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Development of a GATE model for three-dimensional dosimetric estimates of a PET/CT system

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Liver cancer is one of the most commonly diagnosed cancers and a leading cause of cancer-related deaths worldwide due to its high malignancy and typically late diagnosis. Radioembolization (RE) with Yttrium-90 (Y90) loaded glass microspheres is a recent Nuclear Medicine (NM) treatment for unresectable liver tumors. In this procedure, Y90 microspheres are delivered via a microcatheter into the hepatic artery, lodging in the tumor's blood vessels and emitting high-energy beta radiation to induce tumor cell death. However, the risk of radiation damage to healthy liver tissues can potentially lead to liver dysfunction. Accurate absorbed dose calculation is crucial for effective treatment planning and balancing tumour control with normal tissue complications. Therefore, 3D voxel-based dosimetry methods are increasingly explored for their ability to provide personalized dosimetry. These methods operate at the level of each reconstructed voxel, enabling 3D visualization of the tumor-absorbed dose distribution. Monte Carlo GATE (MC-GATE) simulations are the most precise technique for assessing absorbed doses in tissues from a point source of radioactivity. They effectively handle non-uniform activity distributions and heterogeneous tissues using small sub-organ voxel dimensions, allowing simulation of all particle interactions within tissues. This research aims to estimate 3D absorbed dose distributions from non-uniform Y90 activity distributions measured by real PET/CT equipment and compare them with those obtained from MC-GATE simulations towards the optimization of prescribed activities in RE treatment planning.

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