Dosimetric analysis of the contribution of Radionuclides Coproduced through $^{nat}V(p,x)^{47}Sc$ reaction route in Cyclotron Irradiation

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Introduction

Scandium presents different radionuclides with good imaging and therapeutic properties for the development of theranostic radiopharmaceuticals. In particular, ^{47}Sc ($t_{1/2}$= 3.35 d) has suitable features both for SPECT imaging, thanks to the 159 keV γ-ray emission, and for treatment of small-size tumours, thanks to the intense β^- emission (mean β^- energy: 162.0 keV). Its efficacy has been demonstrated at preclinical stage, but its low availability has however limited the application of ^{47}Sc-based radiopharmaceuticals to the clinic. Among the different proposed production routes, the $^{nat}V(p,x)^{47}Sc$ nuclear reaction[1] is of particular interest, due to the low-cost and easy availability of the target material, as well as the widespread availability of medium-energy cyclotrons. However, the nuclear cross section of this reaction is quite low and small amounts of Sc radioactive contaminants are co-produced. The aim of this work is to evaluate the contribution of Sc-contaminants to the patient radiation dose.

Materials and Methods

The yields of Sc radioisotopes for $E_P \leq 45$ MeV on ^{nat}V thick target was calculated, by

considering proton beams of different energy and different irradiation times, and by using experimental cross sections data from EXFOR nuclear database[2] and recently measured data[1]. A ^{47}Sc-labelled DOTA-folate conjugate (^{47}Sc-cm10) was used as an example of radiopharmaceutical to perform the dosimetric analysis. Biodistribution data in tumor-bearing mice, injected with ^{47}Sc-cm10 [3], were used in order to calculate the number of disintegrations in the main human organs, used then as input for dose calculations performed with the OLINDA v.2.1.1 code[4]. Effective dose *(ED_t)* of Sc-cm10 was calculated assuming that the radiopharmaceutical was injected after labelling with the mixtures of Sc-radioisotopes present at the different times after the End of Bombardment (EOB).

Results

Three Sc radioisotopes (i.e. ^{48}Sc, ^{47}Sc and ^{46}Sc) are produced by irradiation at $E_P \leq 45$ MeV on ^{nat}V target. The rising concentration of the long lived ^{46}Sc versus time after the EOB trigger a fast increase of ED_t for both 24 h and 80 h irradiation at the energy range 45-19 MeV and 40-19 MeV. However, the increment is much slower for energy range 35-30 MeV and even lower for 30-19 MeV.

Conclusions

Proton energy below 35 MeV must be used to produce ^{47}Sc through irradiation of a ^{nat}V target, to assure that the contribution to the ED_t of this radionuclide is higher than 90%. In these conditions the assessed values of ED_t and kidneys dose, after Sc-cm10 administration, are comparable to those of theranostic agents radiolabelled with the β^- emitter ^{177}Lu, currently leading the clinical application of radionuclidic therapy.

References

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