The organ and voxel-based individual dosimetry using single measurement approach for patients with multiple cycle ^{177}Lu-DOTATATE therapy

Purpose– For dosimetry after ^{177}Lu-DOTATATE therapy, the sequential SPECT/CT imaging is required to obtain time-integrated activity in interested region. This procedure makes patients visit hospital several times and takes additional costs. Therefore, the dosimetry method with simplified single measurement approach using planar images was suggested [1]. In this study, absorbed doses for kidneys, bone marrow and tumor regions were estimated with voxel-based and organ-based method with SPECT/CT data referring the single measurement approach. Furthermore, we performed dosimetry for patients who took multiple cycle therapy to confirm whether optimized single time point obtained from first cycle can be used for dosimetry for later cycle.

Methods– The SPECT/CT data from 7 patients with 2 cycles of ^{177}Lu-DOTATATE therapy obtained at Seoul National University Hospital were used for dosimetry. The images were acquired at 4, 24, 48, 120 hours after injection. The dosimetry was performed in four different ways: 1) OLINDA/EXM organ-based dosimetry with time-integrated activity using mono-exponential fitting, 2) OLINDA/EXM organ-based dosimetry with single measurement approach, 3) the multiple VSV dosimetry (no of VSV = 20) with time with time-integrated activity using mono-exponential fitting and 4) the multiple VSV dosimetry with single measurement approach. [2] The relative error of absorbed doses between method 1) and 2), and the relative error of absorbed doses between method 3) and 4) were estimated.

Results– In case of OLINDA/EXM organ-based dosimetry, single measurement approach with 120 hour time point data provided reliable dose estimation for kidney when comparing mono-exponential fitting results as the ground truth (mean absolute error: 5.70%). For bone marrow and tumor dosimetry, with 120 hour time point data used, the error was larger than kidneys although it was the smallest among all time points used (mean absolute error: 18.22 and 15.09 % for bone marrow and tumor regions respectively). It implies that mono-exponential fitting for these regions may not be proper. The same tendency was observed in case of voxel-based dosimetry (mean absolute error: 6.57, 17.69 and 15.13 % for kidneys, bone marrow and tumor regions respectively). For most cases, optimized single time point can be used in the next cycle for simplified dosimetry (5/7 cases for kidneys, 7/7 cases for bone marrow and 47/51 cases for tumor regions). Finally, the correlation of errors between voxel-based dosimetry and organ-based dosimetry was very high.

Conclusion– We confirmed that single measurement approach using 120 hour SPECT/CT data provides the smallest errors in most cases regardless of organ-based dosimetry or voxel-based dosimetry. This result is similar to the previous study. Furthermore, we observed that voxel-based dosimetry using single measurement approach showed similar result to the organ-based dosimetry which is used in the previous study. Therefore, we concluded that simplified voxel-based dosimetry which has an advantage for patient-specific dose estimation is available.

Reference

[1] Heribert H et al. “Dose Mapping After Endoradiotherapy with 177Lu-DOTATATE/DOTATOC by a Single Measurement After 4 Days”, J. Nucl. Med. 59, 75-81 (2018).

[2] Lee MS et al. “Whole-body voxel-based personalized dosimetry: the multiple voxel S-value approach for heterogeneous media with nonuniform activity distributions”, J. Nucl. Med. 59, 1133-1139 (2018).