Application for QIBA Project Funding

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| **Title of Proposal:** A Procedure to Facilitate Greater Standardization of PET Spatial Resolution | | |
| QIBA Committee/Subgroup: FDG-PET Committee (also PET Amyloid Biomarker Committee) | | |
| NIBIB Task Number(s) which this project addresses: Not known | | |
| **PI (Project Coordinator or Lead Investigator Information)** | | |
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| Institution/Company: Johns Hopkins University (JHU) | | |
| Total Amount Requested: | | |

**Project Description**

This project relates to a potential gap in the QIBA FDG PET/CT profile, namely that guidance regarding image reconstruction and spatial resolution is not yet adequately developed. PET spatial resolution directly affects standardized uptake values (SUV) so different sites could be QIBA-compliant, yet still produce tumor SUVs that differ substantially due to their use of inconsistent reconstruction parameters. We propose to develop an experimental procedure for measuring spatial resolution that could potentially be incorporated into future QIBA profiles as a tool to aid standardization of protocols across multiple sites.

The anticipated role of the proposed method is slightly different from the ongoing “harmonization” efforts being performed by the U.S. (Dr. Sunderland) and European (Dr. Boellaard) groups. These harmonization projects aim to determine reconstruction parameters and contrast recovery ranges that give rise to comparable quantitative results across scanner systems. Once harmonized reconstruction parameters have been defined, the organizers of multi-center studies will need to verify that potential sites have correctly implemented these recommendations. Specialist phantoms such as the NEMA image quality phantom are useful for determining harmonized parameters but are not well suited for widespread deployment. Phantoms with fillable compartments are notoriously prone to experimental error and many high-quality centers do not have access to these phantoms nor the required experimental expertise. Site qualification that requires special phantoms of this sort is often associated with additional costs, delays and frustration, ultimately creating an unnecessary barrier to study participation. The current proposal describes a more practical experimental procedure that measures spatial resolution using a simple cylinder phantom of the sort that is already available at an overwhelming majority of sites. Cylinder phantoms are widely used for multi-center study qualification (e.g. ACRIN) and could potentially be employed in an expanded role, not just to assess scanner calibration accuracy, but also spatial resolution. It is anticipated that the proposed method will provide an essential verification tool that could be used to help confirm performance at individual sites and is therefore complementary to the ongoing “harmonization” efforts.

Conventional approaches for measuring spatial resolution involve point sources in air but this arrangement gives rise to unrepresentative results when images are reconstructed with the iterative algorithms that are typically used in clinical protocols. A requirement of the current application is that it should reflect the spatial resolution that is achieved with clinical protocols, not the limits of performance that can be obtained under optimized conditions. In addition, the method needs to be implemented uniformly and easily across all sites, including those with little or no physics support. We have previously proposed a method (Lodge et al. J Nucl Med 2009;50:1307-1314) based on measuring the extent of the blurring at the edges of a uniform cylinder phantom. This method has the advantages that it involves an extremely simple experimental procedure and a phantom that is already routinely used across the community for assessing calibration accuracy and image uniformity. Although the procedure worked well at our own institution, it did not transfer effectively to other sites. The problem was related to the need for higher spatial sampling than is usually used for whole-body applications. For the purpose of multi-center study qualification, sites were asked to reconstruct phantom images with 1 mm pixels. While not a major obstacle in theory, this requirement proved to be problematic for certain sites and made the method unsuitable for widespread deployment.

Considering this experience, we developed a modified phantom procedure that did not require sites to change their clinical protocol in any way. Instead of positioning the cylinder phantom in the conventional orientation, parallel to the axis of the scanner, the phantom was positioned at a small angle, offset with respect to the z-axis. In this way the edge of the cylinder intersects the image matrix at slightly different positions in each slice. By appropriately shifting and then combining line profiles from different slices, the edge response function can be measured with very fine sampling despite the fact the original images may have a much wider pixel spacing, e.g. 4 mm. From these finely sampled, composite edge profiles we can determine the spatial resolution of the system by taking the first derivative, fitting a Gaussian function and measuring the full-width-at-half-maximum (FWHM). FWHM is a well-established metric for characterizing spatial resolution that is meaningful and intuitive for imaging specialists and non-specialists alike. While changes in FWHM at different points within the image are not captured with the proposed method, one of the biggest sources of resolution differences between scanner systems is the use of different post-reconstruction smoothing filters, a linear operation (typically) that can be well characterized using cylinder edge profiles.

Note the proposed method is applicable to a wide range of PET applications (including non-$^{18}$F radiopharmaceuticals) and can play a role across multiple QIBA biomarker groups, e.g. FDG PET, amyloid PET & potentially SPECT.