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90Y PET/CT quantitative accuracy and image quality

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Abstract

Purpose: To optimize 90Y-PET/CT image reconstruction for quantitative accuracy and optimal image quality.

Methods: PET/CT scans of a NEMA IEC phantom (3GBq 90YCl2, sphere uptake ratio of ~7) were acquired on 4 GE (BGO:DSTE, DST & LYSO:DRX, D690) and 1 Siemens (LSO:mCT) scanners in 3D list mode with 30 min/bed; replayed to 20, 15, 10 min/bed. Iterative reconstruction parameters explored were SUB × IT (3 – 80) and post-reconstruction filters: transaxial: 5 – 25 mm cutoff & z-axis (GE only): std vs. heavy. The effects of PSF modeling and TOF correction were evaluated for D690 and mCT. VOIs were drawn inside spheres and in adjacent background regions. The accuracy of sphere activity concentration (AC in kBq/mL) and contrast to noise ratio (CNR) was calculated as function of SUB × IT. Reconstructed PET images were also evaluated qualitatively for sphere detectability and artifacts.

Results: AC converged to 70 – 90% accuracy for 37 mm sphere and further degraded for smaller spheres. Spheres at max CNR might not reach AC convergence yet. Smaller spheres have slower convergence but reach CNR max together with other spheres. Scan duration did not strongly affect sphere convergence but shorter scans increased noise and reduced detectability; 13 mm spheres were not visible going from 30 to 15 min/bed. Heavy z-axis (GE) and transaxial filter with 10 – 15 mm cutoff helped suppress noise and increase sphere detectability at the expense of accuracy. Images with PSF+TOF corrections had higher sphere detectability and converged faster. Hot cluster artifacts 5 – 7 times the background were seen in some cases with SUB × IT near convergence and lower filtration.

Conclusion: Accurate 90Y AC was not achieved even at convergence and noise is a major concern. 90YPET/CT reconstruction parameters are different than those for 18F and benefit substantially from PSF+TOF corrections. Optimum image quality and accurate AC may not be simultaneously achievable.

