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The dependence of Calibration Factor and Recovery Coefficients of a hybrid SPECT/CT system on acquisition and processing parameters

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1. Background-Aim

This study aimed to:

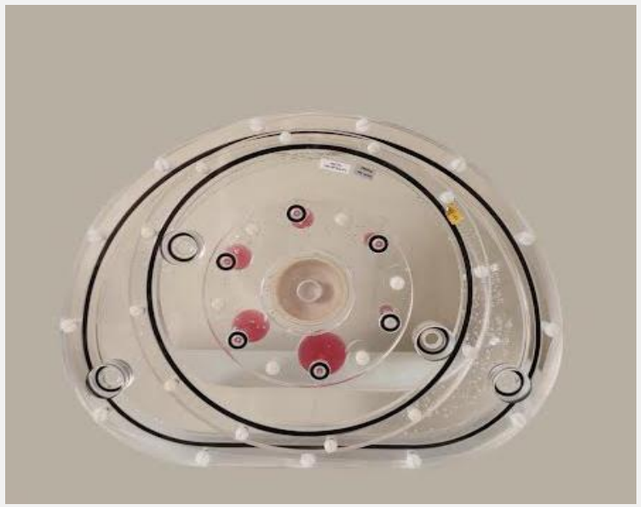
a) determine the Calibration Factor (CF) of a hybrid SPECT/CT system for ^{99m}Tc at varying acquisition conditions and different reconstruction parameters.

b) investigate the effect of different acquisitions parameters on the quantitative accuracy and quality of the images.

2. Materials & Methods

1 A cylindrical phantom uniformly filled with ^{99m}Tc solution (0.88 µCi/ml) was used for CF determination.

2 A NEMA IEC body phantom, with 6 spheres of different diameters, filled with two ^{99m}Tc solutions (background: 0.33 µCi/ml, spheres: 4.38 µCi/ml, sphere to background ratio 13.4:1) was used to assess Recovery Coefficients (RC).



2. Materials & Methods

NM/CT 850 System

Acquisitions were performed with the NM/CT 850 system (GE Healthcare) using LEHR collimators. CT was used for attenuation correction.

Acquisition Protocols

Standard acquisition: 120 projections, 360° rotation (20 sec/proj), 128x128 matrix size.

Fast acquisition: 60 projections, 360° rotation (25 sec/proj), 128x128 matrix size.

SPECT acquisitions were performed for both elliptical and circular orbits, with and without application of Scatter Correction (SC).

Reconstruction parameters

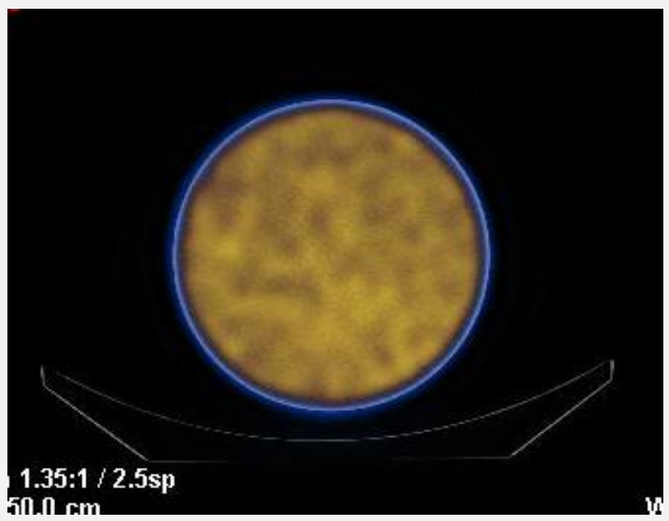
Several reconstructions were performed, including variations in iterations, subsets and filtering methods. OSEM algorithm was used for image reconstruction.

2. Materials & Methods

Determination of Calibration Factor

CF converts counts (C) into units of radioactive concentration (A_C), allowing quantitative analysis of the radiopharmaceutical distribution in a ROI of the image.

