Impact of Modality (2D Planar, 2D/3D Hybrid, 3D SPECT) on Kidneys Absorbed Dose in ^{177}Lu-based PRRT

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Background / Aims

Background: In peptide receptor radionuclide therapy (PRRT) the kidneys are considered an organ at risk for radiation-induced damage. Thus the absorbed dose to the kidneys is one important safety parameter with the potential to influence the therapeutic treatment regimen and therefore also treatment outcome.

The choice of modality is expected to impact the dosimetry results

Theoretical Expectations

Planar	Hybrid	SPECT
» Quantitative accuracy depends on corrections applied » Activity overlap between organs/tumours	» Quantitation from SPECT time point » Activity overlap assumed constant across all time points	» Quantitation: ▪ Attenuation correction (AC) ▪ Scatter correction (SC) ▪ Activity calibration ▪ Resolution recovery / partial volume correction

Quantitative Accuracy

Practical Implications

» Shortest acquisition times for whole body (WB) scan	» Requires additional SPECT to WB planar imaging	» Long acquisition time for multiple bed positions

Speed

Aims – To compare kidneys absorbed dose

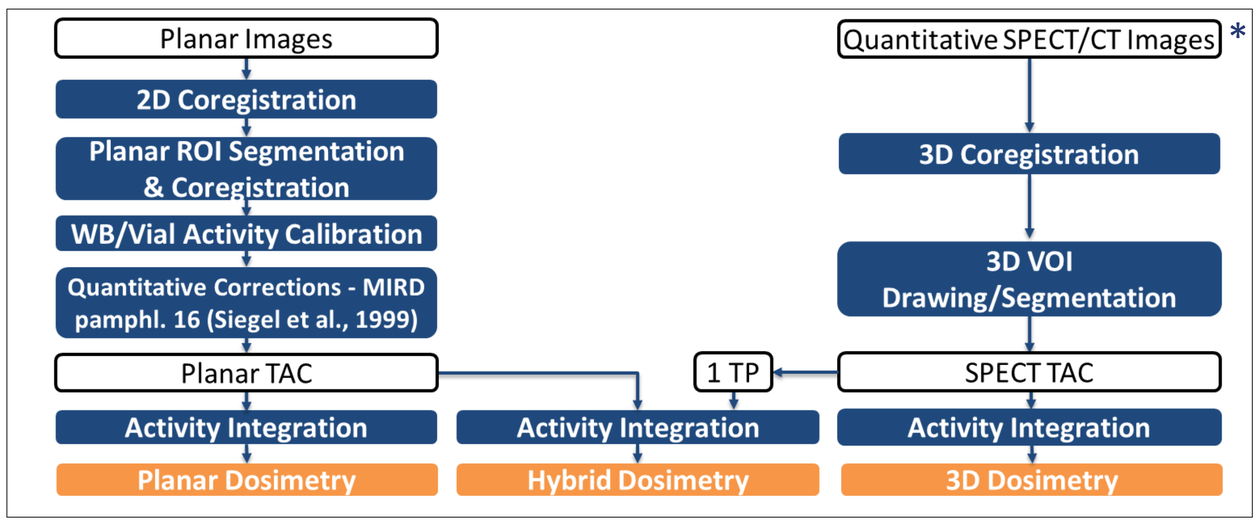
(1) For the different modalities and

(2) For different planar correction / calibration methods according to MIRD pamphlet 16 [1].

Methods

Patients and Imaging: Five patients with neuroendocrine tumours had received ^{177}Lu-Dotatate with injected activities between 6780 and 8505 MBq. 2D planar and 3D SPECT imaging was performed at 0.5h, 4h, 24h and 96h post-injection on a Siemens Symbia T6 camera.

Internal Dosimetry using QDOSE



* SPECT data had been reconstructed with 3D OSEM including attenuation and scatter correction. The SPECT camera sensitivity factor had been estimated using a small point-like source [2].

