Assessment of dose increase after administration of radiopharmaceuticals prepared with cyclotron-produced ^{99m}Tc

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Technetium-99m (^{99m}Tc) is currently available from ^{99}Mo/^{99m}Tc generators as the β-decay product of ^{99}Mo (T½=66 h). Nowadays, ^{99}Mo is mostly obtained as a fission product in nuclear reactors by neutron-induced reactions on highly enriched uranium. Alternative production routes, such as direct production of ^{99m}Tc via ^{100}Mo(p,2n)^{99m}Tc reaction using medical cyclotrons has the potential to be both reliable and relatively cost-effective. However, results showed that the extracted ^{99m}Tc from the proton-bombarded ^{100}Mo-enriched target contains small quantities of several Tc radioisotopes (^{93m}Tc, ^{93}Tc, ^{94}Tc, ^{94m}Tc, ^{95}Tc, ^{95m}Tc, ^{96}Tc and ^{97m}Tc).

The aim of this work was to estimate the dose increase (DI) due to the contribution of Tc radioisotopes generated as impurities, after the intravenous injection of four radiopharmaceuticals prepared with cyclotron-produced ^{99m}Tc (CP-^{99m}Tc) using 99.05% ^{100}Mo-enriched metallic targets.

Four ^{99m}Tc radiopharmaceuticals (pertechnetate, sestamibi (MIBI), hexamethylpropylene- amine oxime (HMPAO) and disodium etidronate (HEDP)), were considered in this study. The biokinetic models reported by the International Commission on Radiological Protection (ICRP) for each radiopharmaceutical were used to define the main source organs and to calculate the number of disintegrations per MBq that occurred in each source organ (Nsource) for each Tc radioisotope present in the CP-^{99m}Tc solution. Then, target organ equivalent doses and effective dose were calculated for each Tc radioisotope with the OLINDA/EXM software versions 1.1 and 2.0, using the calculated Nsource values and the adult male phantom as program inputs. Total effective dose produced by all Tc isotopes impurities present in the CP-^{99m}Tc solution was calculated using the fraction of total activity corresponding to each radioisotope generated by the bombardment of ^{100}Mo-enriched (99.05%) metallic target. Finally, the effective obtained dose was compared with the effective dose delivered by the generator-produced ^{99m}Tc.

The total effective dose increases of CP-^{99m}Tc radiopharmaceuticals, calculated with both versions of the OLINDA software, remained within the 10% limit in all cases, from 6 up to 12 hours after end of bombardment (EOB). The Tc radioisotopes with the highest concentration in the CP-^{99m}Tc solution at EOB are ^{94m}Tc and ^{93m}Tc. However, their contribution to DI 6 hours after EOB is minimal, due to their short half-lives. ^{96}Tc is the radioisotope with the largest contribution to the effective DI, followed by ^{95}Tc and ^{94}Tc, although their concentration in the CP-^{99m}Tc solution is 5 times less than ^{94m}Tc and ^{93m}Tc at the EOB. This is due to the types of their emissions and relatively long half-lives.

The increase in the radiation dose caused by the other Tc radioisotopes contained in produced CP-^{99m}Tc, as described here, is quite low. Although the concentrations of the ^{94}Tc and ^{95}Tc radioisotopes in the CP-^{99m}Tc solution exceed the limits established by the European Pharmacopoeia, CP-^{99m}Tc radiopharmaceuticals could be used in routine nuclear medicine diagnostic studies if administered from 6 to 12 hours after the EOB; thus, maintaining the effective DI within the 10% limit.