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Optimization of [18F]FDG Injected Activity for a New GE Discovery MI PET/CT Scanner Using a NEMA Phantom

A Hart[1], T O'Briain[1], M Bazalova-Carter[1], W Beckham[2,4], A Rahmim[2,3], C Uribe[2,3]

(1) University of Victoria, Victoria, BC, (2) BC Cancer, Vancouver, BC, (3) University of British Columbia, Vancouver, BC, (4) BC Cancer, Victoria, BC

INTRODUCTION

- PET imaging with ^{18}F-fluorodeoxyglucose [^{18}F]FDG is a powerful tool for diagnosis of cancer and subsequent treatment planning.
- Due to high detector sensitivity, state-of-the-art PET/CT scanners can generate diagnostic images of excellent quality.
- The increased sensitivity should allow acquisition of quality images with either less injected activity or shorter scan duration. However, reconstruction parameters, and patient anatomy can also influence image quality.
- This project aims to determine **minimum injected [^{18}F]FDG activity** and **reconstruction parameters** without compromising image quality for patients scanned on a new GE Discovery MI PET/CT.

METHODS

- The procedure described by EANM EARL [1] and Koopman et al. [2] to determine patient specific activity was followed.
- **Assumption**: 300 MBq injected into a 75 kg patient results in a concentration of 2 kBq/mL in the liver.
- A NEMA PET phantom was filled with uniform concentrations of 2 kBq/mL for the background and 20 kBq/mL for the spheres.
- Scans were acquired on a GE Discovery MI using list mode to allow for retrospective reconstructions with different:
  - Reconstruction parameters - iterations, subsets, and filters
  - Scan durations - 38s to 600s
- Image quality was assessed by measuring:
  - Recovery coefficients (RC) calculated from measured ($a_{measured}$) and true (a_{true}) activity concentrations of the spheres
  - Coefficient of variation (COV) calculated by measuring mean (μ_B) and standard deviation (σ_B) of activity concentration in ROIs placed in the background.

$$RC = \frac{a_{measured}}{a_{true}} \qquad COV = \frac{\sigma_B}{\mu_B}$$

- Reconstruction parameters were optimized to meet the EARL recommended RC ranges and reduce COV
- The minimum scan duration (t_{min}), for a reference activity ($A_{ref} = 300\ MBq$) was determined by setting COV = 15% [2]
- The minimum injected activity (A_{min}) for a clinically used scan time (t_{scan}) such that COV <15% was determined from:

$$A_{ref} \cdot t_{min} = A_{min} \cdot t_{scan}$$

RESULTS

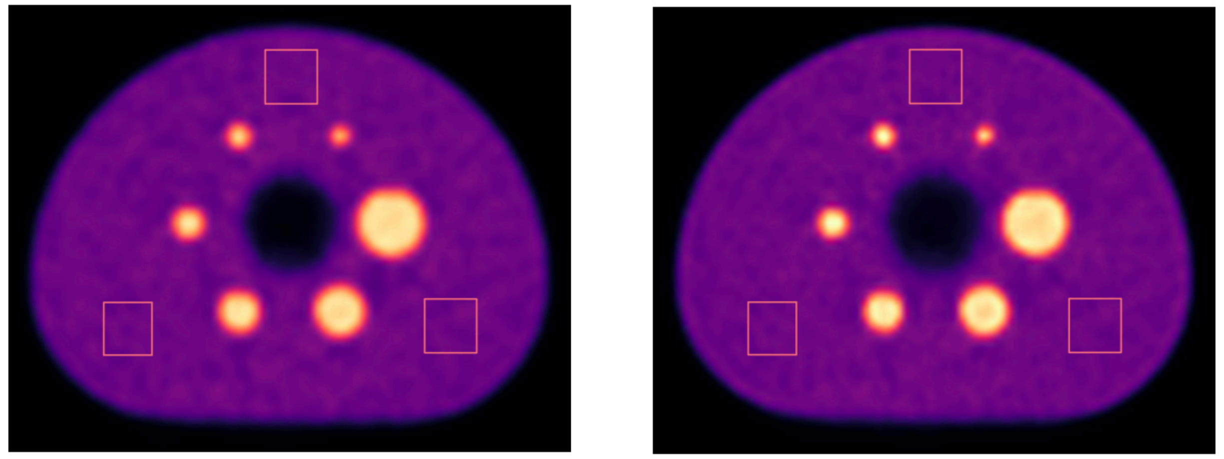

Figure 1: PET images of the NEMA phantom. Reconstructions were made using a variety of different parameters including: PSF OSEM with 2 iterations and 34 subsets with 6.4mm FWHM Gaussian smoothing **(A)** and PSF TOF OSEM with 2 iterations and 16 subsets with 4.0mm FWHM Gaussian smoothing **(B)**. Rectangular ROIs used to calculate COV are shown.

