Less is sometimes more – Accurate Dose Mapping after Endoradiotherapy with ^{177}Lu-DOTATATE/-TOC by One-Single Measurement after 96 h

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Objectives: Dosimetry of normal organ and tumor tissue of patients envisaged for Endoradiotherapy (ERT) with ^{177}Lu-DOTATATE/-TOC is important to assess risks and benefit of therapy. However, dosimetry is usually not routinely performed because effort and complexity of data collection and analysis. Aiming at a well-founded simplification of dosimetry, we analyzed the accuracy of absorbed dose estimates based on one-single measurement of the activity retention.

Methods: Activity kinetics in 67 kidneys (usually the dose limiting organs in ERT), 30 livers, 34 spleen and 52 tumors were analyzed in patients with repeated planar whole body scans (at least 1-4 h, 1 d, 2 d, and ≥4 d) after ^{177}Lu-DOTATATE/-TOC administration. A bi-exponential decay function was fitted to the data of each evaluable organ/tumor r_S and normalized to 100% at its maximum to deduce the relative uptake $u(r_S,t)$. This function, after integration over time to deduce the time integrated uptake $\tilde{u}(r_S)$ and normalization to a high-quality quantitative retention measurement e.g. with a SPECT/CT, can be used to determine the absorbed dose to r_S. For a function $u(r_S,t)$ decaying mono-exponentially with an effective half-live T_{eff}, $\tilde{u}(r_S)$ can be approximated by $\tilde{u}(r_S) \approx \tilde{u}_l(r_S,t_l) = u(r_S,t_l) \cdot t_l \cdot 2/\ln(2)$ from a single measurement $u(r_S,t_l)$ at a late time point t_l (1). The error is theoretically < 6% if $0.85 \cdot T_{eff} < t_l < 1.17 \cdot T_{eff}$. For each uptake function, the values $\tilde{u}_l(r_S,t_l)$ were calculated from the expected $u(r_S,t_l)$ at t_l = 24 h, 48 h, 72 h, 96 h, 120 h, and 144 h and the deviations from $\tilde{u}(r_S)$ were determined. The mean tissue specific error was calculated for each time point t_l.

Results: For a measurement at t_l = 96 h, the deviation of $\tilde{u}_l(r_S,t_l)$ from $\tilde{u}(r_S)$ (figure 1) was determined to be 5% ± 6% (range, -9% to 20%) for kidneys, 7% ± 5% (range, -1% to 20%) for livers, 11% ± 8% (range, 2% to 47%) for spleens, and 2% ± 8% (range, -28% to 16%) for tumors. Accuracy is slightly reduced for measurements after 72 h (kidneys: 9% ± 6%; range, -15% to +25%) or 120 h (kidneys: -5% ± 8%; range, -25% to 8%). Inacceptable underestimates of the absorbed dose to the kidneys are observed for measurements after 24 h (-33% ± 7%; range, -61% to -18%), 48 h (0 ± 8%; range, -33% to 19%), and 144 h (-18% ± 10%; range, -41% to 7%).

For calculating the absorbed dose, assuming a local energy deposition by ^{177}Lu of 0.086 Gy·g/MBq/h, an activity concentration of 1 MBq/g measured in a tumor at 96 h indicates a local absorbed dose of 24 Gy.

Conclusions: A quantitative 3D-image of the abdominal activity concentration distribution in a patient 4 days after the administration of ^{177}Lu-DOTATATE/-TOC is proportional to a map of the absorbed doses to tumors and relevant organs. The proposed method offers a reasonably accurate estimate of the absorbed dose and can be easily implemented to monitor organ and tumor doses in patients with repeated ERT.

Figure 1

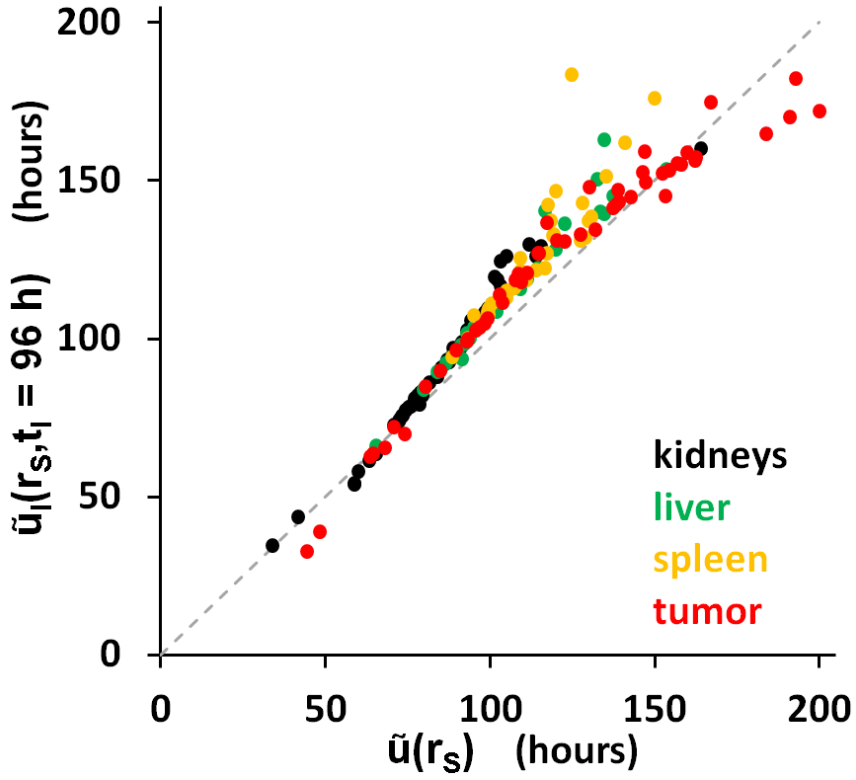

Figure 1. Measurement at t_I = 96 h, for kidney, liver, spleen, and tumors.

References:

(1) Hänscheid et al. Z Med Phys. 2011 Dec;21(4):250-7. doi: 10.1016/j.zemedi.2011.01.006

Research Support: This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 701983.

This research was originally published in JNM. Werner R.A., Lapa C., Buck A.K., Lassmann M., Hänscheid H.Less is sometimes more – Accurate Dose Mapping after Endoradiotherapy with ^{177}Lu-DOTATATE/-TOC by One-Single Measurement after 96 h. J Nucl Med May 1, 2017 vol. 58 no. supplement 1:247. *© SNMMI.*