Evaluation of Attenuation and Scatter Corrections in Lung and Brain SPECT

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Abstract

Single Photon Emission Computed Tomography (SPECT) is used to image functional processes in the human body. The image process is affected by physical effects such as attenuation, scatter, spatial resolution and statistical noise. The aim of this work was to investigate how attenuation and scatter effects and their associated correction methods affect the image quality in lung and brain SPECT.

The effects of attenuation and scattering on the image of a uniform activity distribution in the lungs was investigated using Monte Carlo simulated data and the attenuation effect was evaluated in healthy volunteers. The homogeneity was measured as the *CV* inside a well-defined lung contour. The attenuation effect in lung SPECT was estimated to be about 13-14% expressed as the *CV*. The homogeneity improved with increasing accuracy of the attenuation correction method. After attenuation correction the remaining inhomogeneity in healthy subjects was considerable and could not be explained by statistical noise and camera non-uniformity. A non-uniform attenuation correction was thus required and a TCT-based density map was found to be adequate in most instances.

The accuracy of the attenuation correction methods was studied in Monte Carlo simulated brain SPECT using the normalised mean square error, *NMSE*. The different degrees of accuracy in the methods were also reflected in the absolute deviation of the relative regional cerebral blood flow (rCBF) according to the min-max method. The *NMSE* value improved with the accuracy of the attenuation correction method. The difference in relative rCBF value was generally less than 5%. Therefore, it is unlikely that the choice of attenuation correction method will affect the diagnostic accuracy.

The detectability, expressed as the contrast-to-noise-ratio dependence on the choice of energy window, was evaluated using SPECT studies of a thorax phantom containing cold lesions inside the lungs and a realistic brain phantom. The effects of subtractive scatter correction methods such as the dual-window method (DW), the triple-energy-window method (TEW) and the Klein-Nishina method (KN) were also evaluated. An optimal photopeak window setting was found to be 128-154 keV in lung SPECT for a gamma camera with 10% energy resolution, and 130-154 keV in rCBF SPECT for a gamma camera with 9% energy resolution. The detection limit for lung SPECT for spherical lesions is about 2 cm in diameter when normal variations in the lungs are relatively small compared with the statistical noise level. Under these conditions the detectability is degraded by using scatter correction, except when the TEW scatter correction is used for small lesions (< 3 cm in diameter), when about the same detectability is achieved.

Keywords: SPECT, attenuation, scatter, detectability, Monte Carlo simulation

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