Dose Calculation using IDAC-Dose 2.1 [3] - based on:

- ICRP Adult Reference Computational Phantoms – ICRP publ. 110
- ICRP Specific Absorbed Fractions - ICRP publ. 133

Planar Correction / Calibration Methods

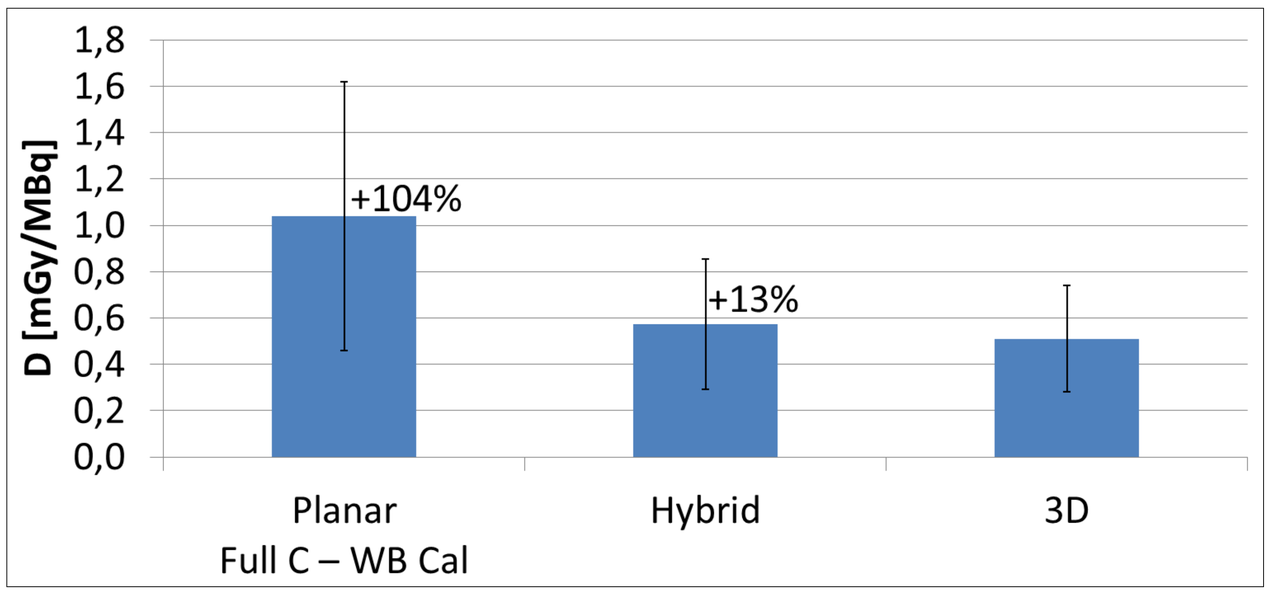
	Attenuation correction*	Background correction	Whole body calibration	Vial calibration
Full C – WB Cal	Yes	Yes	Yes	No
Full C – Vial Cal	Yes	Yes	No	Yes
AC – WB Cal	Yes	No	Yes	No
AC – Vial Cal	Yes	No	No	Yes
BkgC – WB Cal	No	Yes	Yes	
BkgC – Vial Cal	No	Yes	No	No
No C – WB Cal	No	No	Yes	No
No C – Vial Cal	No	No	No	Yes

* Attenuation correction: using a broad beam μ (including source self-attenuation)

Results

Modality Comparison – Kidneys Absorbed Dose

Absorbed dose to kidneys was on average overestimated by 104% due to activity overlap with planar methodology compared to 3D SPECT. Hybrid dosimetry only resulted in an average overestimate of 13%.

