A Software Package of Quantitative SPECT Image Reconstruction for Measurement of Physiological *in Vivo* Parameter

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1. Introduction

Accurate estimation of radioactivity is essential for the quantitative measurement of physiological *in vivo* parameter in the medical field using nuclear medicine imaging. Among many nuclear medicine modalities, single photon emission computed tomography (SPECT) has been widely used in many clinical studies. Many SPECT studies with quantitative manner have been reported and evaluated, which have been contributed to the advance of SPECT technique and wide spread of its use. However, SPECT is still not employed in quantitative study as much as positron emission tomography (PET) has done. Recently, we reported an approach to quantify radioactivity accurately using SPECT, and evaluated its applicability in real measurement of physiological parameter [1-8]. Based on these reports, we developed a software package (QSPECT) for image reconstruction of SPECT data.

2. Methods and Results

2.1 Constitution of QSPECT Package

The software package includes main parts of image reconstruction and scatter correction, and several complementary tools supporting quantitative image reconstruction.

The image reconstruction adopted two-dimensional (2D) expectation maximization algorithm using ordered subset (OS-EM) [9]. Effect of photon attenuation in object was involved in the OS-EM algorithm. Projection data of SPECT was transformed to 2D sinogram, and reconstructed to tomographic image, with the correction for attenuation and scatter of photon in object. In the recostruction process, several setting parameters of SPECT acquisition and image reconstruction is required to get proper image (Figure 1).

Scatter in SPECT is important for accurate measurement of radioactivity in object. Scatter is a main source of degradation of image quality and error in quantitation. In the QSPECT, a technique of transmission dependent convolution subtraction (TDCS) was adopted [10]. The TDCS was optimized for several radioisotopes of ^{99m}Tc [3] and ^{201}Tl [4] and ^{123}I [1], which have been used usually and widely in most hospitals and research institutions. While a unique parameter set for scatter correction can be used for ^{99m}Tc and ^{201}Tl, which is based on the finding of scatter independency of SPECT collimator [1], the several parameter sets obtained previously from experiments is provided for improved correction of scatter component [1,2].

For the corrections of attenuation (AC) and scatter (SC), attenuation map (μ-map) is required. In theory, a transmission data is needed to get a μ-map. In practical, however, most SPECT camera has no equipment for transmission scan. An approach using μ-map of constant coefficient in brain region has been used in brain study, and showed that a proper selection of attenuation coefficient can achieve quantitative image reconstruction with acceptable range of error [5]. In the QSPECT, a technique of generating μ-map from emission data (i.e. emission sinogram) was implemented for brain image reconstruction. A μ-map that can be obtained by transmission scan or registration of image from other modality such CT or MRI, is also possible to be used in the image reconstruction of other region (e.g. chest region).

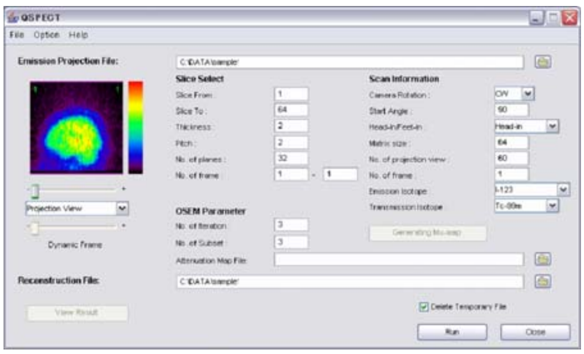

Figure 1. Main window of QSPECT package. On this window, user can easily select raw data file, determine various parameters for proper reconstruction, and check the result of image reconstruction, by means of graphical user interface.

2.2 Physical Phantom Experiment

Physical experiment was performed to evaluate the image reconstruction implemented in QSPECT. Cylindrical phantoms with various size of diameter (10, 16, and 20 cm) were used in this experiment. After filling solution of ^{99m}Tc with the same radioactivity concentration, each phantom was scanned by dual-headed SPECT camera attached with low-energy-high-resolution (LEHR) collimator. Acquired data were reconstructed by OS-EM with AC and SC implemented in QSPECT. The same acquired data was also reconstructed by OS-EM with no AC and no SC. The results of reconstructed image are shown on Figure 2. OS-EM reconstruction with AC and SC could generate the images with the same radioactivity regardless of object size (upper panel), which can be critical to determine a value of cross-calibration-factor that is used in quantitative measurement of *in vivo* parameter. Reconstructed image with no correction of attenuation and scatter showed the dependency of radioactivity on the size of object in central region (lower panel).

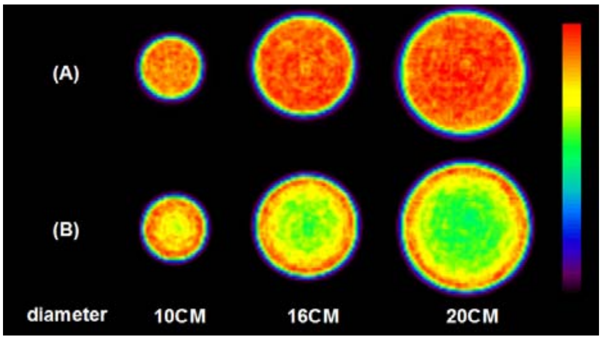

Figure 2. The reconstructed images of cylindrical phantoms with different size. (A) Upper panel shows the images with the corrections of attenuation and scatter (B) Lower panel with no corrections of attenuation or scatter.

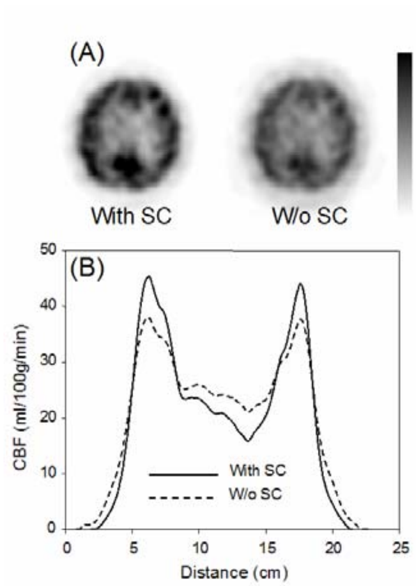

Figure 3. (A) A transverse image reconstructed with and without SC, and (B) its transverse profile showing improved image contrast.

2.3 Human Study

A human brain data of normal volunteer was used in the evaluation of the quantitative reconstruction program. The brain data was acquired for 30 minutes by dual-headed SPECT camera with LEHR collimator, after an intravenous injection of ^{123}I-isopropyl-iodoamphetamione (IMP) that is a radiotracer for cerebral perfusion estimation. The acquired projection data was reconstructed by OS-EM including AC, with SC and no SC, respectively. A μ-map was generated by means of the emission projection of brain and the technique implemented in QSPECT. With the transverse slice of reconstructed image, quality of both reconstructed image was compared, in terms of contrast between the regions of gray and white matters of brain. The transverse image reconstructed with both AC and SC improved the contrast between the both regions in brain, with elimination of background activities outside the brain area (Figure 3).

3. Conclusion

The software package for quantitative SPECT image reconstruction was developed with graphical user interface. With the use of this package, quantitative SPECT image could be obtained in both phantom and human studies. This package is expected to contribute the wide spread of quantitative study using SPECT.

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