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SPECT System Automated Quantified Quality Assurance Using Quantile Plots

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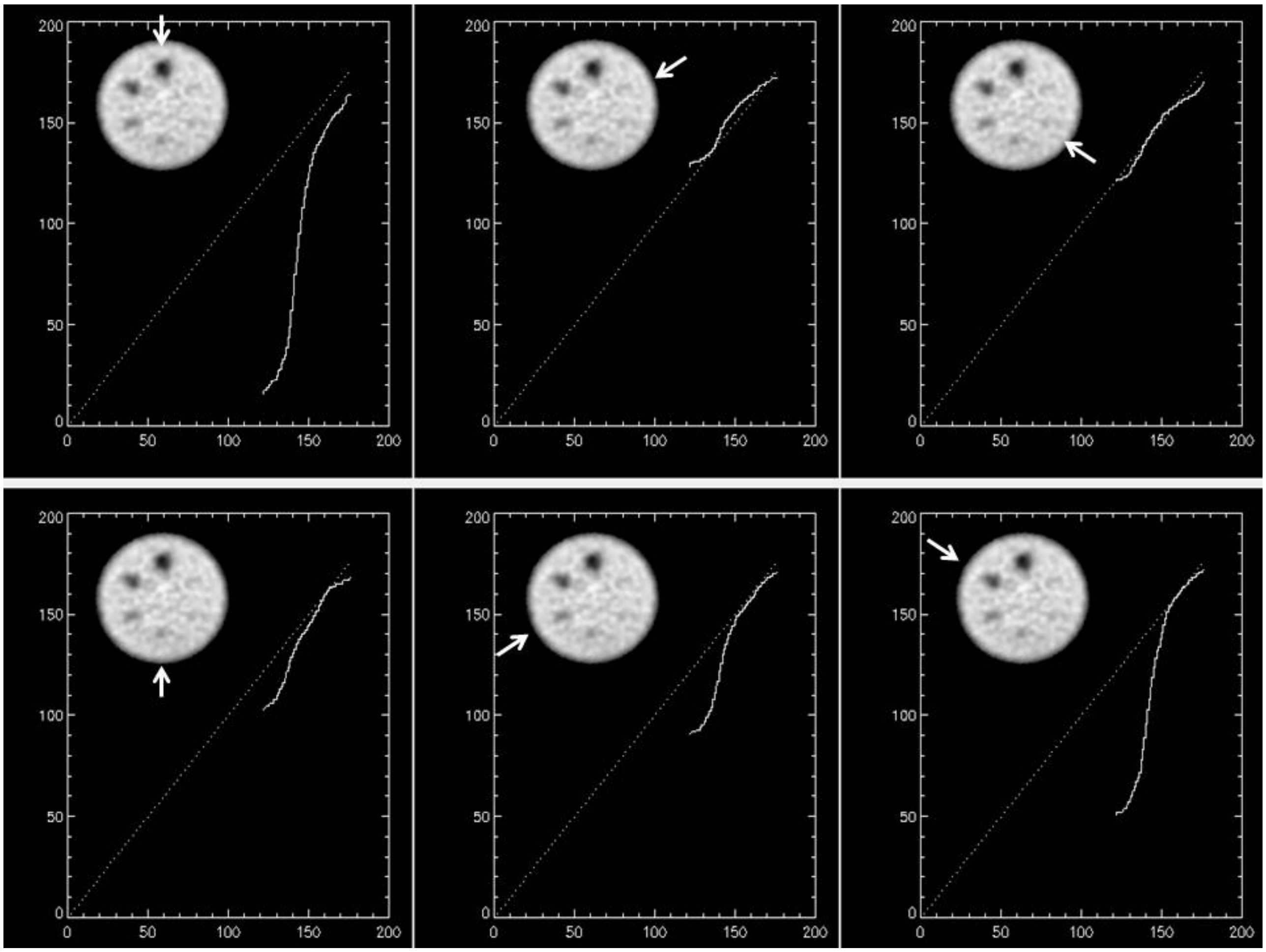
PURPOSE: Testing SPECT systems requires multiple manual data processing steps and relies on visual assessment of image quality. This investigation was conducted to determine whether it is feasible to automate data processing while simultaneously quantifying image characteristics, as a means of providing an unambiguous objective basis for choosing optimal reconstruction parameters.

METHODS: Data were processed retrospectively for SPECT scans of standardized plastic & water phantoms acquired for routine quarterly quality assurance tests. Projection data were acquired as 128x128 matrices for 120-128 projections, using 666-814 MBq $^{99m}$Tc in water in phantoms containing 6 spheres, 6 rod sizes, & background areas. Algorithms were written in IDL v8.4 to identify automatically the transaxial section passing through the tomographic section that optimally sampled spheres. Likely sphere neighborhoods were estimated based on known phantom specifications. Radial count profiles were sampled sequentially until maximum contrast was achieved from 2$^{nd}$ order polynomial curve fits. Comparable radioactive water background volumes were similarly sampled. Contrast was computed as (maximum-minimum)÷(maximum+minimum) both for raw counts and for fitted curves. Sphere & background count curves were sorted from minimum to maximum values by quantiles and plotted against one another to generate sphere count quantile versus background volume count quantile curves, to which linear regression was applied. Deviations from unity constitute evidence that count distributions of potential sphere volumes are significantly different from count distributions of background volumes. Maximizing the sum of quantile curve slopes over all sphere volumes was used to select the optimal transaxial slice location displaying the maximum number of spheres. A physicist judged the adequacy of sphere locations by comparing the appearance of estimated locations to visual appearance of spheres in neighboring locations, and graded sphere visibility on a 5-point scale (0= “definitely not visible” to 4=”definitely visible”).

RESULTS: Twenty eight phantom studies were acquired with 38±19 Mcounts (range 11-77 Mcounts), of pixel size 3.2±0.4 mm (range 2.1-4.7 mm). For background volumes raw contrast, representing noise, was significantly greater than fitted contrast (14±6% versus 2±2%, $p < 0.0001$). Rank correlation versus reading confidence was significantly stronger ($p < 0.03$) for quantile slopes ($\rho = 0.893$, $p < 0.0001$) than fitted contrast ($\rho = 0.832$, $p < 0.0001$) or raw contrast ($\rho = 0.746$, $p < 0.0001$). Quantile curve slopes > 1.79 agreed best with visual impression of visibility of spheres (ROC area = 98±1%, sensitivity = 100%, specificity = 93%), significantly better ($p < 0.02$) than fitted contrast > 19% (AUC = 95±2%) or raw contrast > 25% (AUC = 90±2%). For all 28 phantom studies, use of maximized quantile slopes successfully selected the correct slice number, limited only by magnitude of transaxial section thickness.

CONCLUSION: Use of count quantile plots successfully automated selection of optimal transaxial sections displaying the maximum number of visible spheres, while radial count polynomial fitting effectively quantified contrast for all sphere volumes. We conclude that it is feasible to automate and quantify SPECT system quality assurance.




**Sphere count quantiles versus background count quantiles for 6 sphere sizes**