Image-Guided $^{166}$Ho Microbrachytherapy: Quantification of Radioactive Holmium Microspheres after Intratumoral Injection and Development of a Dosimetry Method Using Computed Tomography. Sebastiaan van Nimwegen, Rob Bakker, Nicole Reijniers, Remco Bastiaannet, Frank Nijsen

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Introduction: Microbrachytherapy by intratumoral injection of radioactive $^{166}$Ho microspheres ($^{166}$HoMS) has promising results and minimal morbidity in companion animals with inoperable tumors. Results in cats with oral squamous cell carcinoma (OSCC) initiated translation of this approach to humans with OSCC, including experimental treatment of humans with end-stage OSCC disease. Recently, an interdisciplinary translational project started for development of an image-guided $^{166}$Ho-microbrachytherapy for brain malignancies. A challenge in $^{166}$Ho-microbrachytherapy is achieving sufficient intratumoral dose distribution. Ideally, real-time dose monitoring would enable adjustments during the treatment procedure. Therefore, a CT-based dosimetry model was developed in a rabbit Vx-2 tumor model.

Materials and methods: $^{166}$Ho calibration curves were created for CT and µCT. Technique of quantification of intratumoral $^{166}$HoMS was investigated by manually determining HU-threshold levels to filter out background tissue and performing adjustments of extracted $^{166}$HoMS images for mean tissue HU values. Subsequently, standardized background HU-threshold levels were applied for CT quantification of intratumoral $^{166}$HoMS in 5 Vx-2 tumors. 3D dose mapping was performed using an existing $^{166}$Ho dose kernel for SPECT adjusted to (µ)CT dimensions. Proof of principle was tested in a feline OSCC after treatment with $^{166}$Ho-microbrachytherapy.

Results: On average 76% of the injected $^{166}$HoMS was detected by CT using a fixed background HU-threshold level. A 3D dose map was constructed for the feline OSCC (Figure 1). Considering the high tumor-absorbed doses with minimal side effects in $^{166}$Ho-microbrachytherapy, underestimation of $^{166}$HoMS content will not necessarily affect treatment outcome.

Conclusions: CT enables fast and high-resolution quantitative imaging of $^{166}$HoMS distribution.

Figure 1: µCT image (2) and dose map (3) of intratumoral $^{166}$HoMS after treatment of a feline OSCC.