Lu-177 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

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Introduction

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

Introduction

- The accreditation has two elements
  i. A verification of the accuracy of Lu-177 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 Lu-177.

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 Lu-177 activity measurement that is traceable to a metrology lab
- This can be achieved by either
    i. Measurements of Lu-177 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 Lu-177 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 Lu-177 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 ☐	Other ☐	Volume:
(b)	Source 2: What container style and volume	Soild Source ☐	Other ☐	Volume:
5.	What dial factors do you use for your constancy checks?			
(a)	Source 1			
(b)	Source 2			

You may only have one source.

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Radionuclide Calibrator: Accuracy

Accreditation REQUIRES some form of traceability to ensure accuracy of Lu-177 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 ☐ (Go to Q7)	Via a secondary standard or other calibrated detector ☐ (Go to Q8)	Other ☐ (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 ☐	Vial ☐ what type:
(c)	What approach did you use?	Purchase a calibrated source ☐	Sent an aliquot of activity to the lab ☐
(c)	What volume of Lu-177 was measured?		
(d)	What accuracy was stated by metrology lab (%)		
(e)	What numerical dial/calibration factor is used for Lu-177 measurements?		

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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 ☐ Other ☐ Details	
(b)	What container was used?	Syringe ☐	Vial ☐ what type:
(c)	What volume of Lu-177 was measured?		
(d)	What accuracy was stated (%)?		
(e)	What numerical dial/calibration factor is used for Lu-177 measurements?		

Radionuclide Calibrator: Other method of calibration

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

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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)

	Parameter	GE	Mediso	Philips	Siemens	Your systems parameters
9	Collimator	Medium Energy GP	Medium Energy GP	Medium Energy GP	Medium Energy GP or Medium Energy Low Penetration (MELP)	
10	Crystal Thickness	Any	Any	Any	Any	
11	Photopeak Energy	208 keV	208 keV	208 keV	208 keV	
12	Photopeak Window Width	20%	20%	20%	20%	
13	Scatter windows Centre and width	6% (above and below)	6% (above and below)	6% (above and below)	10% (above and below)	
14	Number of projections	2 x 60	2 x 60 or 3 x 40	2 x 60	2 x 60	
15	Matrix Size	128 x 128	128 x 128	128 x 128	256 x 256	

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

	Parameter	GE	Mediso	Philips	Siemens	Your systems parameters
16	Reconstruction	Iterative				
17	Corrections	CT AC TEW SC Res Modelling	CT AC TEW SC Res Modelling	CT AC TEW SC Res Modelling	CT AC TEW SC Res Modelling	
18	Iterations/Subsets	25 iter, 2 subs	25 iter, 2 subs	25 iter, 2 subs	25 iter, 2 subs	
19	Filtering	None	None	None	None	

	Parameter	Hermes	MiM	Mirada	Other	Your systems parameters
16	Reconstruction	Iterative				
17	Corrections	CT AC TEW or MC SC Res Modelling	CT AC TEW SC Res Modelling	CT AC TEW SC Res Modelling	CT AC TEW SC Res Modelling	
18	Iterations/Subsets	25 iter, 2 subs	25 iter, 2 subs	25 iter, 2 subs	25 iter, 2 subs	
19	Filtering	None	None	None	None	

Additional Reconstruction request

- 25 iter, 2 subs 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

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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 Lu-177**
  - **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 Lu177 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 ☐	Weight of Liquid ☐	CT Measure ☐	Phantom Spec. ☐
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 ☐	Measuring Cylinder ☐
31	Lu-177 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)		