Title: Harmonization of PET/CT quantitative values between multiple scanners: a phantom study

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Background: New generation of PET/CT systems support resolution modeling (PSF) and time of flight (TOF), enabling improved image quality and detectability; at the same time, advanced reconstruction algorithms having varying effects on quantification of PET images. PSF is available on major PET/CT systems and also increases SUV values in comparison to conventional reconstruction (OSEM). There are significant variations in PET quantification due to differences in scanner hardware and developed reconstruction algorithms, and as such, measured SUVs vary significantly. Consequently, harmonization of quantitative values derived from PET images has to be considered in multicenter studies.

Objective: The aim of the present study is to investigate harmonization of PET/CT systems with different performances to reduce inter- and intra-scanner variability in SUV values.

Methods: NEMA IQ phantom data acquisition was performed for low and high signal-to-background ratios (SBRs of 4:1 and 10:1) on four different scanners in Iran (siemens Biograph 6-TrueV, Biograph 6, and Biograph mCT and Discovery 690 from GE). Reconstruction parameters sets consisting of 6 different sub-iterations, 5 FWHMs for the Gaussian post smoothing filter, and different reconstruction types were evaluated towards finding optimized reconstruction. Curves for RC_{max}, $RC_{50\%}$ and RC_{peak} vs. diameter of sphere, as generated for each reconstruction, that met EARL specification reference value curves were selected as satisfying harmonization for the given reconstruction protocol. Finally, RCs, MCR (mean RC of all spheres sizes), COV_{MCR}, curvature and absolute error were compared between proposed reconstruction protocols for harmonization and those used in routine clinical reconstruction from all scanners.

Results: In this study measured RCs in proposed reconstruction methods for each scanner were compared with average of EARL reference value, and each of them exhibiting minimal RMSE (below 10%) was selected as harmonized reconstruction. Comparison between harmonized and routine clinical reconstruction showed that using harmonized reconstructions are more reproducible than others, especially for SBR 10:1; although overall contrast recovery was a little reduced, COV_{MCR} was decreased about 50% using harmonized reconstruction protocols. No significant difference in curvature and absolute error between harmonized and clinical routine reconstruction was observed in SBR 10:1, whereas in SBR of 4:1, $RC_{50\%}$ and RC_{max} were 10% and 20% higher respectively in harmonized reconstructions.

Conclusion: Harmonization of PET/CT systems equipped with different hardware and reconstruction algorithms such as PSF and/or TOF is conceivable. Using harmonized image reconstruction increases reproducibility of PET images.

Keywords: Harmonization, PET/CT, EARL specification, quantification