Internal Dose Estimation for Radiopharmaceuticals labelled with Accelerator Produced Technetium-99m

L. Meléndez-Alafort [1], L. De Nardo[2,3], G. Ferro-Flores[4], M. Bello[2,5], M. Paiusco[1], A. Zorz[1], N. Uzunov[4,6], A. Rosato[1,7], J. Esposito[5]

[1] *Veneto Institute of Oncology IOV-IRCCS, Padova, Italy.*
[2] *Dipartimento di Fisica e Astronomia dell'Università di Padova, Padova, Italy.* [3] *INFN, Sezione di Padova, Padova, Italy.*
[4] *Instituto Nacional de Investigaciones Nucleares, Ocoyoacac, Mexico*
[5] *INFN, Laboratori Nazionali di Legnaro, Legnaro (Padova), Italy.*
[6] *Faculty of Natural Sciences, University of Shumen, Shumen, Bulgaria.*
[7] *Dipartimento di Scienze Chirurgiche, Oncologiche e Gastroenterologiche dell'Università di Padova, Padova, Italy.*

INTRODUCTION

^{99m}Tc is the radionuclide most widely used in diagnostic nuclear medicine. It is available from ^{99}Mo/^{99m}Tc generators, where ^{99}Mo is obtained by nuclear-fission reaction on HEU-WP (^{235}U) material in nuclear reactors. An alternative production route which can fulfill the shortage of this isotope in case of reactors shutdown exploits proton-irradiation of ^{100}Mo-enriched target [e.g. ^{100}Mo(p,2n)^{99m}Tc]. The TECHN_OSP/LARAMED research project at LNL-INFN has yet experimentally proved that, as expected from theoretical analyses [1], the accelerator-produced ^{99m}Tc (AP-^{99m}Tc) contains small quantities of several other technetium radioisotopes (^{93}Tc, ^{93m}Tc, ^{94}Tc, ^{94m}Tc, ^{95}Tc, ^{95m}Tc, ^{96}Tc and ^{97m}Tc) [2].

The aim of this work was to estimate the total contribution of technetium radioisotopes to the patient radiation absorbed dose after administration of four radiopharmaceuticals prepared with AP-^{99m}Tc, produced by irradiation of an Isoflex Mo target enriched with ^{100}Mo (99.05 %) with a proton beam of 15.7 MeV, accelerated by a PETtrace GE cyclotron.

METHODS

Four radiopharmaceuticals in use at present in the nuclear medicine clinic have been studied: Pertechnetate (used in clinical diagnostic of thyroid function and morphology), Sestamibi (widely used on cardiac scans for diagnosis of heart disease), hexamethylpropyleneamine oxime (HMPAO) (used as tracers of brain function) and disodium etidronate (HEDP) (a phosphonate commonly used for defining bone metastasis in cancer patients). The biokinetics models reported by the International Commission on Radiological Protection (ICRP) for each radiopharmaceutical [3-4] were used to determine the main source organs and to calculated the number of disintegrations that have occurred in each source organ (N_{source}), for each Tc-radioisotope found in the AP-^{99m}Tc. Then equivalent dose in the main organs of the adult male phantom was calculated for each Tc-radioisotope with OLINDA/EXM software version 1.1 and 2.0 [5]. Finally the total effective dose produced by the AP-^{99m}Tc solution was calculated at 5 different times after the end of bombardment (EOB) and compared with the effective dose produced by the Generator-Produced ^{99m}Tc (GP-^{99m}Tc).

RESULTS

The amounts of other technetium radioisotopes in the AP-^{99m}Tc-radiopharmaceuticals produce a low (below 10%) increase of the effective doses with respect to the same radiopharmaceuticals marked with GP-^{99m}Tc, up to 12 h after EOB. ^{96}Tc is the radioisotope with higher contribution to the effective dose, followed by ^{95}Tc and ^{94}Tc, while other Tc-radioisotopes contribution is quite low, being at least 3 orders of magnitude smaller than ^{99m}Tc contribution.

CONCLUSIONS

The effective dose increase remains inside the 10 % limit from 6 to 12 h after EOB, for all the studied radiopharmaceuticals labelled with AP-^{99m}Tc. The percent of dose increase is different for each radiopharmaceutical, because the biological half-life in each source organ differs among compound. Therefore dose calculation must be done for each radiopharmaceutical in order to determine the range of time after the EOB in which the Tc-radiopharmaceutical can be administered to remain under the 10 % limit of dose increase. More details about this study will be published in reference [6].

[1] J. Esposito et al.Sci. Technol. Nucl. Ins. 972381 (2013)
[2]N. Uzunov et al. submitted to Rad. Phys. Chem.
[3] ICRP Publication 53 Ann. ICRP 18 (1988).
[4] ICRP Publication 80 Ann. ICRP 28 (1998).
[5] M.G. Stabin et a, J Nucl Med 46 (2005) 1023
[6] L. Meléndez-Alafort et al. submitted to Phys. Med. Biol.