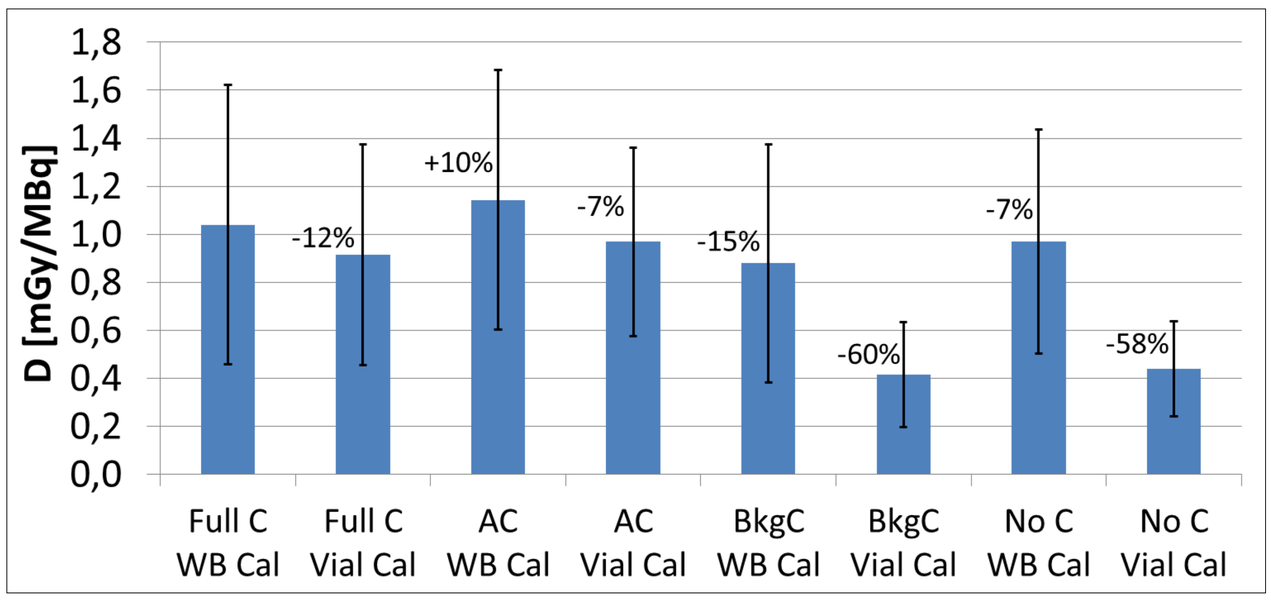


Planar Correction / Calibration Evaluation – Kidneys Absorbed Dose

Generally there was a relative large variation depending on which calibration/correction methods were applied. There was a moderate difference between vial and WB calibration when full correction was applied.

For WB calibration using only background correction or only attenuation correction resulted in only moderate differences of -15% and 10%, respectively.

Vial calibration without attenuation correction resulted in a deviation of approx. - 60 % compared to WB calibration and full correction.



Conclusions

For quantitative accuracy 3D SPECT dosimetry is preferable. If planar imaging is used, results can vary significantly depending on the methods applied and overlapping activity can cause significant overestimation of activity and hence absorbed dose for the kidneys. As absorbed dose limits (23Gy-29Gy) are commonly applied to the kidneys, dosimetry results based on planar imaging could potentially impede treatment efficacy by artificially restricting the administered therapeutic activity. Hybrid dosimetry provided a sufficiently accurate compromise between the higher acquisition time demands of 3D dosimetry and limited accuracy of planar dosimetry.

References

(1) Siegel, J. A.; Thomas, S. R.; Stubbs, J. B.; Stabin, M. G.; Hays, M. T.; Koral, K. F. et al. (1999): MIRD pamphlet no. 16: Techniques for quantitative radiopharmaceutical biodistribution data acquisition and analysis for use in human radiation dose estimates. J Nucl Med 40 (2), S. 37S-61S.

(2) Bailey, D. L.; Hennessy, T. M.; Willowson, K. P.; Henry, E. C.; Chan, D. L. H.; Aslani, A.; Roach, P. J. (2015): In vivo quantification of (177)Lu with planar whole-body and SPECT/CT gamma camera imaging. EJNMMI physics 2 (1), S. 20.

(3) Andersson, M.; Johansson, L.; Eckerman, K.; Mattsson, S. (2017): IDAC-Dose 2.1, an internal dosimetry program for diagnostic nuclear medicine based on the ICRP adult reference voxel phantoms. EJNMMI Research 7 (1), S. 88.