). Knowledge of patient thickness allows the development and implementation of standard image acquisition techniques. Eventually, these patient-specific standards could be even further augmented with the indicated diagnostic task.

**Conclusion**

Subjective assessment was found to provide inconsistent technique in terms of the kVp and mAs considering the patients’ chest thickness as measured with calipers. This inconsistency translates into an inconsistency of the delivered radiation dose and the quality of the acquired radiographs.

**References**


**Keywords**

pediatric, radiography, quality improvement, radiation dose