



## Computed Tomography and Radiation Dose: Is the Technique Appropriately Used for Imaging in Children?

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### Editorial

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Since its first introduction into clinical practice in the early 1970s, the number of indications for Computed Tomography (CT) have been growing. According to the 2000 report (1) of the United Nations Scientific Committee on the Effects of Atomic Radiation, the frequency of CT examinations in developed countries increased on average from 6.1 per year per 1,000 population in the 1970s to 48 per year per 1,000 population in the period between 1991 to 1996 (2). At the same time the average effective dose per CT examination increased from 1.3 mSv (millisieverts) in the 1970s to 8.8 mSv in the period between 1991 to 1996 (2). During the last two decades, CT has undergone rapid technical developments including the introduction of helical CT and multislice CT scanners which decrease or eliminate motion artifacts, acquire volumetric data in a short time with great anatomic coverage, and generate isotropic datasets which facilitate 3D reconstruction of anatomical areas (3, 4). These developments have led to a rapid increase of CT studies in both adults and children, since the clinical value of CT is unquestionable (5, 6). The estimated annual number of CT examinations in the USA rose sevenfold from 2.8 million in 1981 to 20 million in 1995 (7), and more than 62 million CT scans in 2006 including 4 million for children (8). Comparable trends have been reported in European countries such as Germany, Switzerland, Norway and UK (9). All of these data indicate that CT has become the method of choice in many clinical applications, for both adults and children. In this issue of AMJ, Ghosh and Dey (10) in their article entitled "A review on current approaches to diagnosing proptosis in paediatric patients in India" reported the diagnostic value of CT in children presenting with proptosis in rural India. They concluded that CT is the investigation of choice based on a retrospective study of

65 paediatric patients, including 55% of the children under 5 years old. A variety of abnormalities including benign and malignant tumours were studied with CT with 91% of CT findings correlating well with histopathology.

CT and magnetic resonance (MR) imaging are the techniques of choice for imaging the diseases of the orbit (11). MR imaging has become the initial imaging modality for the orbit because of the development of fast imaging and fat-suppression techniques. However, MR imaging is not widely available (especially in rural areas), and it is also a lengthy examination which is unsuitable for imaging children. Currently, CT still remains the modality of choice for bony detail and the diagnosis of orbital tumours, despite the disadvantage of increased radiation exposure.

A rapid increase of the proportion of paediatric CT examinations has been observed worldwide over the last decade. The results of a British survey performed in 1989 showed that approximately 4% of CT studies were performed in children under the age of 15 (12). The increased frequency of paediatric CT is largely driven by the advent of multislice CT which particularly in children, reduces the need for sedation and offers superior image quality (5, 6, 13). Ghosh and Dey's study was performed with dual slice CT since the investigation is based in a rural teaching hospital in India, in other parts of the world such technology might be regarded as outdated. Currently 16- and 64-slice scanners are more common in many hospitals, while some clinical centres have installed the latest CT models such as dual source CT, 128-, 256- or 320-slice scanners (4). These scanners are advantageous because they provide faster imaging and acquisition of high resolution images. Consequently, it is expected that the number of the CT scans used for diagnosing children will continue to increase significantly.

By their very nature, CT examinations contribute disproportionately to the collective radiation dose to any given population. It is estimated that up to 10% of all radiological procedures are CT examinations; however, their contribution to the collective dose is about 40-60% (14-16). Depending on the machine settings, the organ being studied typically receives a radiation dose in the range of 15 mSv (in an adult) to 30 mSv (in a neonate) for a single CT scan, with an average of two to three CT scans per study (17). The most likely risk (although small) associated with these doses is radiation-induced carcinogenesis (18). Paediatric examinations represent a comparatively small, but increasing fraction of the overall number of CT



examinations. However, Brenner et al. (7) revealed in their study that the combination of higher radiation doses to children for a given CT examination and the larger lifetime risks per unit dose of radiation that apply to children result in lifetime cancer mortality from CT significantly higher in children than in adults. For example, a best estimate of the lifetime cancer mortality risk attributable to the radiation exposure from a single head examination in a 1-year-old child is approximately one in 1500 (7). Hence, CT should be used appropriately in paediatric imaging, given the fact that children have longer life expectancies and their organs are more sensitive to ionizing radiation than adults.

Weight ranges in paediatrics may vary in range from less than 1 kg to more than 100 kg, thus, a greater understanding of CT technology and protocols is essential to ensure radiation dose reduction (19). In their recent study Singh et al. (20) investigated compliance of new paediatric scanning protocols based on a combination of clinical indications, prior CT history, and weight-adjusted protocols (based on tube current modulation) during a 17-month period. The authors proposed a systematic method for paediatric CT protocols in the reduction of dose at paediatric CT. Their results showed that adjustments in tube current were made on the basis of weight categories and by using tube current modulation. Up to 88% compliance for chest CT and 82% compliance for abdominal CT was achieved in the study, with dose reductions (based on dose-length product) ranging from 16.0% to 89.5% compared with noncompliant examinations. This novel study simplified the complexities of paediatric CT scanning, and proposed important strategies in dose management in children.

