Automated Phantom Analysis for Gamma Cameras – An Efficient, Accessible, Consistent, and Sensitive Method for Quality Control

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Purpose: To introduce and test the consistency of a simple yet quantitative image analysis package for efficiently assessing gamma camera image quality in a busy clinical setting.

Methods: Four Siemens Symbia gamma cameras were used to acquire planar images of a 4-quadrant bar phantom and tomographic reconstructions of a Jaszczak phantom as part of a standard gamma camera quality assurance program. Images were sent to QC-Track (Atirix, Minneapolis), which automatically placed predetermined regions of interest (ROIs) and performed analysis. For the bar phantom, a standard deviation (SD)-based modulation transfer function (MTF) was calculated for an ROI in each quadrant. The bar widths at MTF values of 0.15 and 0.1 were reported using linear interpolation across the three largest bars. For the Jaszczak phantom, the contrast to noise ratio (CNR) for each sphere and a modulation for each rods section was calculated. Spheres corresponding to a CNR $\geq$3, and the rod size at modulations 0.5 and 0.2 were also reported. Visual analysis was performed by two medical physicists for evaluating inter-observer variability and correlation to quantitative values.

Results: Bar phantom images returned mean bar width of 3.04 ± 0.04 mm (MTF = 0.15) and 2.70 ± 0.05 mm (MTF = 0.1). Jaszczak phantom acquisitions ranged in quality; the sphere corresponding to a CNR value of 3 ranged from 6.54 -12.52 mm (mean: 9.3 mm, std. dev: 2.0 mm) over 6 acquisitions and the rods with modulation values of 0.5 and 0.2 were 12.2 ± 0.4 mm and 8.4 ± 0.7 mm respectively. Results of automated QC correlated well with visual analysis.

Conclusion: Our method for quantitative image analysis shows consistency over images of similar quality. Thresholds set correspond well with visual analysis, making our framework suitable for use in a busy nuclear medicine department.

Innovation/Impact: Quality control (QC) is key to maintaining image quality in a nuclear medicine department. Both 4-quadrant bar phantoms and the Jaszczak phantom are important tools for a complete QC program. In a typical clinical setting, these are evaluated visually making the test subject to individual bias and limited to discrete levels of assessment dictated by the physical design of the phantom. However, automated quantitative analysis ensures objectivity and cvonsistency while increasing sensitivity. Other automated methods have been proposed, but here we propose one that is packaged to be easy to implement clinically, not only for physicist use but also for technologist use, so that the efficiency of automated analysis can be applied across the QC program.

Experimental Details and Key Results: Images were acquired by technologist or physicist and sent via a DICOM send to QC-Track (Atirix, Minneapolis), a quality control database with technologist-friendly user interface and image analysis capabilities, for processing. Comparison for all data sets were made with physicist visually determined values.

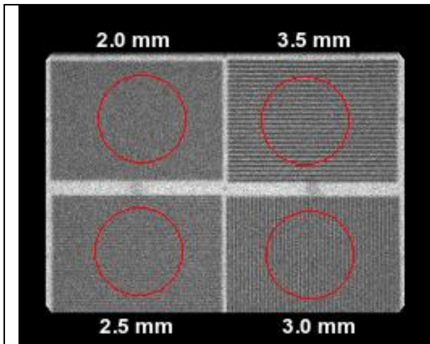

Figure 1: Bar phantom ROI placement

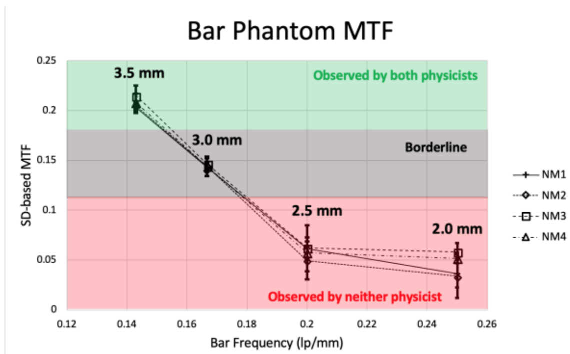

Figure 2: Bar phantom results

Bar phantom images were acquired on a 256x256 matrix with a zoom factor of 1 for 5M counts (Co 57; 20% energy window centered at 122 keV) using a low energy high resolution (LEHR) collimator. A standard-deviation based modulation transfer function[1] (MTF) for circular ROIs shows the value of a quantitative analysis.

