Mapping contrast enhanced CT images to Liver Radioembolization Doses: a comprehensive approach for improved patient guidance in treatment

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Résumé

Introduction: Radioembolization is the cornerstone of unresectable hepatocellular carcinoma (HCC) and metastatic liver tumor treatment. Glass or resin microsphere with a diameter of 20 to 60 μm that are coupled or coated with radioactive yttrium 90 (Y-90) are injected into the tumor-feeding artery (hepatic or parasitized) to deliver localized radiation to the tumor. As the microspheres are passively transported by the blood flow to the tumor and surrounding tissues, the treatment efficiency highly depends on the tumor vascularization, which is driven by tumor volume and disruption of the normal vascular anatomy. Contrast-enhanced computed tomography (CECT) is commonly used in the pre-treatment evaluation of liver Y-90 radioembolization feasibility. CECT provides detailed imaging of the liver and surrounding structures, allowing healthcare providers to assess the size, location, and characteristics of liver tumors prior to the treatment. Here we propose a method for translating CECT images to an expected dose distributions for tumor and normal liver tissue.
Material and Methods: To build expected dose maps, from CECT images several steps are required. A pre-procedure CECT is used to obtain an iodine arterial-phase distribution by subtracting the non-contrast CT from the late arterial phase. The liver segments surrounding the targeted tumor are selected using Couinaud's classification. The resolution of the resulting images is then degraded to match the resolution of the Positron Emission Tomography (PET) images, which can image the Y-90 activity distribution post-treatment. This method was previously validated with a phantom study. An intensity threshold computed using Otsu's method was used to remove image noise and eventually parenchymal enhancement. The resulting images are then used the same way as PET images would be to compute doses with the Local Deposition Method (LDM). CECT images from three patients were used to test this method retrospectively and were compared with Y-90 PET-based dose distributions through dose volume histograms.

Results: Dose distributions between PET and CECT dosimetry appear visually similar which was confirmed by the Dose Volume Histograms (DVHs) calculated for each imaging modality. Results show a concordance between predicted and delivered Y-90 dose distributions with less than 10% difference in terms of mean dose, for doses greater than 10% of the 98th percentile (D2%). CECT-derived predictions tended to predict more homogeneous dose distributions than those estimated from the Y-90 distribution, which can be explained by less

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sensitivity of iodine transport to blood flow compared to Y-90 microspheres since sizes are not comparable. The injection is also performed downstream and intravenously. Hence, the mixing of iodine with blood is more homogeneous.
Conclusions: CECT-derived predictions of Y-90 radioembolization dose distributions seems promising as a supplementary tool for physicians when assessing treatment feasibility. This dosimetry prediction method could provide a more comprehensive pre-treatment evaluation - offering greater insights than a basic assessment of tumor opacification on CT images without any additional scan or tracer injection, since CECT is on some institutions routinely performed on liver cancer patients.

Mots-Clés: Contrast Enanced CT, Y90, Dose prediction