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COMMENTARY

Rebalancing the risks of Computed Tomography and Magnetic Resonance imaging

S. Bruce Greenberg

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The concern for fatal cancers caused by ionizing radiation exposure associated with the increased use of CT in children is well documented. Inappropriate adult CT techniques applied to children can result in excessive radiation exposure [1], exposures similar to the dose received by a group of nuclear bomb survivors who later developed an increased cancer rate [2, 3]. CT examinations are projected by some to eventually account for up to 1.5–2.0% of future cancers in the United States [4]. Although only 7% of CT scans are in children, they are expected to account for up to 15% of the additional cancers because of increased life expectancy and sensitivity of children to radiation. Risk estimates for excess cancer mortality from radiation exposure of 1 death per 2,000 scans assume an effective dose of 10 mSv per scan and a risk of 5% per sievert [4].

MRI by contrast is perceived as a panacea for many applications performed by CT because it uses no ionizing radiation. General anesthesia risks associated with performing MRI in children need to be compared to the risk of ionizing radiation associated with CT. General anesthesia presents both acute and long-term risks to children undergoing MRI. The death rate for patients undergoing general anesthesia for MRI is cited to be 5.3 deaths per million [5]. Greater anesthesia risk for children undergoing an MRI examination is recognized [6, 7]. One study found that the mortality rate for general anesthesia performed on children in the MRI suite is 1:3,900, almost double the rate for general anesthesia performed in the operating room [8]. An awareness of long-term complications of general anesthesia performed on children has emerged in the anesthesiology community [9–12]. General anesthetics are thought to induce apoptosis through γ-aminobutyric acid receptor agonism and N-methyl-D-aspartate receptor antagonism during critical neurodevelopment that leads to disruption of mitochondrial membrane permeability, which progresses to neuronal apoptosis [11]. Neuroapoptosis in the developing brain during periods of rapid synaptogenesis can lead to learning disabilities. Behavior and learning disorders following anesthetic agent exposure in rodent and primate models are established. The peak sensitivity in humans is thought to be the last trimester of gestation through the first 2 years of life [10]. The evidence for the same neurodegenerative effects in humans is preliminary, but mounting.

CT practice in children has dramatically improved during the last decade. The use of proper pediatric CT techniques, the result of increased physician awareness, has led to reduced radiation exposure [13]. The Image Gently campaign has been and continues to be a leading force for reduced patient exposure. The reduction in average patient exposure requires a re-examination of the relative risk of CT. We will have to await the results of large cohort studies of children who have undergone CT to identify whether measureable risk exists for low–dose CT examinations. The National Cancer Institute and European Commission have sponsored multiple such studies [14, 15]. Newer technologies allow for sub-millisievert examinations, well below the dose at which an increase in cancer risk is currently detectable [16, 17]. The long-term risk of general anesthesia

S. B. Greenberg (✉)
Department of Radiology, University of Arkansas for Medical Sciences, Arkansas Children's Hospital,
1 Children's Way, Slot #105,
Little Rock, AR 72202, USA
e-mail: GreenbergSBruce@uams.edu

has its own uncertainties [18], and cohort studies are also underway to quantify the long-term risk to children [12].

MRI is not the panacea for the problems of CT. A low-dose CT examination might be less risky than the general anesthesia required for MRI. The challenge for pediatric radiology in the immediate future is threefold. We need to re-discover and expand the use of US for clinical problem-solving. US is more user-dependent than either CT or MRI, making study consistency more variable when performed by different technologists. This can lead to less efficacy of US. For example, if US is to be the primary imaging tool for appendicitis workup, the number of technologists capable of reliably performing this examination must increase. Second, we must continue to ratchet down radiation exposure for pediatric CT. This includes optimizing existing techniques [19] as well as quickly adopting promising new dose-reduction technologies such as iterative reconstruction [20], denoising software [21] and volume imaging [16]. The final challenge is to develop MRI protocols that reduce dependence on general anesthesia. Perhaps the number of sequences per examination can be reduced. Faster sequences and free-breathing techniques need to be developed.

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