A $^{67/64}$Cu-mixture as a therapeutic alternative to pure ^{67}Cu

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Aim

Two copper radioisotopes, ^{64}Cu and ^{67}Cu, are currently considered among the most promising radionuclides for both diagnosis and therapy of cancers. ^{64}Cu radionuclide is already commercially available, as it can be produced with high specific activity by using proton beams available at low energy (i.e. 18-24 MeV), so called medical, cyclotrons. On the other hand, high yield production of ^{67}Cu is difficult, due to the co-production of other Cu-isotopes, especially ^{64}Cu. To address this issue, currently preventing the spread use of ^{67}Cu in preclinical as well as clinical research programs, the possibility of using a mixture of ^{64}Cu and ^{67}Cu radioisotopes for therapeutic applications has been considered in this work.

Methods

Copper radioisotopes yields were calculated by considering proton beam irradiation of both ^{70}Zn and ^{68}Zn targets under different energy ranges and irradiation times. A simple spherical model, representing tumours of different sizes, was used to calculate the absorbed dose due to the self-irradiation for a uniformly distributed $^{67/64}$Cu mixture. The biokinetic model for $CuCl_2$ published by ICRP 53 [1] was used to assess the human absorbed dose to healthy organs due to the $^{67/64}$Cu mixture with the OLINDA software [2].

Results

By comparing the absorbed doses to a sphere model due to uniformly distributed ^{64}Cu and ^{67}Cu, it was found that ^{64}Cu administered activity must be about five times higher than that of ^{67}Cu to obtain the same absorbed dose for tumour mass 0.01-10 g and about ten times higher for smaller ones. By administration of a $^{67/64}$Cu mixture, a supplemental activity is therefore required to get the same tumour absorbed dose produced by pure ^{67}Cu. This supplemental activity, triggering a dose increment in healthy organs, depends on the time of injection of the $^{67/64}CuCl_2$ mixture, decreasing with increasing time post the end of the bombardment (EOB), due to the increasing ^{67}Cu radionuclide fraction in the mixture.

Conclusions

A mixture of $^{67/64}$Cu radioisotopes could impart the same tumour absorbed dose as that due to pure ^{67}Cu, with a minimal (<10%) dose increment to healthy organs when injected afterwards a few tens of hours post the EOB. In this way, the exploitable amount of activity will be about 7.5 times larger compared to the hypothesis of injecting pure (RNP>99%) ^{67}Cu, obtained after waiting times after the EOB sufficiently long (120-145 h) to allow ^{64}Cu decay [3].

References

(1) ICRP Publication 53 [1988] Ann. ICRP 18 (1-4)
(2) Stabin M, Farmer A [2012] J Nucl Med. 53 (1): 585
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