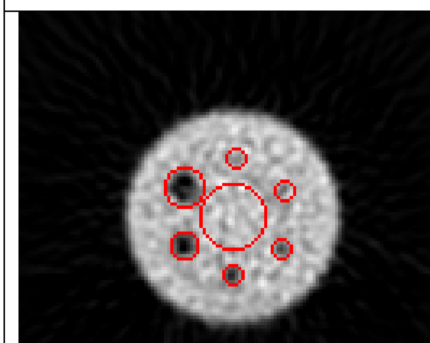

Figure 3: Spheres section ROI placement (Jaszczak phantom)

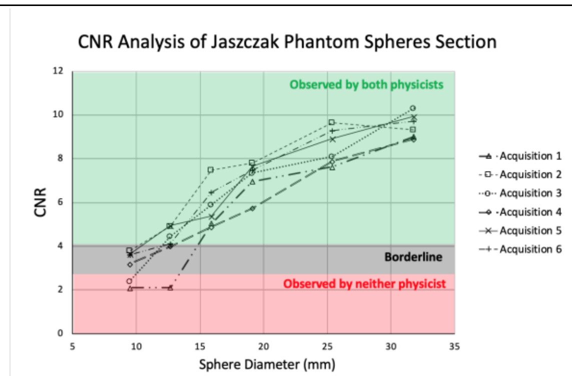

Figure 4: Spheres section results

Jaszczak phantom images were acquired on a 128x128 matrix size, zoom factor of 1.45 (Tc-99m; Injected Activity 10-15 mCi; 15% energy window centered at 140 keV) using a LEHR collimator. Contrast-to-noise ratio[2] (CNR) for the spheres shows correlation with visual analysis.

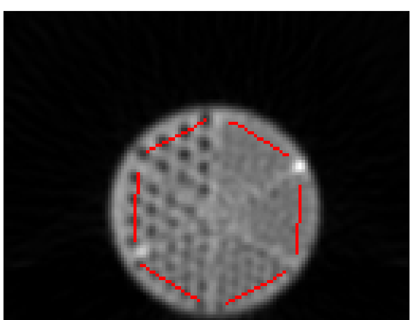

Figure 5: Rods section ROI placement (Jaszczak phantom)

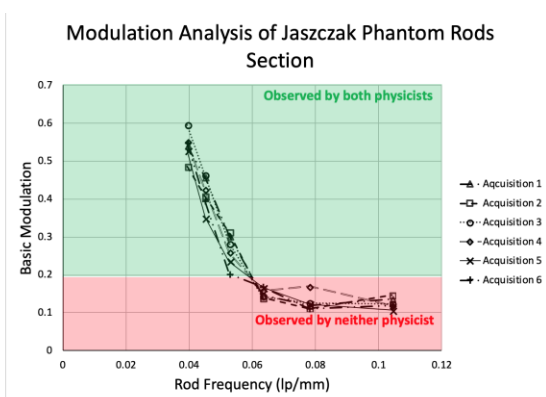

Figure 6: Rods section results

Acquisition parameters were as above. A modulation calculation of the rods section shows improvements in consistency over visual analysis and the value of increased sensitivity.

[1] Hander TA et. al. An improved method for rapid objective measurement of gamma camera resolution. Med Phys. 2000; 27:2688:2692.
[2] AAPM Report 52: Quantitation of SPECT Performance. Med. Phys.,22 (4), April 1995