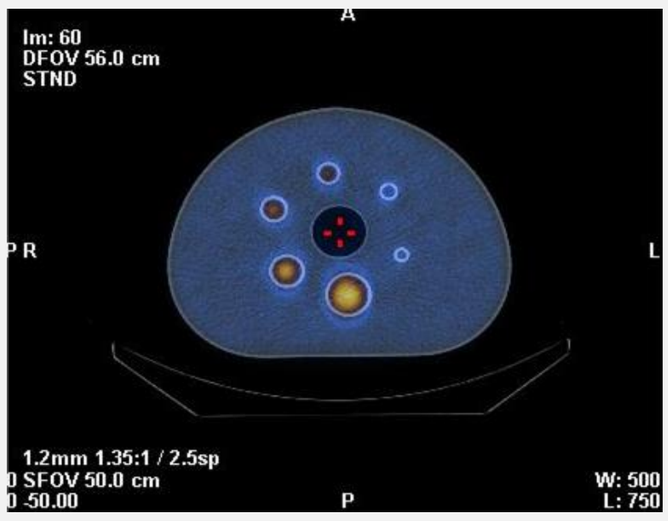
$$CF\left[\frac{cpm}{\mu Ci}\right] = \frac{C}{A_C}$$



Recovery Coefficient (RC)

RC expresses the effect of Partial Volume Effect (PVE) on quantitative accuracy (ideally RC=1). It is defined as the ratio between the measured sphere radioactive concentration ($\alpha_{j,max}$) and the actual sphere radioactive concentration at the time of acquisition ($\alpha_{j,loaded}$).

$$\mathrm{RC}_{\mathrm{j,max}} = \frac{a_{\mathrm{j,max}}}{a_{\mathrm{j,loaded}}}$$



Calibration Factor

Table 1: Mean values and standard deviations (sd) of CF from the measured values in each reconstruction, for each acquisition, from composite images of the cylindrical phantom with and without SC.

