Abstract

Image quality is a general term used to refer to the degree of visibility of relevant information in an image. The quality of a nuclear medicine image depends mainly on the imaging properties of the gamma camera, which generally result in images with low contrast and a high level of noise.

There are several methods to improve image quality in terms of noise reduction and contrast enhancement, thus increasing the sensitivity and specificity of nuclear medicine examinations. Various methods of attenuation and scatter correction, image processing with different types of mathematical filters and different reconstruction techniques in SPECT and PET can be used. The overall aim of this study was to develop and apply new and existing phantoms for use in quality assurance and optimization in nuclear medicine imaging and imaging systems.

A slice phantom with a 1 mm thin slice was designed for measuring transfer functions for different organ thicknesses and depths. The slice was filled with a radioactive solution to heights that corresponded to certain organ thicknesses. The phantom could be placed in a water tank at depths corresponding to the depths of simulated organs. The phantom also contained a holder for a line source, which could be placed at different depths in the same water tank.

Transfer function measurements with the slice phantom placed at different depths with different heights of activity were compared with a set of line source measurements at different depths. Effective attenuation coefficients μ_{eff} for ^{99m}Tc ^{111}In and ^{201}Tl were determined. The effective attenuation coefficient μ_{eff} for ^{111}In reached lower values with increasing depth in the phantom, while the effective attenuation coefficient μ_{eff} for ^{201}Tl reached lower values with increasing height of activity.

A line source and a plane source filled with ^{99m}Tc were used to calculate the detective quantum efficiency (DQE) of two gamma camera systems. From measured modulation transfer function, normalized noise power spectrum and emitted photons, DQE was calculated for different measuring depths, energy window settings, collimators and crystal thicknesses. For examinations with organs at larger depths, a 15 % energy window is to prefer. An all purpose collimator is preferable, except for examinations of fine details at larger depths. A 5/8" crystal has advantages (higher DQE) over a 3/8" crystal at larger depths.

A transmission bone phantom was used with ROC analysis to evaluate different digital filters. The results showed that digital filtering increased the area under the ROC curve significantly compared to unfiltered images. The results also showed that more uptakes having low contrast were detected in filtered than in unfiltered images.

Patient examinations were used together with visual grading analysis for evaluating different reconstruction techniques in bone SPECT of the spine. A three energy windows technique was used in order to perform scatter correction. Each study, with and without scatter correction, was reconstructed using filtered back projection and iterative reconstruction followed by 3D post-filtering. Using visual grading analysis it was shown that the iterative reconstruction with a Metz filter without scatter correction was significantly better than filtered back projection and reconstruction techniques which include scatter correction.

Keywords: phantom, image quality, attenuation coefficients, detective quantum efficiency (DQE), digital filtering, iterative reconstruction, bone scintigraphy, bone SPECT, visual grading analysis (VGA), ROC-analysis.

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