

¹⁷⁷Lu EARL Quantitative SPECT

prototype

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Summary

1. Introduction
2. Radionuclide Calibrator
3. General SPECT Parameters
4. Large volume quantitative accuracy
5. Spatial resolution characterisation



Introduction

- The aim of EARL ¹⁷⁷Lu Quantitative SPECT accreditation is to provide:
 - A framework for Quantitative ¹⁷⁷Lu SPECT to be used for single and multi-centre trials which require radionuclide therapy dosimetry
 - An accreditation badge of quality for sites performing ¹⁷⁷Lu SPECT

Introduction

- The accreditation has two elements
 - i. A verification of the accuracy of ^{177}Lu quantification in large volumes.
 - ii. The characterization of the recovery of activity concentration in small features using activity recovery curves
- Together these elements will help to bring confidence and utility to quantitative SPECT measurements with ^{177}Lu .

The Radionuclide Calibrator



Radionuclide calibrator: Need

- Dosimetry requires
 - An accurate knowledge of the administered activity
 - An accurately calibrated SPECT system to measure in-vivo uptake of radiopharmaceutical.
- Both factors require accurate measurements of radioactivity within the radionuclide calibrator

Radionuclide calibrator: Requirement

- Accreditation requires an assessment of ^{177}Lu activity measurement that is traceable to a metrology lab
- This can be achieved by either
 - i. Measurements of ^{177}Lu accuracy confirmed by a metrology lab to be within 5% of the true value
 - ii. Measurement of a NIST or equivalent calibrated source with accuracy within 5% and with a ^{177}Lu dial factor that corresponds to an appropriate figure stored in an available database of dial factors
- The preferred method is method 1.
- A PROGRAM OF RADIONUCLIDE QUALITY CONTROL IS ALSO REQUIRED BASED ON IAEA, AAPM, NPL OR EQUIVALENT GUIDELINES

Radionuclide Calibrator: General Questions

Question		Response
1	Please give details of the radionuclide calibrator used for ¹⁷⁷ Lu measurements	
(a)	Manufacturer	
(b)	Model	
(c)	Year of manufacture or installation	
2	Please give details of the QC you perform on your radionuclide calibrator	
(a)	Daily QC	
(b)	Annual AC	
(c)	Other QC	



Radionuclide Calibrator: General Questions

Question		Response
3.	What radionuclide(s) do you use for constancy checks?	
(a)	Source 1	
(b)	Source 2	
4.	What source geometry and volume?	
(a)	Source 1: What container style and volume	Solid Source <input type="checkbox"/> Other <input type="checkbox"/> Volume:
(b)	Source 2: What container style and volume	Soild Source <input type="checkbox"/> Other <input type="checkbox"/> Volume:
5.	What dial factors do you use for your constancy checks?	
(a)	Source 1	
(b)	Source 2	

You may only have one source.

Radionuclide Calibrator: Accuracy

Accreditation **REQUIRES** some form of traceability to ensure accuracy of ^{177}Lu radionuclide calibrator measurements

Question		Response		
6	How do you confirm the accuracy of the Lutetium-177 measurements made on your radionuclide calibrator?	Via a metrology lab <input type="checkbox"/> (Go to Q7)	Via a secondary standard or other calibrated detector <input type="checkbox"/> (Go to Q8)	Other <input type="checkbox"/> (Go to Q9,10)

Radionuclide Calibrator: Metrology Lab Calibration

Question		Response	
7	Questions on metrology lab traceability		
(a)	What metrology lab are you traceable to?		
(b)	What container was used?	Syringe <input type="checkbox"/>	Vial <input type="checkbox"/> what type:
(c)	What approach did you use?	Purchase a calibrated source <input type="checkbox"/>	Sent an aliquot of activity to the lab <input type="checkbox"/>
(c)	What volume of ¹⁷⁷ Lu was measured?		
(d)	What accuracy was stated by metrology lab (%)		
(e)	What numerical dial/calibration factor is used for ¹⁷⁷ Lu measurements?		

Radionuclide Calibrator: Calibration via a secondary standard or other calibrated detector

Question	Response
8 Questions	
(a) What calibrated detector was used for the comparison?	Secondary Standard <input type="checkbox"/> Other <input type="checkbox"/> Details
(b) What container was used?	Syringe <input type="checkbox"/> Vial <input type="checkbox"/> what type:
(c) What volume of ¹⁷⁷ Lu was measured?	
(d) What accuracy was stated (%)?	
(e) What numerical dial/calibration factor is used for ¹⁷⁷ Lu measurements?	

Radionuclide Calibrator: Other method of calibration

Question		Response
9	Please describe how you ensure the accuracy of your ¹⁷⁷ Lu measurements	
10	What numerical dial/calibration factor is used for ¹⁷⁷ Lu measurements?	



SPECT Scanner Details and Imaging Parameters



General SPECT Imaging Parameters

- Evidence has shown that harmonizing protocols reduces variance in quantitative measures
- For data acquisition EARL will set out required acquisition parameters to minimize variation.
- However, in terms of reconstruction, data from both harmonized parameters and site preferred parameters will be gathered.

SPECT scanner: General Questions (duplicate if more than one scanner)

	Question	Response
7	Please give details of the SPECT system to be used for Quantitative SPECT measurements	
(a)	Manufacturer	
(b)	Model	
(c)	Year of manufacture or installation	
8	Please give details of the QC you perform on your SPECT system	
(a)	Daily QC	
(b)	Annual AC	
(c)	Other QC	

SPECT scanner: Required Acquisition parameters (duplicate if more than one scanner)

Collimator	Medium energy
# of energy windows	3
Photopeak energy (keV)	208.40 \pm 10%
Lower scatter energy (keV)	181.30 \pm 3% ^[1]
High scatter energy (keV)	235.50 \pm 3% ^[1]
Matrix	128 ^[2]
SPECT movement	Body contour
# of projections	120 (60 per detector)
Time per projection	variable in order to reach 7 million counts in total for all projections
CT	Standard low dose protocol, but \geq 100keV

- ^[1]: Acquisitions on Siemens Intevo (xSPECT Quant reconstruction) will be acquired with \pm 5% scatter windows.
- ^[2]: Acquisitions on Siemens Intevo (xSPECT Quant reconstruction) will be acquired with a 256 matrix but regridded to 128 for the centralized data analysis.

