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Dosimetric study of PET/CT tests using pediatric and adult phantoms

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Introduction: Positron Emission Tomography (PET) associated with Computed Tomography (CT) scanning is becoming increasingly important in noninvasive imaging studies and in the monitoring of children with known or suspected malignant diseases [1, 2]. These compound tomographic scanners allow the fusion of functional images obtained from the administration of radionuclides, such as ^{18}F, and anatomical images generated by X-ray beam attenuation from CT [3-5]. Although the immediate benefit to the individual patient may be substantial, relatively high radiation doses associated with PET/CT, compared with conventional exams have raised health care. This is especially concerning for children, who are more sensitive to radiation-induced carcinogenesis and have many remaining years of life for the development of cancer [6]. The aim of this study is to evaluate and compare the absorbed and effective doses using two phantoms, a male adult and a 10-year-old.

Methodology: In this study, the absorbed and effective doses generated by the CT scan and incorporated by the administration of the radionuclide ^{18}F-FDG were evaluate in the most radiosensitive organs. To evaluate the CT dose, radiochromic film strips (Gafchromic XR-QA2) [7,8] were positioned into two the body phantoms. To represent the adult, Alderson Rando male model phantom was used. It consists of a human skeleton wrapped in a polymeric material with equivalent tissue characteristics, with the trunk and the head sliced in thicknesses of 2.5 cm, a total of 33 slices [9]. The children's phantom is similar to 10-years-old, built by PMMA volumes. The CT protocol performed was the standard whole-body scanning used in the service where the study was done, being the scan distance of 150 cm to the adult phantom, and 73.9 cm to the child phantom. The activity of the radiopharmaceutical ^{18}F-FDG to be injected may vary according to the patient mass and the detector sensitivity. The Effective Dose was evaluated using the biokinetic model proposed by the International Commission on Radiological Protection (ICRP) number 106 [10]. The protocol used was 3.33 MBq.kg-1 (0.09 mCi.kg-1), this amount is commonly used in the service were the study was done, and it was multiplied by the mass of each phantom, 73.5 kg for the male adult and 31 kg for the 10 years old.

Results: The absorbed doses from CT scan were approximately on average 69% higher in the adult phantom. This can be explained by the scan distance, which was 150cm cm for the adult phantom and 73.9cm for the 10-year phantom. For the adult phantom, the organs that presented the highest absorbed dose from CT scan were thyroid and gonads. In the 10-year phantom, the highest absorbed doses were found in bone marrow and stomach. The highest values were found in the central region of the phantom, that can be explained by the scattered radiation. Different values are due to the variations in the format and size of the phantoms. Analyzing the effective dose from ^{18}F, the bladder had a higher value for both phantoms, explained by the excretion route of the radiopharmaceutical.

Conclusions: The CT scan is responsible for more than 60% of the effective dose in the PET/CT examination for both phantoms, hence the importance of the tomographic protocol optimization, reducing doses to the minimum necessary. It is important to emphasize the importance of patient-specific size use in exposure dose estimation for ^{18}F-FDG PET/CT.

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