KERMA ratios vs. SSDE: is one better at estimating pediatric CT radiation doses?

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Introduction

Reasonable estimates of pediatric CT radiation doses are necessary to better understand the potential radiation risks of this modality. This issue of *Pediatric Radiology* includes a paper titled “KERMA Ratios in Pediatric CT Dosimetry” [1] that presents a method to estimate organ doses in pediatric CT patients. In 2011, the American Association of Physicists in Medicine (AAPM) published a different approach to estimating pediatric radiation doses associated with CT scanning [2]. Is one of these methods better suited to the task or preferred over the other?

Methods

The paper in this issue provides KERMA ratios with which the radiation dose to the critical organs of the body for a newborn, 1-year-old, 5-year-old and 10-year-old can be estimated. These ratios are calculated from measured data on CT scanners from two different manufacturers. The product of the air KERMA at the isocenter of the CT gantry (measured by a qualified medical physicist) and the appropriate KERMA ratios allow a calculation of estimated organ doses.

The method of the AAPM, reviewed previously [3], requires that the operator know: (1) the displayed CTDI_{vol} on the scanner, (2) the dosimetry phantom the CT scanner assumes when estimating the CTDI_{vol} and (3) the lateral or posterior-anterior dimension of the region scanned within

the child. The product of the appropriate conversion factor and the displayed CTDI_{vol}, Size-Specific Dose Estimate (SSDE), estimates the radiation dose to tissues irradiated by the primary CT beam.

Strengths and weaknesses

Using either method, calculated patient doses are estimates. The accuracy of the estimate is significantly affected by the child's size and the radiation output of the scanner [1]. A qualified medical physicist should verify the radiation output of the CT scanner before either method of dose estimation is employed. Each child's size should be measured. The child's age and weight are not reasonable indicators of the path length (patient size) through which the CT X-ray beam must pass. The lateral dimension of the abdomen of the largest 3-year-old patients exceeds the dimension of the smallest 18-year-olds [4].

The KERMA ratio method has weaknesses and strengths. KERMA ratios are provided for only one CT scanner type at multiple high-voltages and another CT scanner type at a single high voltage. These measurements, which require considerable effort, were not performed for the other two major CT manufacturers. While the authors propose that the CT scanner's design does not significantly impact the ratios (based on the results of the two scanners measured), measured data for all CT manufacturers was not presented. While the required measurement of air KERMA at the isocenter of the CT gantry (verification of CT scanner's radiation output) is relatively easy, most qualified medical physicists do not complete this measurement during annual surveys of CT dosimetry. The reported measured ratios are inflated by the presence of extra scatter not present during clinical scanning since the entire length of each pediatric phantom was irradiated. The ratios are presented for four different pediatric patient ages;

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these phantom ages must be converted to appropriate patient thicknesses and interpolation is required among the four phantom sizes. The strength of this method is that organ doses are directly estimated.

The calculation of SSDE also has strengths and weaknesses. The method is validated for the four major CT scanner manufacturers at all available high voltages. The report provides conversion factors directly related to patient thickness. Annual dosimetry data from the site's qualified medical physicist is required to ensure proper calibration of the displayed CTDI_{vol} (verification of CT scanner's radiation output), information that should be available upon request at most clinical sites because of state radiation protection regulations. The operator must also accurately identify which dosimetry phantom the CT scanner assumes when it calculates and displays CTDI_{vol} .

Unfortunately, the SSDE does not provide a direct estimate of organ doses. Since the SSDE is based on CTDI_{vol} , it represents a single averaged dose across the entire transverse plane of the child. While the dose varies less than 10% in the transverse plane for a small pediatric patient, the central dose is approximately 50% of the surface dose for large patients. The qualified medical physicist must account for this varying dose distribution when estimating organ doses from SSDE.

Conclusion

Both methods of estimating pediatric radiation dose during CT contain significantly less error than previously available dose indices, e.g., CTDI_{vol} and DLP [5]. A qualified medical

physicist should quantify the radiation output of the CT scanner (measurement of air KERMA at the isocenter or CTDI_{vol} in a CTDI phantom) to minimize the error in either clinical dose estimate. Operators armed with correct conversion factors and a handheld calculator can calculate estimates of pediatric patient dose with either method. The SSDE calculation might be more understandable to the technologist or radiologist. However, the KERMA ratio calculation directly estimates organ doses whereas further steps are required, with the help of a qualified medical physicist, to estimate organ doses from the calculation of the SSDE. Technologists and radiologists might embrace the SSDE method while the KERMA ratio method might be the choice of qualified medical physicists. If one were to do a comparison of estimated organ doses using both methods, the estimated results should be similar.

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