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COMMENTARY

Reply to commentary – CT radiation dose reduction: can we do harm by doing good?

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The co-editors of the ALARA supplement would like to thank Dr. Cohen for bringing attention to the dangers of overemphasis on dose reduction alone in pediatric CT [1]. The issue of dose efficiency and optimization rather than minimization was afforded substantial attention and discussion at the 2011 CT ALARA meeting but was unfortunately not as well represented as it might have been in the supplement. The editorial attempted to represent the importance of this balance by citing Dr. Paul Guillerman's comments at the ALARA meeting "This should not be a race to the bottom; we should not be thinking only of Image Gently but rather Image Intelligently" [2, 3].

In his commentary Dr. Cohen suggests that while CT dose and some risks were thoroughly discussed in the 2011 CT ALARA supplement, the cancer risk of CT was not placed in the context of other everyday risks such as dying in an auto accident and the baseline risk of cancer. While the cancer risk of CT might not have been documented in exactly the way that Dr. Cohen describes, the relatively small additive risk relative to the huge clinical value of CT was repeatedly mentioned at the conference, is reflected in the written supplement [4] and is widely disseminated in the literature.

A radiologist's ability to render an accurate interpretation on a diagnostic imaging study is a very complex process with many facets; dose is not the only factor involved and is not necessarily the predominant determinant as Dr. Cohen's commentary implies. Image quality attributes include both contrast and spatial resolution as well as noise, motion effects, contrast opacification and artifact interference in addition to subjective perception and radiologist confidence. Lack of patient motion and high-quality contrast imaging in children, as appropriate, are probably just as important as radiation dose in producing a high-quality diagnostic image. In a recent study that reviewed both dose reduction and subjective/objective evaluations of image quality in pediatric chest CT scans, the only cases deemed poor quality were not related to low dose but rather to patient motion or obscuration by artifact [5]. Some image quality determinants have an inverse relationship with dose, allowing for specific improvement in desired image quality along with reduced dose. The prime example is judicious reduction of kVp for CT angiography to take advantage of improved contrast resolution at lower kVp [6, 7].

Perception and training also play very important roles; missed diagnoses and overlooked findings on CT scans are not a new phenomenon in the era of ALARA. Several studies have indicated that even highly trained radiologists overlook large high-contrast findings such as lung nodules ~8 mm [8]. The oft repeated dogma is that most missed diagnoses in radiology are not caused by lack of seeing the abnormalities but rather by misinterpreting or not appreciating the importance of the findings. Personal experience suggests that part of imaging interpretation and perception of quality depends on repeated exposure and that the eye and clinical abilities can accommodate somewhat noisier images.

However, any virtue can become a vice if taken to the extreme; it is clearly important that dose reduction does not become such an all-consuming passion that we lose sight of image quality and thereby diminish our diagnostic abilities

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and the benefit of the CT examination to the patient. No study or dose is appropriate if it's not the right examination to answer the clinical concerns. The difficult questions are which examination is most appropriate and how low is too low. This important topic has not been ignored; a number of studies have systematically addressed these issues, and certainly more should be encouraged. Multiple published studies have shown that in certain clinical situations, radiation dose can be reduced much below prior levels before diagnosis is significantly impaired [5, 9–13]. Clearly this depends on the type of examination, indication and body habitus of the patient. Lower doses are more appropriate for high-contrast or large structures, while higher dose is needed for small low-contrast structures, especially in larger patients [6, 9, 11]. Additional image viewing features are important and can greatly enhance interpretation. These include optimal windows and reconstruction algorithms, e.g., reviewing lung parenchyma on lung windows, looking at images with appropriate slice thickness (thinner slices, more noise), and viewing the data in different planes, e.g., coronal or sagittal.

The surge in interest and concern regarding CT and radiation dose has resulted in many positive advances and we should not lose these gains or underestimate their benefits. Radiologists, technologists and physicists have partnered to bring about many changes in the last decade in the manner in which CT examinations are perceived and performed [4, 14]. Radiologists have greatly enhanced their knowledge of how the various CT parameters interact and how to approach intelligent imaging. Reducing unnecessary studies and series, matching the CT protocol to the clinical question and individual patient and substituting other modalities when appropriate have all contributed to substantially reduced CT radiation doses in children [6, 7, 15]. Vendors have become engaged in the issues of CT and radiation dose, resulting in development of a number of effective dose-reduction features [6, 16]. Nonetheless, it is important to recognize that lowering of overall radiation dose reduces the margin for error and compels us to be more attentive to other important facets of imaging such as patient positioning and contrast administration.

We also need to remember that the vast majority of pediatric CT imaging is not performed in academic pediatric hospitals [14], that there is still a great deal of variability in how pediatric CT scans are performed and that adult-type exposure factors and scanning protocols are still often used in children [4]. It is therefore important that we continue to support and spread the concept of ALARA as well as evidence-based patient evaluation and imaging protocols to minimize variation in practice and improve outcomes, for example in pediatric appendicitis [17–19].

