Evaluation of medical and occupational shielding in cerebral angiography using Monte Carlo simulations and virtual anthropomorphic phantoms

William S. Santos[1]; Lucio P. Neves[2]; Ana P. Perini[2]; Linda V.E. Caldas[2] and Ana F. Maia[1]

[1]Departamento de Física, Universidade Federal de Sergipe, 49100-000, São Cristovão, SE, Brazil.
[2]Instituto de Pesquisas Energéticas e Nucleares, Comissão Nacional de Energia Nuclear (IPEN-CNEN/SP); Av. Prof. Lineu Prestes, 2242, 05508-000, SP, Brazil.

Key words: Cerebral angiography, dosimetry, Monte Carlo simulation

Cerebral angiography (CA) exams may provide valuable diagnostic information for the patients with suspect of cerebral diseases, but it may also deliver high doses of radiation to the patients and medical staff. These high doses are mainly due to the greater fluoroscopy time and number of images acquired during the exams. Furthermore, the dose rates around the patient are a complex function of several factors. In order to evaluate the medical and occupational expositions from different irradiation conditions, Monte Carlo (MC) simulations were employed. Virtual anthropomorphic phantoms were used to represent the patient and physician inside a typical fluoroscopy room, also simulated in details. The physician and the patient were represented by adult virtual anthropomorphic phantoms (MASH), incorporated in the MCNPX 2.0.7 MC code. The evaluation was carried out by means of dose conversion coefficients (CCs) for equivalent (H) and effective (E) doses normalized by the air-kerma product (KAP). CCs for the surface entrance dose of the patient (ESD) and equivalent dose for the eyes of the medical staff (H_L), because CA exams present higher risks for those organs. The X-ray spectra used during the simulations were obtained by simulating the X-ray system. The tube voltage was 80 kVp, and Al filters with thicknesses of 2.5 mm, 3.5 mm and 4.0 mm were inserted in the beams. Two projections were simulated: posterior-anterior (PA) and right side (RLAT). Regarding the patient and physician, the results indicate that the CCs are dependent of certain technical parameters as projection and Al filtration. In all situations, there was an increase of the CCs values with the increase of the Al filtration. The higher dose was obtained for a RLAT projection with a 4.0 mm Al filter. In this projection, the ESD/KAP and E/KAP values to patient were 11(14%) mGy/Gy.cm² and 0.12(0.15%) mSv/Gy.cm², respectively. For the physician, the use of mobile shielding beneath the table and suspended glass shielding, resulted in a significant reduction of the CCs, E/KAP and H_L/KAP. The mean reductions were 66% (PA) and 95% (RLAT). The use of MC simulations proved to be a very important tool in radiation protection dosimetry, and specifically in this study several parameters could be evaluated, which would not be possible experimentally.

williathan@yahoo.com.br