Dosimetry of $^{51}MnCl_2$ and $^{52}MnCl_2$ for PET application

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Introduction

Manganese has been so far mainly used for in-vivo animal studies of tissue anatomy of liver, kidneys, heart and pancreas, as well as to monitor cellular activity, cytoarchitecture and neuronal tract tracing in the brain by using the so-called Manganese-Enhanced Magnetic Resonance Imaging (MEMRI)-based techniques. However, the large amount of manganese necessary for MEMRI may induce neurotoxic effects that result in manganism, a neurological syndrome similar to Parkinson's disease. The much higher sensitivity of positron emission tomography (PET) over MRI enables, instead, the use of non-toxic trace level concentrations of Mn. The radioisotopes ^{52}Mn ($t_{1/2}$= 5.591 d, β^+= 29.4%, $E(\beta^+)_{avg}$= 241.6 keV) and ^{51}Mn ($t_{1/2}$= 45.59 min, β^+=97.1%, $E(\beta^+)_{avg}$ = 970.2 keV) have already been used for preclinical PET imaging in the past, mainly administered in free ionic form as $MnCl_2$ [1-2]. However, internal radiation dose assessment due to the administration of $^{52}MnCl_2$ to humans is still missing, while only one study has been reported for $^{51}MnCl_2$ dosimetry calculations[2]. The aim of this work is to fill this gap by assessing the radiation effective dose (ED) of $^{51}MnCl_2$ and $^{52}MnCl_2$.

Materials and Methods

Biodistribution data in healthy mice after $^{52}MnCl_2$ injection[1] and the reported manganese biological half-life in human[3] have been used to obtain the number of disintegrations in the main human organs, by the relative mass scaling method. The calculated number of disintegrations was used to assess the ED through the anthropomorphic phantoms based on human standardized masses defined by ICRP 89 [4] and tissue-weighting factors recommended by the ICRP 103 [5] with the OLINDA code v2.0 [6].

Results

Organ dose assessment shows that, for both radioisotopes, pancreas is the critical organ, followed by kidneys and liver, both for male and female phantoms. The ED due to $^{52}MnCl_2$ for male phantoms is 1.35 mSv/MBq, about one hundred thirty times higher than that of $^{51}MnCl_2$, 0.0102 mSv/MBq. Female EDs calculated for both radionuclides are about 30% higher than male EDs.

Conclusions

The ED of $^{51}MnCl_2$ is comparable to that of ^{18}FDG (0.0192 mSv/MBq, gender-averaged value), allowing its safe application for PET imaging. The high ED due to $^{52}MnCl_2$ is instead a limiting factor for human application. To exploit the potentiality of ^{52}Mn, whose low positron energy value is similar to that of ^{18}F, this radionuclide should be linked to receptor-specific molecules that could improve its pharmacokinetic properties.

References

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