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Radiation dose estimative using computational murine model from Gd-159 nanostructured radiopharmaceutical

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Different therapeutic radiopharmaceuticals containing the P-32, Re-188, Sr-89, and Y-90 radioisotopes have been used effectively in alleviating bone pain resulting from metastases, synovectomy, and tumors. These radioisotopes all present the ability to emit high doses of beta radiation, leading to the death of tumor cells. Similarly, the Gd-159 isotope emits negative beta (1001 keV) and gamma radiation (main energy: 363.54 keV) suitable for therapeutic applications in nuclear medicine. Previous in vitro studies showed that Gd-159-DTPA-BMA complex presents a high in vitro cytotoxicity against tumor cells. However, when administered internally, this radioisotope does not accumulate in target tissues, being rapidly eliminated through renal excretion. Thus, seeking to solve these problems, different pharmaceutical formulations consisting of nanostructured carriers, such as liposomes, have been proposed to reduce the toxicity in non-target organs, especially in patients with chronic kidney diseases, while increasing the effective concentration and contact time in target tissues. In the present work, a computational tool was developed to simulate this effect, which occurs in experiments in vitro, helping to predict the possible results, saving time and resources, presenting a possible direction for studies of interest. The computer model was formed by a murine voxel phantom coupled to the Monte Carlo code MCNP5. The murine voxel phantom was constructed from 157 axial tomographic images using a PICKER SeleCT/SP CT scanner. The voxels dimensions were 0.71 x 0.71 x 1.5 mm3, equivalent to 118 columns, 76 lines and 157 slices. All murine phantom organs have homogeneous composition and homogeneous density. The elemental composition and mass density for the phantom organs and tissues were taken from the International Commission on Radiation Units and Measurements (ICRU) Report 46. The results obtained by the computational simulation, using biodistribution data in mice, showed to be in good agreement with the experimental data obtained in vitro and presented errors of less than 5%. This indicates that the computational tool can be used in future studies for more accurate analysis of biokinetic effects caused by radiopharmaceuticals in target organs and its vicinity.

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