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Examination of Combined Attenuation and Scatter Corrections for Thallium-201 Myocardial Perfusion SPECT

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PURPOSE

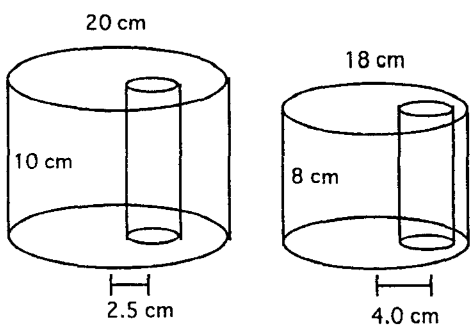
Thallium-201 myocardium perfusion SPECT with attenuation and scatter correction, using transmission line source, was considered as surplus correction in the inferior portion because the low density area was seen in the antero-lateral portion of myocardium. But many studies were performed without consideration of the heart motion and location of the heart and lung. In this study, using original phantom, we estimate the accuracy of Thallium-201 myocardium perfusion SPECT for location of the heart and lung by filtered backprojection (FBP) with no correction and ordered subset expectation maximization (OSEM) with attenuation and scatter correction.

METHODS

Data Acquisition------Three-detectors SPECT system with fan beam collimator and transmission line source (Prism 3000 XP; Ohio Imaging of Picker International, Bedford Heights, Ohio) was used for simultaneous transmission (^{99m}Tc) and emission (^{201}Tl) data acquisition. The line source unit was attached to the rotating gantry of Prism 3000 XP and was aligned the focus to one of the three detectors (detector 3). Transmission and emission data were acquired in 128×128 matrix (pixel length 3.72 mm), 3 ° steps over a 360 ° circular orbit for 10 sec per step, total scan time was 20 min. The energy window for transmission was established 15% in width centered on 140 keV. The emission data acquisition was performed with three energy window, the window for photopeak data was set 30% in width centered on 73 keV and one of the two windows for scatter data was set 7.3% in width centered on 54.5 keV, the other one was set 4.4% in width centered on 91.0 keV. Attenuation and scatter corrected data were reconstructed by OSEM. These images were compared with the images that reconstructed by FBP without corrections.

Phantom Design------The two cylindrical phantoms with different size was used for fundamental study. The one is 20 cm in diameter, 10 cm in height, and it has the other cylinder as the diameter is 5.5 cm and the height is 10 cm. The lean cylinder was 2.0 cm distant from center of the cylindrical phantom and was fixed (Figure 1-a). The other one is 18 cm in diameter and 8 cm in height, and it has the other cylinder as the diameter is 5.5 cm and the height is 10 cm. The lean cylinder was 4.0 cm distant from center of the cylindrical phantom and was fixed (Figure 1-b). These

Fig.1(a) Fig.1(b)



lean cylinder (hot-rod), was filled with 179 kBq ml^{-1} solution of ^{201}Tl and the circumference was filled with 44.7 kBq ml^{-1} solution of ^{201}Tl as a background activity. For non-uniform phantom, the styrene foam formed as contacting with myocardium and lung was used for substitutive lung, and it was installed to the cylindrical phantom (the diameter is 22 cm) with myocardial phantom and was fixed. And the phantom removed lung was used for the uniform phantom. Normalized absolute error (NAE) and image contrast of hot-rod to background were used as criteria for quantitative accuracy of radioactivity concentration.

$$NAE = \frac{|A_m - A_t|}{A_t} \bullet 100\%$$

where A_m and A_t are measured and true radioactivity concentration respectively.
The percentage of the average counts to max. count (%UpTake) was used quantitative accuracy of the radioactivity concentration of cardio-body phantom using the bull's eye map was separated to 17 segmentation.

RESULTS

Table 1 shows the accuracy of the radioactivity concentration, using cylindrical phantom, calculated with the cross caribulation factor (CCF) of each corrections, and image contrast. Figure 2 shows the %UpTake of bull's eye map of cardio-body phantom. The decrease of radioactivity concentration of myocardial phantom was shown in the infero-septal portion with FBP. But it was shown in the antero-lateral portion with OSEM.