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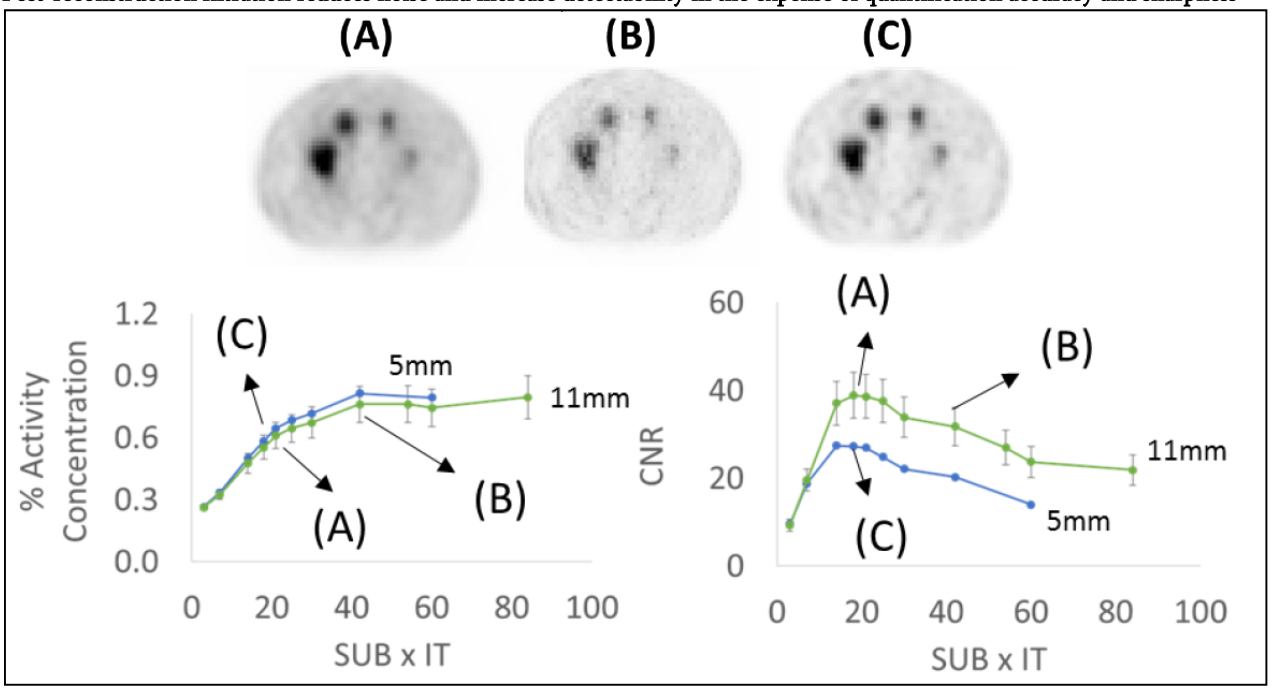
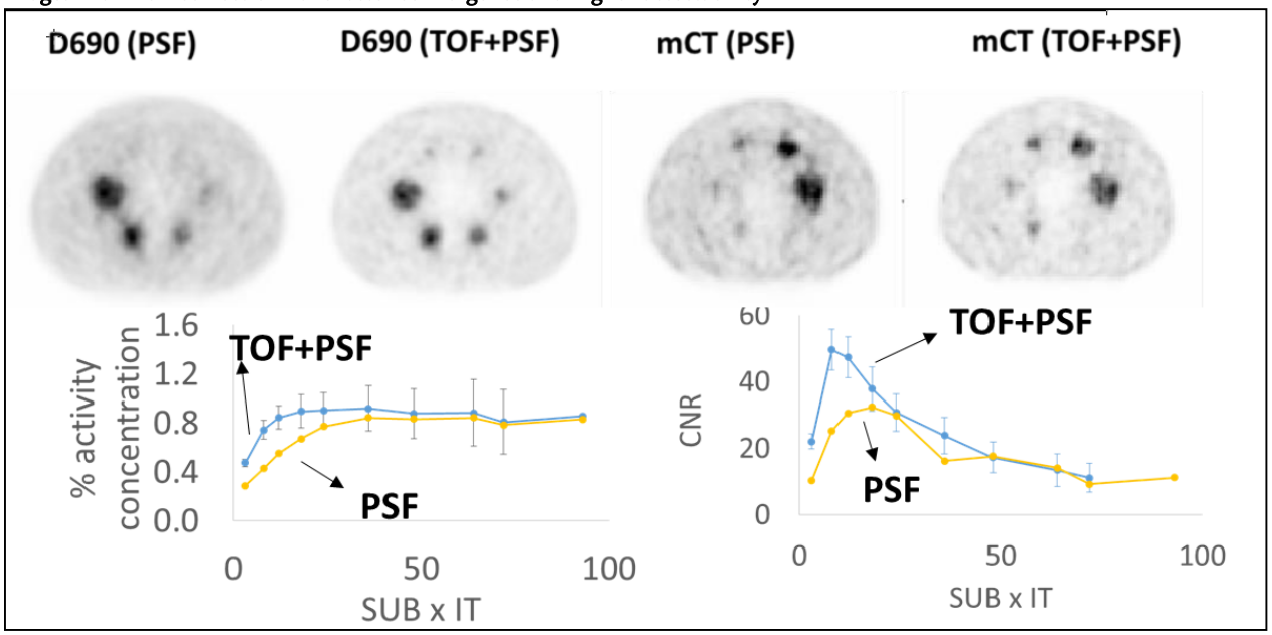
Post-reconstruction filtration reduces noise and increase detectability in the expense of quantification accuracy and sharpness



Curves for 37 mm spheres and images are generated from GE DRX. 5mm and 11mm cutoff were used for OSEM reconstruction. The max CNR (A) occurs before convergence is achieved (B). Image (B) has higher noise and potentially lower detectability. Images (A) vs (C) show the effects of filtration.

Images with TOF correction have faster convergence and higher detectability



Spheres with TOF correction converge faster than non-TOF images. The quantitative accuracy at convergence, however, is not strongly affected. The curves shown above were calculated for the 37mm sphere. TOF corrections also improve detectability. The curves were calculated for GE D690. The images were reconstructed at 18 SUB×IT with 6.4mm filtration for D690 and 21 SUB×IT with 5mm filtration for mCT.

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SUB×IT needed for AC convergence and max CNR for 37mm sphere.				
scanner	SUB×IT@ max CNR	# of spheres	SUB×IT@ convergence	% activity concentration
DSTE	16	5	24	80 +/- 10
DST	21	5	35	75 +/- 10
D690	8	6	18	90 +/- 15
DRX	18	4	42	75 +/- 10
mCT	21	5	21	70 +/- 15
Note: Heavy z-axis filter (GE). 11mm cutoff transaxial filter applied.				

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