Quantitative SPECT/CT ^{177}Lu-DOTATATE imaging in patients with in-vivo validation

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Aim:

^{177}Lu-DOTATATE is a promising radioisotope for therapy of neuroendocrine tumors (NETs). Current dosimetry methods based on planar scintigraphy utilize non-patient specific conversion factors that ignore anatomical variations, improperly account for attenuation, and are error prone when there is overlap between organs with significant uptake. Quantitative SPECT/CT imaging of ^{177}Lu could overcome these limitations and is a prerequisite for more accurate, individualized, 3-D dosimetry. In this study, we aimed to extend a previously established SPECT/CT quantitation protocol to ^{177}Lu and validate it *in vivo* using urine samples.

Methods:

In our quantitation protocol, counts in images reconstructed using an ordered subset-expectation maximization algorithm are converted to kBq/mL using a volumetric calibration factor derived from a phantom experiment. While varying the number of iterations (*iter*) at a constant 8 subsets (*ss*), we tracked the ratio of image to true activity (recovery coefficient, RC) in hot spheres and normalized standard deviation (NSD) in a volume of interest (VOI) in the warm background. The optimal *iter* level was selected as the point where recovery in the largest 3 spheres (16, 8, and 4 mL) stagnated, while the NSD continued to increase.

For validation, 12 SPECT/CT acquisitions from 3 female and 6 male patients undergoing therapy for NETs were included. Patients were scanned 24 hours after injection of 6.1 GBq of ^{177}Lu-DOTATATE. Urine samples were collected following each acquisition, and activity concentration was measured in a well counter. Data was reconstructed using parameters chosen in the phantom experiment, and an ellipsoidal VOI was placed inside each bladder. The resulting activity concentrations were then compared to the urine. We calculated RCs by taking the urine concentration as truth.

Results:

Our chosen 16*iter*8*ss* yielded RCs in the 16, 8, and 4 mL spheres of 0.87, 0.81, and 0.87, respectively, and NSD of 13.6%. For patients, the mean bladder RC was 1.0±0.14 (range: 0.84-1.27), with a 95% confidence interval between 0.92 and 1.07. The mean deviation of SPECT/CT concentrations from urine was 10.1±8.3% (range: -15.5-26.8).

Conclusion:

Any dosimetry approach is limited by the quantitative accuracy of its input data. Our results show that quantitatively accurate ^{177}Lu SPECT/CT *in vivo* is possible. However, use of ^{177}Lu quantitation in practice would benefit from improved reconstruction methods. Quantifying activity in the bladder is analogous to determining the amount of activity in the kidneys, which is an important task in dosimetry, and our results provide a useful benchmark for future efforts.