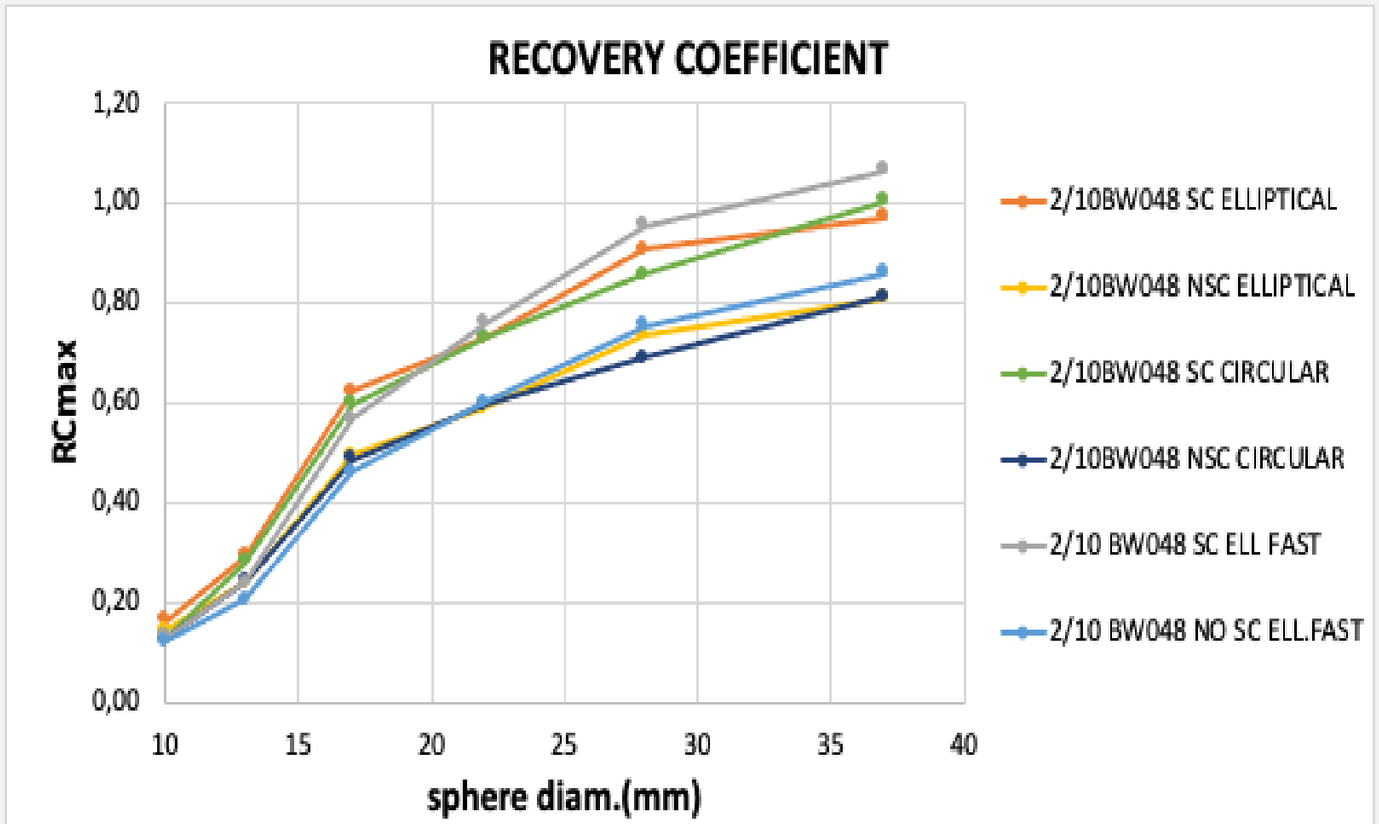
	SC		NO SC	
Orbit	CF_{ell} [cpm/µCi]	CF_{circ} [cpm/µCi]	CF_{ell} [cpm/µCi]	CF_{circ} [cpm/µCi]
$\overline{CF}_{it}$ (sd_{it})	149.2 (0.1)	148.6 (0.1)	194.5 (0.1)	193.6 (0.2)
$\overline{CF}_{subs}$ (sd_{subs})	149.1 (0.4)	148.6 (0.3)	194.3 (0.2)	193.6 (0.3)
$\overline{CF}_{fil}$ (sd_{fil})	149.2 (0.1)	148.5 (0.1)	194.5 (0.1)	193.6 (0.1)
$\overline{CF}$ (sd_{mean})	149.2 (0.1)	148.5 (0.1)	194.4 (0.1)	193.6 (0.1)

it: OSEM iterations, subs: OSEM subsets, fil: reconstruction filters, ell: elliptical orbit, circ: circular orbit

