A Monte-Carlo study of Sn-117m radiosynoviorthesis to treat arthritic joints

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Abstract

Objectives: Tin-117m is a promising radionuclide for the treatment of arthritis. Currently, radiosynoviorthesis employs Y-90 or P-32 for large joints, Re-186 for medium-sized joints and Er-169 for small joints based upon the energies and hence the ranges of their emitted beta particles. This study sought to demonstrate the utility of a Sn-117m colloid in the treatment of various sized joints. While the 300 µm range of its conversion electrons makes it intrinsically suitable for small joints, its relatively long 14-day half-life might allow the colloidal particles to be transported by macrophages deeper into the synovial tissues and thereby effectively treat larger joints.

Methods: Static and dynamic models of Sn-117m radiosynoviorthesis were developed using the Geant4 Application for Emission Tomography (GATE) Monte-Carlo software. The geometry of a synovial joint in the simulation was adopted from the planar layered model in the dissertation of LS Johnson. All five radionuclides were simulated in both static and dynamic situations. The 6 µm colloidal particles labeled with one of the radionuclides were initially arrayed in a rectilinear grid with a center-to-center spacing of 0.1 mm in a plane at the interface between the joint capsule and the intima. In the dynamic model, the particles then moved perpendicular to the planes of the joint layers with a uniform distribution of velocities. Their maximum speed of 8.58×10^{-8} mm/s was estimated from an analysis of post-mortem autoradiographs of the elbows of treated dogs. The dose as a function of depth in the model was plotted for both the static and dynamic models for all five radionuclides.

Results: The activity that was required to deliver the same peak dose as that from 1 MBq/cm^2 of Sn-117m was 7.68 MBq/cm^2 of Y-90, 2.07 MBq/cm^2 of Er-169, 4.74 MBq/cm^2 of Re-186, and 1.41 MBq/cm^2 of P-32 in the static simulation and 5.30 MBq/cm^2 of Y-90, 1.81 MBq/cm^2 of Er-169, 3.38 MBq/cm^2 of Re-186, and 1.16 MBq/cm^2 of P-32 in the dynamic simulation. The shapes of the dose distribution curves were very similar for Sn-117m and Er-169. Tin-117m and Re-186 can each deliver 100 Gy as deeply as 0.5 mm into the synovial tissue with dosages of 4.19 MBq/cm^2 and 1.46 MBq/cm^2 respectively.

Conclusion: Tin-117m could be substituted for Re-186 in the treatment of medium-sized joints as well as for Er-169 in the treatment of small joints.

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