◈ Original Article ◈

The Lowest Dose for CT Attenuation Correction in PET/CT

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Abstract

PET/CT(Positron Emission Tomography/Computed Tomography) is an examination combining morphological and functional information in one examination. The purpose of this study is to see the lowest CT dose for attenuation correction in the PET/CT maintaining good image quality when considering CT scan dose to the patients. We injected ^{18}F-FDG and water into the cylinder shaped phantom, and obtained emission images for 3 mins and transmission images(140 kVp, 8 sec, 10～200 mA for transmission images), and reconstructed the images to PET/CT images with Iterative method. Data(Maximum, Minimum, Average, Standard Deviation) were obtained by drawing a circular ROI(Region Of Interest) on each sphere in each image set with Image J program. And then described SD according to the CT and PEC/CT images as graphes. Through the graphes, we got the relationships of mA and quality of images. SDs according to CT graph were 16.25 at 10 mA, 7.26 at 50 mA, 5.5 at 100 mA, 4.29 at 150 mA, and 3.83 at 200 mA, i.e. the higer mA, the better image quality was presented. SDs according to PET/CT graph were 1823.2 at 10 mA, 1825.1 at 50 mA, 1828.4 at 100 mA, 1813.8 at 150 mA, and 1811.3 at 200 mA. Calculated SDs at PET/CT images were maintained. This means images quality is maintained having nothing to do with mA of high and low.

Key Words : PET/CT, Attenuation correction, Cylinder shaped phantom, Transmission images

Ⅰ. Introduction

PET(Positron Emission Tomography) study is the cutting edge study which can estimate glucose metabolism in the body using ^{18}F-FDG. In contrast existing image methods(MRI or CT) can diagnose organs and cancer through their molpholoy, PET study diagnoses and estimates them through the amount of metabolism, i.e. activity rate.[1~2] Accordingly, even the smallest cancer if it is high malignancy can be detected accurately. And the number of PET study has been tending to increase rapidly of late years in the United States, Japan, etc, because it was verified that PET is very effective on early diagnosis of cancer, knowing relapse whether or not, and remedial value conclusion could be everywhere of the body by imaging the whole body.[3~7] There are pros and cons of PET. It is that PET makes biological examination possible

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which can find the spot of lesion and see functions of organs, while it is hard to reveal the clear anthropotomy though the PET.[8~9] But this defect came to be made up for by fusing CT into PET. Among the reconstruction methods of PET/CT system, we used attenuation correction method. Recently, PET/CT systems use the CT scan for attenuation correction instead of a radioactive source(^{68}Ge and ^{137}Cs) as is used in stand-alone PET systems. Through using CT, the scan time can be reduced a lot. On the other hand, the need to reduce CT scan dose to the patients has grown considerably since the introduction of multi slice CT scanner. We studied the optimum conditions maintaining the image quality and reducing the patients scan dose.

Ⅱ. Material & Method

1. Materials

This phantom was designed to reflect the human tissue(Fig. 1).

2. Methods

1) Scanning protocols

All studies were done with GE DSTe PET-CT systems. ^{18}F-FDG 2.03 mCi(Back ground : 0.3 mCi) was injected into the cylindrical phantom. We mixed ^{18}F-FDG with water equally for 30 min. and fixed cylinderical phantom to the table. At first, the emission image was acquired a period of 3 min and then transmission images were acquired on the increase in tube current ranging from 10 to 200 mA(beginning point 10 mA, an image per 10 mA). Transmission images are to make attenuation correction map. The scanning time and tube voltage are fixed 8 sec and 140 kVp. Each image was reconstructed with Iterative method used clinically. Attenuation correction method is used for reconstruction in the PET/CT(Fig. 2).

2) Deriving data and getting SD(Standard Deviation) from the data

A circular ROI(Region of Interest) was drawn on each sphere in each image set with Image J program and SDs were computed. SDs were determined according to the following equation 1.

$$\sqrt{\left\{\sum_{k=1}^{n}(x_k-\bar{x})^2\right\}/n} \quad (1)$$

We drew the SDs graphes of CT images and reconstructed images and saw the correlation between SD and dose.