SPECT scanner: Required Reconstruction parameters (duplicate if more than one scanner)

Parameter	GE	Mediso Siemens	Philips	Mediso	Your system parameters
Reconstruction	Iterative				
Corrections	CT AC TEW SC Res Modelling			CT AC MC SC Res Modelling	
Iterations/subsets	20i4s				
ICF					
Filtering	None				
Vendor neutral	Hermes	MiM	Mirada	Other	Your systems parameters
Reconstruction	Iterative				
Corrections	CT AC TEW or MC SC Res Modelling	CT AC TEW SC Res Modelling		CT AC TEW SC, MC or model-based Res Modelling	
Iterations/Subsets	20i4s				
ICF					
Filtering	None				

Additional Reconstruction request

- 20i4s will be used as a basis
- For investigational purposes only, please could you also reconstruct with:
 - 5 iter, 2 subs
 - 10i, 2s
 - 20i, 2s
 - 30i, 2s
 - 50i, 2s
- The aim is to investigate the required number of updates for convergence, but without artifact.

SPECT scanner: Site Preferred Reconstruction parameters (duplicate if more than one scanner)

Parameter		Your systems parameters
20	Reconstruction	
21	Corrections	
22	Iterations/Subsets	
23	Filtering	

Large Volume Quantitative Accuracy



Large Volume Quantitative Accuracy

- Aim: To assess the calibration of the scanner and its measurement of activity concentration
- Using a cylindrical phantom with no inserts to assess accuracy in the absence of partial volume effects
- General approach taken to include all scanner and software types
- Those with dedicated quantitative hardware/software (e.g., xSPECT Quant), please can you also ADDITIONALLY submit data from this software i.e., send the following two datasets:
 - Flash 3D reconstruction (128 matrix) for traditional count-to-activity calibration
 - xSPECT Quant reconstruction (256 matrix, decay correction to the start of acquisition, user-defined reconstruction parameters) to cross check the traditional calibration method. If a radionuclide calibrator is set up, the SUV data will additionally be cross checked.

Large Volume Quantitative Accuracy: Phantom filling

- The aim is to achieve 7 million acquired counts in a 208 keV (20% photopeak) energy window by
 - Ideally filling the phantom with 400 MBq ^{177}Lu
 - Adjusting the time per projection to achieve 7 million acquired counts

Large Volume Quantitative Accuracy: Phantom filling

- Use a cylindrical phantom with no inserts, e.g., an empty Jaszczak phantom
- Determine the filling volume of the phantom (e.g., from the phantom specification or from vol. of liquid, weight or CT measurements).
- Fill more than three quarters of the phantom (make sure to leave some space for mixing).
- Draw the activity into a syringe noting the activity and time of measurement.
- Inject activity into phantom, flush the syringe and mix within phantom.
- You may also want to add 0.1 molar HCl to prevent ^{177}Lu sticking to the walls
- Fill up the rest of the phantom, leaving no bubbles.
- Note the residual activity in the syringe and the time this measurement is made.
- Acquire SPECT data using the defined imaging parameters, adjusting the time per projection to acquire a total of 7 million counts.

Large Volume Quantitative Accuracy (duplicate if more than one scanner)

Parameter		Your parameters			
24	Volume of liquid in cylindrical phantom				
(a)	Volume of Liquid (mL)				
(b)	Volume determined by	Measured Volume <input type="checkbox"/>	Weight of Liquid <input type="checkbox"/>	CT Measure <input type="checkbox"/>	Phantom Spec. <input type="checkbox"/>
25	Injected activity and time of measurement				
26	Residual activity and time of measurement				
27	Time of SPECT scan start				
28	Total counts acquired				
29	Total Duration of emission scan (mm:ss)				

Spatial Resolution Characterisation



Spatial Resolution Characterisation

- Use NEMA phantom to mimic body shape. Do **not** use the lung insert.
- Replace smallest sphere with Data Spectrum fillable 6cm diameter sphere
- The background compartment of the phantom should be filled with water *only*
- Fill spheres with an activity concentration of 2 MBq / mL by for example:
 - Fill stock solution container with a small amount of 0.1M HCl and around 100 mL water
 - Draw 400 MBq into a syringe noting the activity and time of measurement.
 - Inject activity into container, flush the syringe and mix within container.
 - Note the residual activity in the syringe and the time this measurement is made.
 - Top up stock solution to make a total volume of 200 mL.
Use a balance or measuring cylinder to get an accurate volume.
 - Fill spheres
- Acquire SPECT data using the defined imaging parameters. Adjust the time per projection to acquire 3 Million counts.

Note: The aim is to achieve 2 MBq/mL. Other activities could be used being mindful that the total sphere volume is 160 mL

Spatial Resolution Characterisation (duplicate if more than one scanner)

Parameter	Your parameters	
30 Sphere stock solution information		
(a) Volume of stock solution (mL)		
(b) Method of determining volume	Balance <input type="checkbox"/>	Measuring Cylinder <input type="checkbox"/>
31 ¹⁷⁷ Lu activity and time of measurement		
32 Residual activity and time of measurement		
33 Time of SPECT scan start		
34 Total counts acquired		
35 Total emission scan duration (mm:ss)		