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Study of the influence of count's number in myocardium in the determination of reproducible functional parameters in Gated-SPECT studies simulated with GATE

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OBJECTIVE

Evaluate the influence of the total number of counts acquired from myocardium, in the calculation of myocardial functional parameters (LVEF – left ventricular ejection fraction, EDV – end-diastolic volume, ESV – end-sistolic volume) using routine software procedures.

BACKGROUND

Myocardial Perfusion Gated Single Photon Emission Tomography (Gated-SPET) imaging is used for the combined evaluation of myocardial perfusion and left ventricular (LV) function. But standard protocols of the Gated-SPECT studies require long acquisition times for each study [1,2,3]. It is therefore important to reduce as much as possible the total duration of image acquisition. However, it is known that this reduction leads to decrease on counts statistics per projection and raises doubts about the validity of the functional parameters determined by Gated-SPECT.

Considering that, it's difficult to carry out this analysis in real patients. For ethical, logistical and economical matters, simulated studies could be required for this analysis.

METHODOLOGY

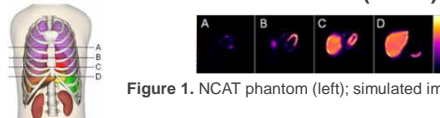Gated-SPET studies were simulated using Monte Carlo GATE package[4] and NURBS-based cardiac-torso (NCAT) phantom[5].

Figure 1. NCAT phantom (left); simulated images (above)[5].

This was done taking into account the recommendations made by national European regulatory authorities, national societies and the EANM Guidelines[1] with respect to injected activities for 99mTc-labelled tracers for adults of normal weight.

Table 1. Reference values for a normal patient, suggested by EANM Guidelines: Whole body activity (MBq), corresponding myocardium activity (MBq) and myocardium *voxel* activity (≈ myocardium activity / 11005 *voxels*) [1,6].

Injected activity (MBq)	Myocardium activity (1.2% of whole body activity) (MBq)	Activity at *voxel* Myocardium (≈ Bq / *voxel*)
250	3.0	275
350	4.2	385
450	5.4	500
680	8.2	750

Tomographic studies for all myocardium activities (Table 1) were simulated with 72 projections, including 8 intervals/cardiac cycle in an 202.5° angle, starting in right anterior oblique and ending in left posterior oblique view, within the time period recommended in the Gated-SPECT studies protocol in HPP–MM[7], with 15 and 30 sec/projection. All simulations were repeated five times.

Simulated data were reconstructed and processed using the commercial software package *Quantitative Gated-SPET* to obtain the functional parameters.

Bland-Altman and Mann-Whitney-Wilcoxon tests were used.

RESULTS

Table 2. N.º of total counts in studies with different activities in myocardium and acquisition times by projection.

Activity in myocardium (MBq)	seconds/projection	Total counts/*pixel* in myocardium (N=5) Mean±SD	Total counts in myocardium (N=5) Mean±SD
3.0	15	10.5±2.3	3.20521E+5±719
	30	21.0±3.1	6.42277E+5±950
4.2	15	14.5±1.5	4.49754E+5±671
	30	25.0±2.6	8.99812E+5±948
5.4	15	19.5±2.5	5.84315E+5±764
	30	35.7±3.3	11.64923E+5±1079
8.2	15	23.5±2.5	8.74780E+5±935
	30	55.5±4.1	17.52107E+5±1320

Based on the average counts per pixel and average number of total counts in the myocardium (Table 2) the functional parameters of the LV myocardium were obtained to evaluate if they have differences between the values of LVEF, EDV and ESV (Tables 3, 4, 5).

Table 3. Influence of the count's number in the values of left ventricular ejection fraction.

LVEF						
Activity in myocardium (MBq)	[a]15sec.	[b]30sec.	[c]Mean	[d]DIF	Mean difference±1.96SD	*p value*
3.0	45.6±1.44	48.2±1.06	46.9	-2.6	±2.10	0.01*
4.2	47.6±0.89	46.0±0.00	46.8	1.6	±0.90	0.05
5.4	50.4±0.55	49.6±0.55	50.0	0.8	±1.00	0.06
8.2	50.4±0.80	49.6±0.55	50.0	0.8	±1.00	0.59

[a] Mean±SD LVEF (%) in each 5 simulations with the activity in myocardium of 3, 4.2, 5.4 and 8.2 MBq and with 15sec/projection;
[b] Mean±SD LVEF (%) in each 5 simulations with the activity in myocardium of 3, 4.2, 5.4 and 8.2 MBq and with 30sec/projection;
[c] Average LVEF (%) with different times/projections, *i.e.* (a+b)/2 or (b+c)/2;
[d] Difference between the values of LVEF(%) simulated with different times/projections, *i.e.* (a-b) or (b-c).
* Statistically significant differences for *p*<0.05.

Table 4. Influence of the count's number in the values of end-diastolic volume.

EDV						
Activity in myocardium (MBq)	[a]15sec.	[b]30sec.	[c]Mean	[d]DIF	Mean difference±1.96SD	*p value*
3.0	91.2±1.16	90.6±1.65	90.9	0.6	±1.65	0.53
4.2	92.0±1.22	88.8±0.45	90.4	3.2	±1.61	0.01*
5.4	91.4±0.45	90.4±0.67	90.9	1.0	±1.07	0.05
8.2	90.2±0.45	90.6±0.71	90.3	-0.4	±0.44	0.14

[a] Mean±SD EDV in each 5 simulations with the activity in myocardium of 3, 4.2, 5.4, and 8.2 MBq and with 15sec/projection;
[b] Mean±SD EDV in each 5 simulations with the activity in myocardium of 3, 4.2, 5.4 and 8.2 MBq and with 30sec/projection;
[c] Average EDV with different times/projections, *i.e.* (a+b)/2 or (b+c)/2;
[d] Difference between the values of EDV simulated with different times/projections, *i.e.* (a-b) or (b-c).
* Statistically significant differences for *p*<0.05.

Table 5. Influence of the count's number in the values of end-sistolic volume.

ESV						
Activity in myocardium (MBq)	[a]15sec.	[b]30sec.	[c]Mean	[d]DIF	Mean difference±1.96SD	*p value*
3.0	49.2±1.66	46.8±1.77	48.0	2.4	±2.46	0.03*
4.2	48.4±0.55	48.0±0.71	48.2	0.4	±1.12	0.34
5.4	45.8±0.55	45.4±0.61	45.6	0.4	±0.82	0.22
8.2	48.2±0.65	48.6±0.45	48.4	-0.4	±1.28	0.42

[a] Mean±SD ESV in each 5 simulations with the activity in myocardium of 3, 4.2, 5.4 and 8.2 MBq and with 15sec/projection;
[b] Mean±SD ESV in each 5 simulations with the activity in myocardium of 3, 4.2, 5.4 and 8.2 MBq and with 30sec/projection;
[c] Average ESV with different times/projections, *i.e.* (a+b)/2 or (b+c)/2;
[d] Difference between the values of ESV simulated with different times/projections, *i.e.* (a-b) or (b-c).
* Statistically significant differences for *p*<0.05.

CONCLUSION

The total number of counts per simulation doesn't significantly interfere with the determination of Gated-SPET functional parameters (LVEF, EDV and ESV) using the administered average activity of 450 MBq corresponding to 5.4 MBq in myocardium.

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