Fig. 1. Cylinderical Phantom

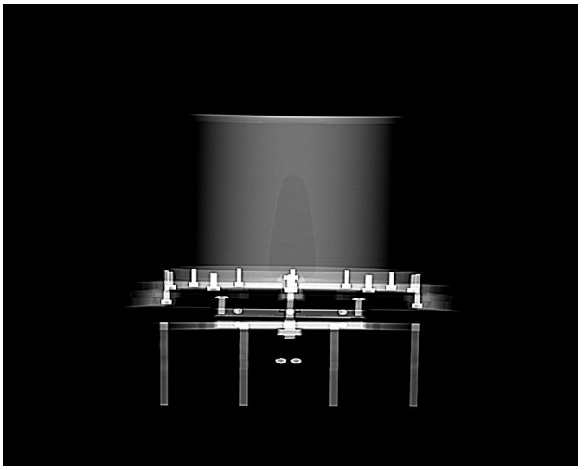

Fig. 2. Scout view of CT (Scan time : 3 min)

Ⅲ. Result

1. The results of CT images

Table 1 is the calculated data by drawing ROI on each CT image. ROI scales are all the same.

The SDs according to the CT graph were 16.25 at 10 mA, 7.26 at 50mA, 5.5 at 100 mA, 4.29 at 150 mA, and 3.83 at 200 mA. With these Figures 3 graph was drawn. The results showed that the higer mA was, the better quality of images was and the lower mA was, the worse quality of images was.

Table 1. Data of CT images

mA	Area	Mean	SD	Min	Max
10	29830.90	8.21	16.25	−63	77
20	29663.06	2.35	11.46	−52	49
30	29214.83	2.32	9.31	−38	47
40	29214.83	2.19	8.04	−37	36
50	29214.83	2.15	7.26	−34	32
60	29214.83	2.27	6.62	−29	29
70	28928.73	2.27	6.10	−26	32
80	28942.08	2.16	5.72	−26	26
90	28942.08	2.13	5.41	−25	27
100	28942.08	2.12	5.15	−20	23
110	29500.93	2.32	4.86	−21	25
120	29365.51	1.84	4.70	−23	21
130	29110.88	1.84	4.57	−21	24
140	29110.88	1.88	4.44	−20	19
150	29079.41	1.78	4.29	−19	18
160	29110.88	1.78	4.18	−17	24
170	28942.08	1.78	4.10	−19	19
180	29110.88	1.96	4.02	−17	18
190	29214.83	1.97	3.91	−14	17
200	29079.41	1.995	3.83	−19	16

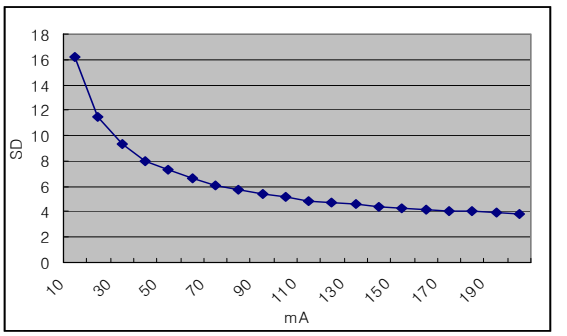

Fig. 3. Graph of CT Images' SDs

2. The results of PET/CT images

Table 2 is the calculated data by drawing ROI on each PET/CT image. ROI scales are all the same.

Table 2. Data of PET Images.

mA	Area	Mean	SD	Min	Max
10	25750.1	24721.2	1823.7	15209	32767
20	25750.1	24707.2	1822.8	15173	32767
30	24882.8	24718.8	1812.8	15205	32767
40	26378.2	24711.1	1802.8	15186	32766
50	24284.7	24699.2	1825.1	15135	32767
60	24882.8	24708.5	1815.0	15114	32766
70	24284.7	24710.9	1827.4	15141	32766
80	25750.1	24705.0	1826.3	15117	32767
90	24882.8	24685.9	1839.6	15114	32767
100	24882.8	24718.4	1828.4	15131	32767
110	25750.1	24712.0	1825.2	15146	32767
120	24284.7	24706.6	1823.4	15121	32767
130	24882.8	24676.8	1835.8	15174	32767
140	26378.2	24717.4	1803.5	15172	32767
150	24882.8	24748.0	1813.8	15189	32767
160	24284.7	24709.5	1821.9	15154	32767
170	24284.7	24708.7	1823.1	15166	32767
180	25750.1	24719.9	1820.9	15221	32766
190	24882.8	24730.3	1814.0	15257	32767
200	24882.8	24739.5	1811.3	15193	32767

