PET Scanner Quality Assurance and Acceptance Testing

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Quality assurance of PET scanners must be performed on a regular basis to maintain and confirm proper scanner performance. These procedures should track system stability and be sensitive to changes in scanner operation. The quality control and calibration of a PET scanner includes detector and electronic characterizations such as adjustment of PMT gain, definition of crystal and energy maps and coincidence timing calibration. Briefly, the crystal map converts the analog position of the detected event to a specific crystal within the block detector, while the coincidence timing calibration adjusts for timing delays so events from each block are time stamped equivalently. These characterizations are applied to the PET data during acquisition.

A PET quality control regimen includes system corrections such as normalization, calibration and blank scans. In short, the normalization correction compensates for the variation in efficiency in each line of response (LOR) in the sinogram and, depending on the scanner, it may be used to compensate for the axial sensitivity variation of the scanner. The calibration correction is used to convert the reconstructed image pixel values into activity concentration and it may be used to compensate for the axial sensitivity variation of the scanner. These characterizations are applied to the PET data after acquisition.

Strictly speaking the blank scan is not a correction, rather it is used with the transmission data in the computation of attenuation correction factors. The blank scan is acquired daily using transmission rod sources and as such is a good source of quality control data. The blank scan can be used to monitor system stability and to determine which crystals, blocks and modules (buckets) are more (or less) sensitive than the respective system average. Not all vendors provide software for the quantitative evaluation of blank scans.

The NEMA PET NU2-2001 standard should be followed for acceptance testing. This standard uses a polyethylene phantom of 700mm axial length with a 3.2 mm line source to measure scatter fraction, count losses and randoms. This new phantom better approximates the out-of-field activity distributions of whole body scans. The measurement of sensitivity is conducted with a line source surrounded by known absorbers, and the sensitivity with no absorbers can be found by extrapolation. The intent of the image quality measurement is mimic a whole body scan using a torso phantom containing hot and cold spheres of various diameters (representing lesions) in a warm background.

This presentation will focus on the calibrations and corrections required to maintain proper system performance. The presentation will also describe the rationale and methodology of the new NEMA NU2-2001 performance standards.

Objectives:

1. Review the design of multi-ring dedicated PET scanners.
2. Describe the calibrations required to properly detect the location of a coincident event.

3. Describe the post acquisition corrections required to minimize image artifacts.
4. Provide a typical PET quality control schedule
5. Describe NEMA NU2-2001 PET performance standards