Contribution ID: **80** Type: **Oral**

Phantom Studies to Characterize Total-Body PET System Performance

Sunday, 29 May 2022 18:40 (15 minutes)

Introduction: Total-body PET systems have two main advantages over scanners with standard axial fields-of-view (AFOVs): their high sensitivity and the capability to image dynamic processes in major organs of the body simultaneously. NEMA PET performance standards (NEMA NU-2) were developed more than 2 decades ago for scanners with AFOV of 65 cm or less, and these measurements may not adequately reflect the performance differences of TB-PET systems compared to those with standard AFOV. Thus, it may be necessary to modify the measurements to handle both TB-PET and standard PET systems, while recognizing that any change should be driven by an interest in reflecting performance of all scanners in the clinic. Methods: We have performed standard NEMA tests on the PennPET Explorer, a system with 142-cm AFOV, augmenting them with additional tests that highlight the behavior of a TB-PET system. For the sensitivity measurement, while the standard 70-cm line source is indicative of counts that would be detected in the range of the most common whole-body clinical surveys (i.e., eyes-to-thighs), an additional measurement with a 170-cm line, which is the average height of an adult human, better reflects the full advantage of a TB-PET system with increased acceptance of oblique coincidence pairs. An even longer source would provide useful information about the variation in sensitivity across the AFOV, particularly for a system such as the uEXPLORER with 194-cm AFOV. In the measurement of count rate performance, because injected activity does not leave the AFOV of a TB-PET system during a dynamic study (except through physical decay), a 70-cm phantom underestimates the randoms fraction, and overestimates the noise equivalent count rate seen in the clinic. For this reason, we also have imaged two 70-cm phantoms back-to-back to form a 140-cm long distribution, more reflective of the range where activity accumulates in the body. The axial spatial resolution can degrade in the center of the AFOV of a TB-PET system due to depth-of-interaction uncertainties for oblique lines of response; therefore, a measurement of spatial resolution at more than two axial locations characterizes any spatial variation more fully. In addition, the use of rebinning techniques prior to the prescribed filtered back-projection reconstruction can alter the point spread function in a way that is not observed in images reconstructed with the clinical algorithms - notably, iterative reconstruction. The requirement for an analytic algorithm does not reflect performance of the system under clinical conditions and should be reassessed, being mindful of the potential for iterative reconstruction of point sources in air to result in artificially better (lower) spatial resolution. Similarly, there is merit in acquiring the image quality phantom measurement at several axial locations to demonstrate any impact of spatial resolution and sensitivity variations with axial position on contrast recovery and image noise. Finally, we have used a long cylindrical pipe phantom that extends through the AFOV to assess the uniformity of image noise and quantitative accuracy throughout the AFOV, since the axial sensitivity and correction factors (e.g., attenuation, detector normalization) vary quite dramatically from the center to the end of the system. Conclusions: In order to properly compare systems and estimate performance in practice, standard measurements of performance may need to be adjusted to handle TB-PET systems, either by modifying the activity distribution or the processing/analysis. We have performed the NEMA measurements and additional studies on the PennPET Explorer, a scalable TB-PET system that has operated with an AFOV ranging from 64 cm to 142 cm, and have gained understanding of how phantom studies relate to performance of human studies with a variety of radiotracers. The goal is to characterize the system in a way that predicts performance, with measurements that apply to all PET systems, and provide guidance for future NEMA NU-2 updates.

Primary authors: DAUBE-WITHERSPOON, Margaret (University of Pennsylvania); Dr DAI, Bin (University of Pennsylvania); Prof. KARP, Joel (University of Pennsylvania)

Presenter: DAUBE-WITHERSPOON, Margaret (University of Pennsylvania)

Session Classification: Special session on PET/MR and TB-PET phantoms

Track Classification: PET/MR and TB-PET phantoms