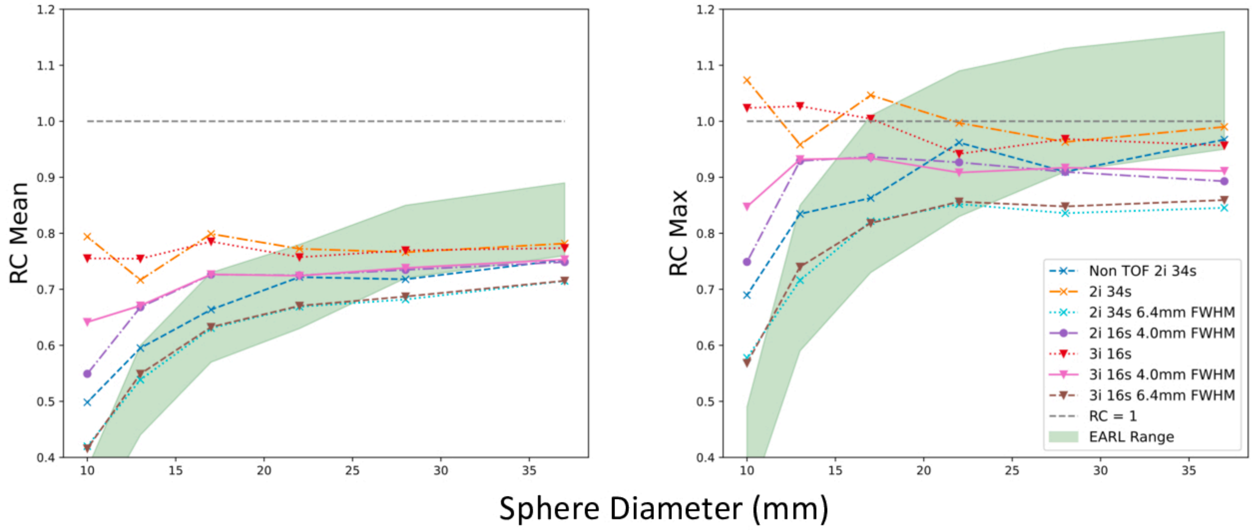

Figure 2: Recovery Coefficient Curves. Recovery coefficients were calculated by normalizing the maximum voxel (RC_{max}) in each sphere and the mean of the background corrected voxels above 50% of the max value (A50 RC_{mean}) by the true activity concentration. The curves shown were calculated from 600s scans.

- Reconstructions without Gaussian smoothing resulted in recovery coefficients closer to 1 but exhibited higher noise.
- The range of EARL recovery coefficients was developed for non digital PET and as such underestimates RCs for small diameter spheres. For this reason, measured RCs exceeding the EARL range are considered acceptable.
- **TOF PSF OSEM** with **2 iterations, 16 subsets, and 4.0mm FWHM** smoothing was chosen as a compromise between maximizing recovery coefficients and minimizing image noise.
- t_{min} was determined to be 56 seconds.
- <u>For clinical scans of 2, 2.5, and 3 minutes per bed position the minimum injected activities that result in COV = 15% were found to be 139, 111, and 93 MBq, respectively for a 75 kg patient</u>.
- Injected activity could be scaled linearly or quadratically with patient weight [2] according to:

$$A \cdot t_{scan} = 3.71\ min \cdot \frac{MBq}{kg} \cdot w \qquad A \cdot t_{scan} = 0.0494\ min \cdot \frac{MBq}{kg^2} \cdot w^2$$

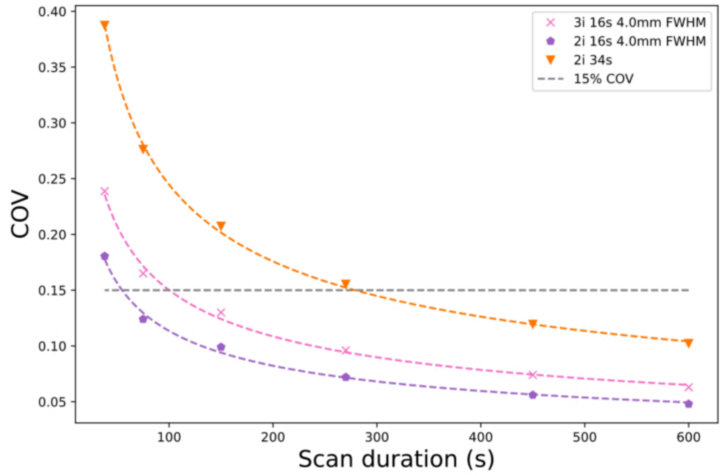

Figure 3: COV Analysis. The minimum scan duration and minimum injected activity were determined by using a COV threshold of 15%. Either reducing the scan duration or reducing the injected activity had similar effects on image noise because PET follows Poisson statistics.

CONCLUSIONS

- The assumption that the phantom preparation corresponds to a 75 kg patient injected with 300 MBq and whether activity should be scaled linearly or quadratically with patient weight still needs further investigation.
- However, the NEMA phantom experiment presented here suggests that for a 2.5 minute scan, a minimum injected [^{18}F]FDG activity of 111 MBq is required to achieve acceptable image quality for a 75 kg patient.
- <u>This injected activity would represent a 47% reduction from the current EANM guidelines recommendation of 210 MBq for the same patient weight and scan time</u> [3].

REFERENCES

1. Boellaard, earl.eanm.org, 2010
2. Koopman, *EJNMMI Physics, 2016*
3. Boellaard, *European Journal of Nuclear Medicine and Molecular Imaging, 2015*

CONTACT INFORMATION

Alexander Hart, University of Victoria alexanderjhart@uvic.ca www.qurit.ca.