Dr. Cohen discusses patient safety and risk-to-benefit ratio extensively in his commentary and describes the potential problems of missing the correct diagnosis. His advice is sound, and his point is well taken. There is a definite need for refinement of appropriateness criteria and outcomes research in pediatric CT [14] along with careful evaluation of diagnostic efficacy with the goal of adequate dose for reliable, confident diagnoses rather than best image quality or lowest dose [2]. Several institutions are currently working together with the American College of Radiology to institute the first national children's dose registry to ensure necessary, safe imaging for children [20]. To quote Dr. Marilyn Goske, the essential question that needs to be answered is: "How do we lower the radiation dosage and still make the diagnosis? The challenge for pediatric radiology is determining the optimal quality of CT scans for children" [21]. Clearly there is much interest in the topic of pediatric CT dose reduction and there are still many questions to be answered when it comes to the appropriate use of ionizing radiation in children.

References

1. Cohen M (2012) CT radiation dose reduction: can we do harm by doing good? Pediatr Radiol. doi:10.1007/s00247-011-2315-9
2. Guillerman RP (2011) Lowering dose – how low can you go? Proceedings of the ALARA-CT Conference, March 5–6. SPR/ACR, Dallas, Texas, pp 123–128
3. Newman B, Callahan MJ (2011) ALARA (as low as reasonably achievable) CT 2011 – executive summary. Pediatr Radiol 41 (Suppl 2):S453–S455
4. Frush DP (2011) CT dose and risk estimates in children. Pediatr Radiol 41(Suppl 2):S483–S487
5. Kim JE, Newman B (2010) Evaluation of a radiation dose reduction strategy for pediatric chest CT. AJR 194:1188–1193
6. Callahan MJ (2011) CT dose reduction in practice. Pediatr Radiol 41(Suppl 2):S488–S492
7. Newman B, Vasanawala SS (2011) Point/counterpoint: dose-related issues in cardiac CT imaging. Pediatr Radiol 41(Suppl 2): S528–S533
8. Kakinuma R, Ohmatsu H, Kaneko M et al (1999) Detection failures in spiral CT screening for lung cancer: analysis of CT findings. Radiology 212:61–66
9. Frush DP, Slack CC, Hollingsworth CL et al (2002) Computer-simulated radiation dose reduction for abdominal multidetector CT of pediatric patients. AJR 179:1107–1113
10. Karmazyn B, Frush DP, Applegate KE et al (2009) CT with a computer-simulated dose reduction technique for detection of pediatric nephroureterolithiasis: comparison of standard and reduced radiation doses. AJR 192:143–149
11. Kosucu P, Ahmetoglu A, Koramaz I et al (2004) Low-dose MDCT and virtual bronchoscopy in pediatric patients with foreign body aspiration. AJR 183:1771–1777
12. Lucaya J, Piqueras J, Garcia-Pena P et al (2000) Low-dose high-resolution CT of the chest in children and young adults: dose, cooperation, artifact incidence, and image quality. AJR 175:985–992
13. Udayasankar UK, Braithwaite K, Arvaniti M et al (2008) Low-dose nonenhanced head CT protocol for follow-up evaluation of children with ventriculoperitoneal shunt: reduction of radiation and effect on image quality. AJNR 29:802–806

14. Goske MJ, Applegate KE, Bulas D et al (2011) Image Gently: progress and challenges in CT education and advocacy. Pediatr Radiol 41(Suppl 2):S461–S466
15. Newman B (2011) Ultrasound body applications in children. Pediatr Radiol 41(Suppl 2):S555–S561
16. Mahesh M (2011) Advances in CT technology and application to pediatric imaging. Pediatr Radiol 41(Suppl 2):S493–S497
17. Macias CG, Sahouria JJ (2011) The appropriate use of CT: quality improvement and clinical decision-making in pediatric emergency medicine. Pediatr Radiol 41(Suppl 2):S498–S504
18. Krishnamoorthi R, Ramarajan N, Wang NE et al (2011) Effectiveness of a staged US and CT protocol for the diagnosis of pediatric appendicitis: reducing radiation exposure in the age of ALARA. Radiology 259:231–239
19. Wan MJ, Krahn M, Ungar WJ et al (2009) Acute appendicitis in young children: cost-effectiveness of US versus CT in diagnosis – a Markov decision analytic model. Radiology 250:378–386
20. Goske MJ (2011) Getting it right: are regulation and registries for CT radiation dose in children the answer? Pediatr Radiol 41(Suppl 2):S567–S570
21. Hovsepian DM (ed) (2010) First national children's dose registry to ensure necessary, safe imaging. RSNA News [serial online] August. Available via http://www.rsna.org/Publications/rsnanews/August-2010/dose_registry_feature.cfm. Accessed 12 Dec 2011