Quantitative analyses of two SPECT/CT calibration factor at three-time points for imaging ^{177}Lu activity in clinical radionuclide dosimetry workflow

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Introduction

Patient-specific dosimetry in Radionuclide Therapy (RNT) is based on pharmacokinetic assessment, quantitative imaging and absorbed dose calculations. The clinical radionuclide internal dosimetry workflow performs six steps: i) Calibration acquisitions, ii) Patient Image acquisitions, iii) Reconstruction & Corrections, iv)Registration & Segmentation, v) Time activity curve fittings and vi) Absorbed dose calculations. The purpose of the study is to quantitatively analyse the first step which is the calibration acquisition of SPECT/CT imaging to visualize the absolute activity distribution of ^{177}Lu- DOTATATE (Lutathera®) activity in the volume of interest (VOI) across the patient body. This is obtained by a calibration factor that depends on the different types of gamma camera, radionuclide and reconstruction settings. For accurate activity quantification in the patient study, it is necessary to convert the counts in the reconstructed images into the activity, which is done by using the appropriate calibration factor [1]. The study aims to calculate and analyse the calibration factor (CF), at three time-points for the tomographic scans of two different SPECT/CTs, using a large cylindrical phantom with no inserts and filled with uniform activity in water.

Materials & Methods

For the analyses of the calibration factor, a known activity of ^{177}Lu- DOTATATE (370 MBq) (half-life of 6.65 days) is filled in a cylindrical phantom (Jaszczak phantom), uniformly distributed in water with a volume of 6.09 litre. The scans were performed by two SPECT/CTs for three time-points (Day0, Day4 & Day7) using a dual-headed GE Healthcare, Discovery NM 630 SPECT/CT and MEDISO Nucline ANYSCAN 3.05.025.0000 SPECT/CT, with high energy general purpose (HEGP) collimator. The SPECT/CT acquisition parameters details are described in Table 1. The ^{177}Lu emits a range of gamma radiations with two main energy peaks at 113 keV (6.4%) and 208 keV (11%) and the triple energy window (TEW) at 208 keV photopeak window with 20% energy window width. The image reconstruction was performed using *XELERIS* and *INTERVIEW-FUSION* workstations, with ordered subset expectation maximization (OSEM) algorithm. The calibration factor (CF) was derived using the equation; CF = C / A t, where CF is expressed in counts per second per MBq (unit: cps/MBq), C is the counts in the reconstructed image within a cylindrical VOI, t is the acquisition duration (unit: second(s)) and A is the activity dispensed in the phantom (Unit: MBq) [2].

Table1: SPECT/CT acquisition parameters details

S No	Acquisition Parameters	SPECT/CT (GE/MEDISO)
1	Matrix size	128 x 128
2	Detector movement	Step & Shoot
3	SPECT movement	Body contour
4	Projection per detector	60 (Mediso), 30 (GE)
5	Total time of Acquisition (SPECT)	20 min (Mediso), 14 min (GE)
6	Low dose CT	120keV/100mA

Results & Discussion

The calibration factor calculation results are shown in Table 2 and the analysis is shown in Figure 1. The result shows that the CF for each SPECT/CT remains approximately constant at three time-points.

Table2: Quantitative analyses of calibration factor for ^{177}Lu activity

	Quantity	Day0	Day4	Day7
GE SPECT/CT	Counts(C)	27,32,808.06	7,47,680.43	13,52,019.71
	Activity (A) (MBq)	361.786	239.364	175.124
	Time (t) (s)	840	840	840
	Calibration factor (CF) cps/MBq	8.992	5.744	9.190
MEDISO SPECT/CT	Counts(C)	26,25,560.62	35,55,552.16	23,99,962.72
	Activity (A) (MBq)	365.476	238.517	162.428
	Time (t) (s)	1200	1200	1200
	Calibration factor (CF) cps/MBq	6.060	12.422	12.312

The calculated data suggest that the preparation of the calibration source and measurement of the activity are the sources of error, hence proper evaluation would improve the calibration factor. Scatter correction was included in the tomographic image reconstruction, using the triple energy window (TEW) method and CT-based attenuation correction was also employed. It is recommended to acquire the reconstruction images and apply corrections for degrading factors in the same way as it is done in the patient studies at different time-points. The clinical reconstruction method of patient images is replicated in the reconstructed images of the extended source cylindrical phantom, at three time-point approach.

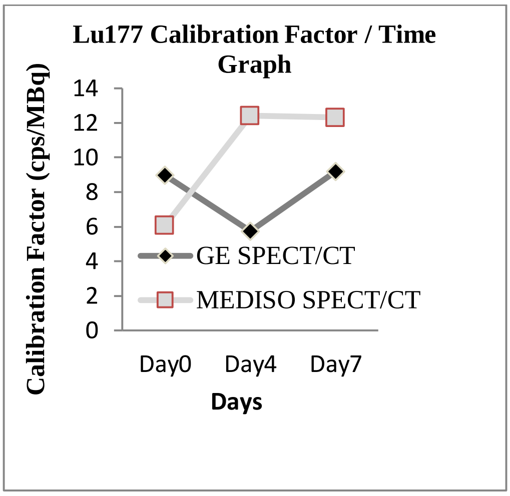

Fig. 1 CF analyses for each SPECT/CT

Conclusion

For quantitative imaging, the accurate determination of the SPECT/CT gamma camera CF is important in translating the counts in the reconstructed images into the activity values. The MIRD pamphlets 23, 26 and ICRU report 96 recommendations for data acquisition, which were followed in the reconstruction of images for accurate activity quantification of CF. For more personalized approach in obtaining the calibration factor for accurate activity quantification, the SPECT images of the extended source phantom should mimic the actual patient at different time-points for the calculation of time activity curve fittings. *(This work is part of a DST Women Scientist Scheme A (WOS-A) project; SR/WOS-A/PM-14/2019.)*

References

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[2] Zhao W et al, EJNMMI Physics. **5(1)**, 1-6 (2018)