- $CF_{SC} < CF_{NO\ SC}$
- $CF_{elliptical} \approx CF_{circular}$

3. Results

Recovery Coefficient

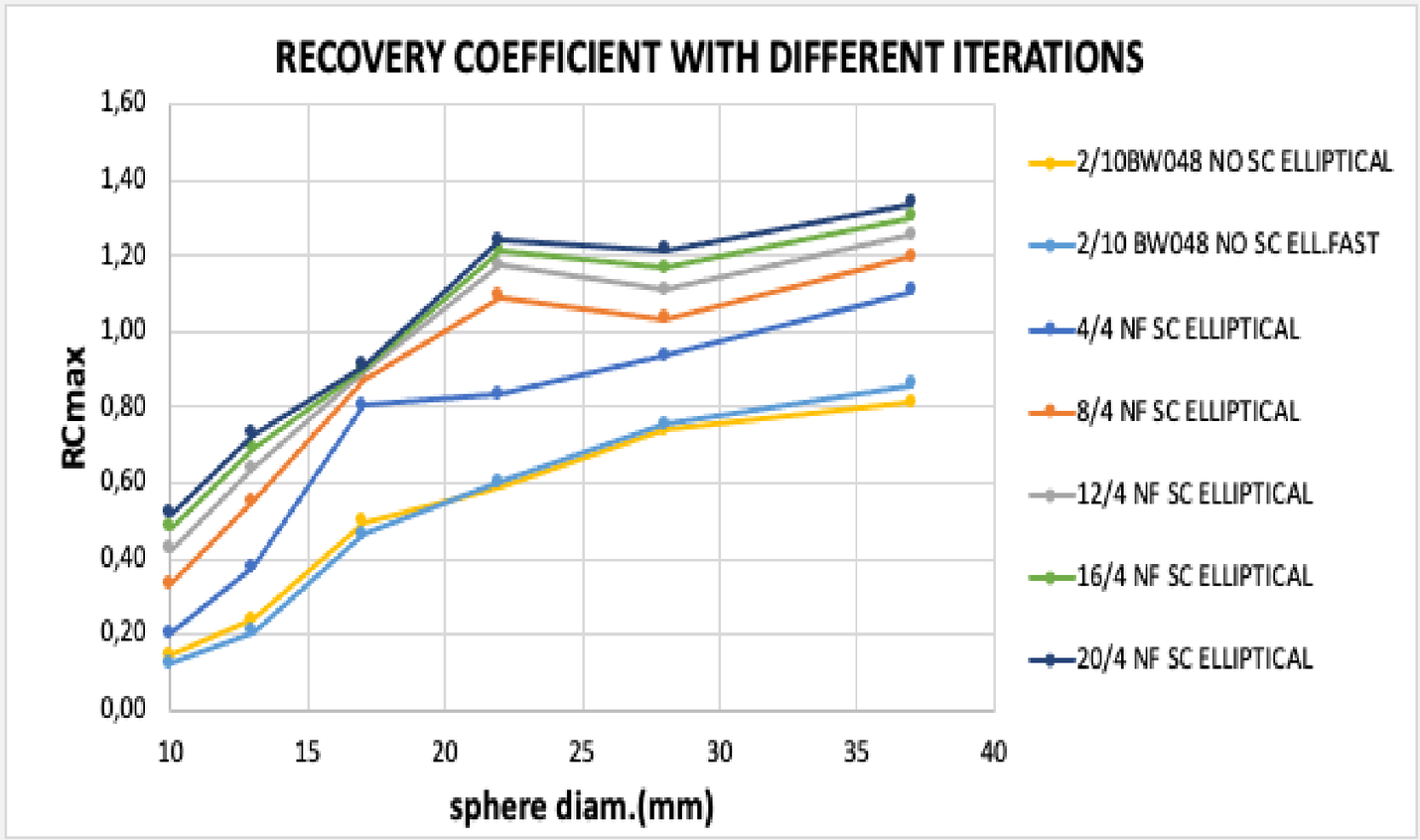


1 RC decreases with the diameter of the spheres (due to PVE).

2 SC increased RC_{max} by 20% compared to no SC application. In the elliptical and circular orbits, the RC_{max} values ranged from 0.13 (10mm) to 1.00 (37mm) while, without SC, the RC_{max} ranged from 0.13 to 0.81 in the respective spheres.

3. Results

Recovery Coefficient



1 RC_{max} values for the 22 mm sphere showed a relative increase of 30% when iterations were increased from 4 to 8, 13% for 8 to 16 iterations and 2% for 16 to 20 iterations.

4. Conclusions

Calibration Factor

CF Consistency	Scatter Correction Impact	Elliptical vs. Circular Acquisition
CF is not affected by reconstruction parameters (iterations, subsets, filter).	SC leads to a lower CF value compared to the reconstructions without SC.	In elliptical and circular orbits, the differences in the CF are not noticeable.

4. Conclusions

Recovery Coefficient

RC Consistency

There is a threshold beyond which further iterations offer little improvement in quantitative accuracy.

PVE

An underestimation of the activity concentration due to PVE was observed, due to limitations in the spatial resolution of the imaging system.

Scatter Correction Impact

SC improves the accuracy of quantitative measurements by increasing RC_{max} in the spheres by 20% compared to no SC application.