The SDs according to the PET/CT graph were 1823.7 at 10 mA, 1828.8 at 100 mA, 1811.3 at 200 mA. With these Figures 4 graph was drawn. The results showed that Calculated SDs at PET/CT images had little changes(Fig. 5).

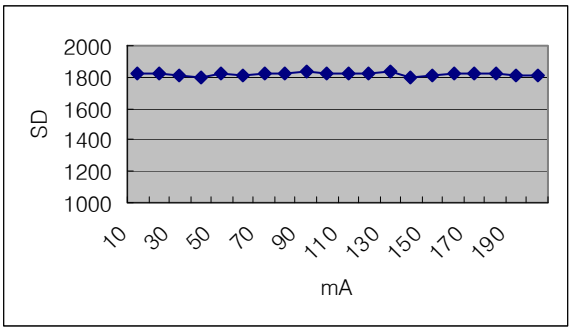

Fig. 4. Graph of PET images' SDs

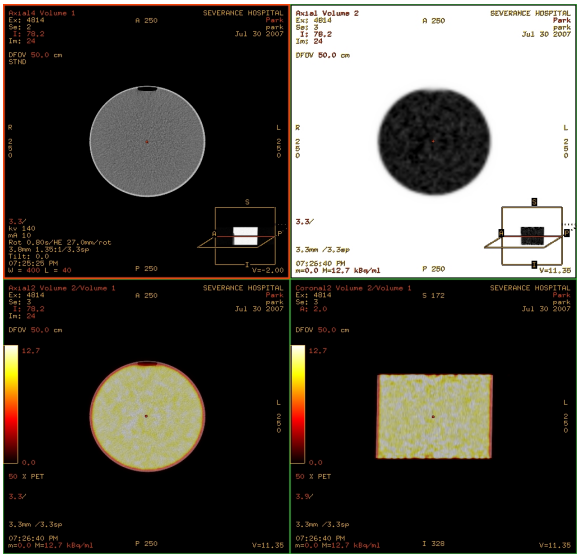

Fig. 5. CT Image, PET Image and fusion Image

The results demonstrated that there is a close relationship between CT image and scanning dose and that there is little relationship between the PET/CT image and the dose.

Ⅳ. Discussion and Conclusion

The interest of the PET/CT has been arising in compliance with the development of medical technique. Because PET/CT has a big advantage; functional and morphological information can be obtained in a single examination. On the other hand there has been a problem about the patient scanning dose.[10~11] So this study was implemented. The purpose of this study is to grope the lowest CT scanning dose considering image quality. ^{68}Ge and ^{137}Cs were used to utilize for attenuation correction at the beginning in the PET, however we experimented with ^{18}F-FDG, which is used mostly nowadays for CT dose estimation. Scanning dose is due to the tube current. Each manufacturer propses 40~50 mA as a optimum dose(at 140 kVp). But above study's results show that the CT images' SDs curve falls quickly on the increase in mA(Table 1, 2) but, relatively, little changes can be seen in the SDs graph of PET/CT images(Fig. 4). It means that mA cannot affect the PET/CT images, in other words, low mA has little effect on the image quality of reconstructions derived from the images obtained at the setting. Therefore PET/CT images can be obtained by using the lowest mA value to examin lesions and, at the same time, can preserve the image quality. Although a decrease in mA results in a reduction in radiation dose, it is also associated with an increase in image noise and streak artifacts which may affect the diagnostic result of the study. However, such artifacts in PET images can be easily distinguished from metabolically active disease. The lowest dose CT has the advantage of the short scanning time and provides adequate image information. Moreover, the patient scan dose can be reduced

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