Paediatric Imaging Methods in Oncology – The Key is in Dosimetry, Do We Have a Solution?

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Radiation dose reduction is a major goal within the imaging community, particularly in children and young adult patients. According to the recently published study in USA, analyzing the use of diagnostic ionizing radiation imaging procedures in over 350,000 children, 43% of these children were exposed to radiation from at least one diagnostic imaging procedure performed over the 3-y observation period. Based on continuous enrollment during that period 25% of the children had at least two imaging procedures and 16% had at least three procedures. These statistics are important to recognize because children are at greater risk of radiation side effects such as latent malignancy due to their rapid development and relatively long remaining life expectancy. Based on atomic bomb survivor data, the likelihood of solid tumor malignancy after exposure to ionizing radiation is 1.5 times higher in a 10-y-old child than in a young adult, and the risk of leukemia is approximately double.

Bone scintigraphy was the most commonly performed nuclear medicine procedure, followed by renography, and recently 18F-FDG PET/CT. Multimodal camera systems, integrating positron emission tomography (PET) or single photon emission computed tomography (SPECT) with computed tomography (CT) now combine the contrast provided by tumor-avid radioactive drugs with the anatomic precision of CT. Although hybrid imaging has revolutionized nuclear medicine, the use of PET/CT in children has been still controversial, since even the lowest dose CT protocol, which is necessary for the attenuation correction, adds approximately 1-2 mSv to the radiation dose of about 4 mSv from the PET-study with F-18-fluorodeoxyglucose (F-18-FDG).

As we know that many of children and young adults have multiple imaging procedures, cumulative exposure must also be considered. To reduce radiation dose, a low-dose CT in PET procedures is being recently replaced with magnetic resonance imaging (MR) for the assessment of anatomy and attenuation correction. Several studies are published to compare PET/MR and PET/CT imaging for lesion detection and interpretation, quantification of F-18-FDG uptake, and accuracy of MR-based PET attenuation correction in pediatric patients with solid tumors. However, PET/MR is still not standard procedure. Currently both PET/CT and SPECT/CT play a role in pediatric oncology. PET/CT using F-18-FDG is used for staging and follow-up of lymphoma, brain cancer, bone and soft tissue sarcomas. SPECT/CT with I-123-metaiodobenzylguanidine (MIBG) is used for tumors of the sympathetic nervous system such as neuroblastoma and pheochromocytoma while the remaining neuroendocrine tumors are imaged with radioactively labeled somatostatin analogues.

It is important to use the lowest amount of radiation possible when imaging children. However, too low dose can lead to misinterpretations or, ironically, to a higher dose if the study has to be repeated, particularly for smaller children, those weighing less than 20 kg. Dosage card of the European Association of Nuclear Medicine (EANM) or the North American consensus guidelines, are providing recommendations of administered activities

of radiopharmaceuticals in children that are acceptable, but ongoing quality assurance should be performed on these patients as they are imaged to ensure that the images are of adequate quality. Images should be evaluated closely before release of the patient from the imaging department to determine if there is a significant chance that disease will be missed on lower-activity images and whether additional imaging should be performed. Increasing the imaging time for smaller children should be considered but must be balanced with the potential for increased motion artifacts. Therefore, it is very important for technicians to understand the artifacts that may arise, to recognize unsatisfactory image quality and to evaluate further possibilities for patient scanning. For example, scanning in pediatric patients usually do not include 3-phase studies or studies with SPECT imaging, which are frequently performed in adult imaging. Majority of pediatric oncology guidelines are not clearly defined regarding use of ionizing imaging methods for follow-up, although it is well known that CT procedure has high accuracy.

Good balance of minimum radiation dose and maximum image quality can be achieved if estimating the minimum dose which is required and using maximum technical imaging options in a trusting atmosphere, ensuring good communication with the child and accompanying person.

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