Table 1 : NAE and Image Contrast of Cylindalical Phantoms

Large

	AC+,SC+	AC+	SC+	AC-,SC-
hot-rod	7.84	13.5	43.64	51.18
background	5.92	8.37	28.64	25.29
contrast	1:4.08	1:3.20	1:3.16	1:2.62

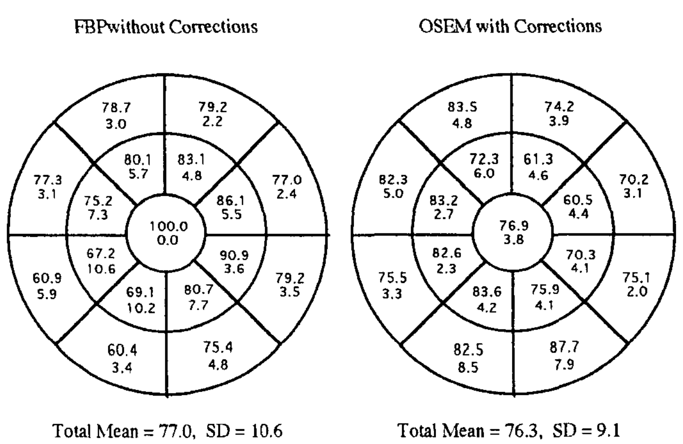
Small

	AC+,SC+	AC+	SC+	AC-,SC-
hot-rod	6.42	14.89	20.78	33.92
background	1.68	4.94	17.97	22.51
contrast	1:4.19	1:3.59	1:3.87	1:3.42

DISCUSSION

Truncation was not generated in the size of these cylindalical phantom and this fundamental study was shown satisfactory data in OSEM with (AC+,SC+). Without these corrections, the NAE of hot-rod was 51.18% in large cylidalical phantom and was 33.92% in samll cylidalical phantom. These differance of NAE was suggested that the position in large cylidalical phantom is near the center but, in small cylidalical phantom, is far the center so that the large cylidalical phantom had a stronger influence of

Figure 2 %UpTake of Cardial with lung Phantom



attenuation than the small cylidalical phantom. This result suggests that attenuation and scatter corrections is neccesary to quantitative accuracy of SPECT.
Myocardium is beating with lung, and the location of heart and lung is that as the lung covered the anterior ~ lateral portion of myocardium. The linear attenuation coefficients per matrix was calculated from the expectation of total attenuation during study. Then a matrix of antero-lateral portion (contacting with myocardium and lung) was selected, the linear attenuation coefficient should be calculated lower than true value. Because if the measured value of the matrix in end of diastole is equal to the coefficient of tissue, it in end of systole may be equal to the averaged value of tissue and lung or singleness of lung. Therefore it is possible to be calculated lower than true value. In clinical data, defected images in the apex, anterior, lateral, and antero-lateral portion was pointed out and indexed mismatch of the images with or without attenuation and scatter corrections This study was used with no-motion cardiac phantom, but the decrease of radioactivity concentration was shown similar to clinical case (Figure 3). We suggest that the decreased portion of cardiac phantom may be concerned with pertial volume effect.

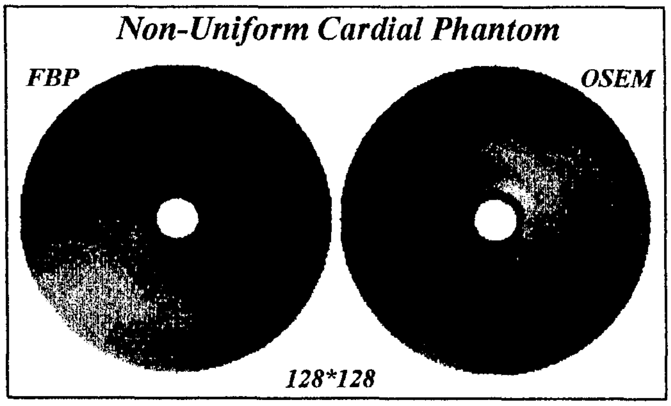


Figure 3 : Comapare with FBP without Corrections and OSEM with Corrections

CONCLUSION

The presented phantom study is to evaluate quantitative accuracy of combined attenuation and scatter correction and indicates that motion correction of myocardium and lung is indispensable to thallium-201 myocardium perfusion SPECT. Hereafter, we perform to simulate the motion correction of the heart and lung model and evaluate quantitative accuracy of thallium-201 myocardium perfusion SPECT.