Ghosh and Dey's study raise several important issues. First, CT is an accurate imaging modality for diagnosis of paediatric disease, especially for tumours of the orbit. Second, paediatric CT could be used as the first line technique in patients with proptosis. Third, the CT scanning protocol applied may be suboptimal according to the strategy proposed by Singh et al. Although CT scanning protocols of 80 kVp and 80-100 mA were applied in these cases, there exist possibilities of overexposing some children with such protocols. Singh and colleagues lowered mA to 50 based on weight and clinical indications while still achieving high quality diagnostic images. Their results emphasised the point that CT doses and technique should be based on patient size. Ghosh and Dey's study focused only on the diagnostic value of CT in paediatric proptosis; however, experts need to be aware of need for reduced radiation dose while choosing CT technique in paediatric imaging. Moreover, dose reduction is only possible when technicians and physicians are informed and committed to applying minimal dosages. Singh et al (20) highlighted the need for and benefit of multidisciplinary expertise in addressing the complicated topic of radiation dose reduction in children. There continues to be a need to address appropriate radiation dose used in paediatric CT imaging. While the strategies have been proposed as mentioned above, the question is

when is CT appropriate? Work in this area is promising and will significantly improve the safety of investigations in children. However we urge caution and recommend further research to reduce radiation dosage while aiming to acquire high quality diagnostic images.

## Reference

1. United Nations Scientific Committee on the Effects of Atomic Radiation report to the general assembly, annex D: Medical radiation exposures. United Nations, New York
2. Verdum FR, Gutierrez D, Vader JP, et al. CT radiation dose in children: a survey to establish age-based diagnostic reference levels in Switzerland. *Eur Radiol* 2008; 18: 1980-1986
3. McCollough CH, Zink FE. Performance evaluation of a multi-slice CT system. *Med Phys* 1999; 26: 2223-2230
4. Rybicki FJ, Otero HJ, Steigner ML, et al. Initial evaluation of coronary images from 320-detector row computed tomography. *Int J Cardiovasc Imaging* 2008; 24: 535-546
5. Altes TA. Multislice CT computed tomographic scanning: technological innovations bring new indications in pediatric chest CT. *Pediatr Ann* 2002; 31: 761-675
6. Salamipour H, Jimenez RM, Brec SL, et al. Multidetector row CT in pediatric musculoskeletal imaging. *Pediatr Radiol* 2005; 35: 555-564
7. Brenner D, Ellison C, Hall E, Berdon W. Estimated risks of radiation-induced fatal cancer from pediatric CT. *AJR* 2001; 176: 289-296
8. IMV 2006 CT Market Summary Report. Des Plaines, IL: IMV Medical Information Division, 2006
9. Heyer CM, Hansmann J, Peters SA, Lemburg SP. Paediatrician awareness of radiation dose and inherent risks in chest imaging studies-A questionnaire study. *Eur J Radiol* 2009 (in press)
10. Ghosh S, Dey S. The Investigation of Proptosis in Paediatric Practice. *AMJ* 2009, 1, 8, 36-43. Doi 10.4066/AMJ.2009.59
11. Peh WC, Hiramatsu Y. The Asian-Oceanian textbook of radiology. Singapore: TTG Asia Media 2003, 243-269
12. Shrimpton PC, Hart D, Hiller MC, et al. Survey of CT practice in the UK. 1. Aspects of examination frequency and quality assurance. NRPB report. Chilton, England: National Radiological Protection Board; 1991
13. Garcia K, Hernanz-Schulman M, Bennett DL, Morrow SE, Yu C, Kan JH. Suspected appendicitis in children: diagnostic importance of normal abdominopelvic CT findings with nonvisualized appendix. *Radiology* 2009; 250: 531-537
14. Borretzen I, Lysdahl KB, Olerud HM. Diagnostic radiology in Norway trends in examination frequency and collective effective dose. *Radiat Prot Dosimetry* 2007; 124: 339-47
15. Aroua A, Bize R, Buchillier-Decka I, Vader JP, Valley JF, Schnyder P. X-ray imaging of the chest in Switzerland



in 1998: a nationwide survey. *Eur Radiol* 2003; 13: 1250–9

16. ArouaA, Trueb P, Vader JP, Valley JF, VerdunFR. Exposure of the Swiss population by radiodiagnostics: 2003 review. *Health Phys* 2007; 92: 442–8
17. McCollough CH. CT dose: how to measure, how to reduce. *Health Phys* 2008; 95: 508-517
18. Brenner DJ, Doll R, Goodhead DT, et al. Cancer risks attributable to low doses of ionizing radiation: assessing what we really know. *Proc Natl Acad Sci U S A* 2003; 100: 13761-6
19. Frush DP. Radiation, CT, and children: The simple answer is ... It's complicated. *Radiology* 2009; 252: 4-6
20. Singh S, Kalra MK, Moore MA, et al. Dose reduction and compliance with pediatric CT protocols adapted to patient size, clinical indication, and number of prior studies. *Radiology* 2009; 252: 200–208

#### **PEER REVIEW**

Commissioned; not externally peer reviewed

#### **CONFLICTS OF INTERESTS**

None