Original Paper

The Comparison of PET and MCD Imaging

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Molecular Coincidence Detection, MCD, has been recently introduced to Nuclear Medicine. This technique is to acquire data from positron emitter in the same way as or as possible as PET study. This study is the comparison between MCD images and PET images as a gold standard. Two parameters, percent contrast and noise are studied using Partial volume effect phantom and Hoffman phantom. Various parameters were applied in the reconstruction for both PET and MCD. PET study gives higher percent contrast (r = 0.92) and noise than MCD in partial volume effect study. For Hoffman phantom study, MCD gives percent contrast closely to PET (r = 0.96). The patient data of MCD study gives the same lesion site as PET study.

INTRODUCTION

Positron Emission Tomography,PET, has been known as a gold standard for metabolic study in Nuclear Medicine since 1951[1].To perform PET study, we need to have cyclotron-produced short half-life radionuclides such as Oxygen-15 (120 second), Fluorine-18 (110 minute), etc.

Mostly, PET is used for glucose metabolism study, therefore it can be applied for several clinical assessments such as Coronary Artery Disease[2] , Epilepsy[3] , Oncology and other whole-body studies[4], etc. A principle advantage of PET is its capability for studying physiological and biochemical processes of human. The emission of a positron from a radiotracer and its subsequent annihilation with an electron yields two photons, 511 keV each, emitted nearly 180 degree from one another. Detection of both photons in coincidence defines a line along which the positron decay occurred. The coincidence data is then integrated for each detector pair of the system and tomographic images are reconstructed by filtered backprojection method or others.

There are about four generations of PET system[5]. The current generation can acquire both 2D and 3D. Three-dimensional acquisition gives higher sensitivity but poorer resolution than two-dimensional acquisition.

Unfortunately, PET center is costly, therefore there are some attempts to develop advanced single photon emission computed tomography (SPECT) whole-body imaging equipment for positron imaging[6]. In 1992, Lingen AV et al[7] studied the use of standard gamma camera for positron emitters imaging. Also, Drane WE et al[8] reported the study of FDG-SPECT by using gamma camera.

The latest application of gamma camera is Molecular Coincidence Detection (MCD). This process is the modification of performing coincidence imaging of positron-emitting radiotracers, such as 18-FDG by using dual-detector SPECT. Dual-detector scintillation cameras operating in coincidence mode do not use lead collimators to determine the location of the radiotracer within the body. Because the two 511 keV photons associated with positron decay are emitted at 180 degree from each other, electronic means, called coincidence detection are used to localize the site of positron emission. In MCD imaging, the two detectors rotate around the body, acquiring counts from photon coming from different angles surrounding the region of interest.

This study is performed to compare the image quality between PET and MCD imaging. Moreover, the various parameters in PET reconstruction are studied as well.

MATERIALS AND METHODS

Phantom

By using Shimadzu HEADTOME V PET system and ADAC vertex plus MCD SPECT system, situating in Osaka University Hospital, the PET and SPECT data are acquired and reconstructed for both partial volume effect phantom and Hoffman phantom.

Partial volume effect phantom:

This phantom has six different rod sizes i.e., 38, 27, 20, 16, 13 and 10 mm. For PET study, we use Ga-68 (t1/2 = 60 minute) activity about 1.5 mCi (55.5 MBq) with 5:1 for rod:background ratio for emission scan and Ge-68 (Eγ t1/2 = 270.8 days) line source activity about 5 mCi (185 MBq) for transmission scan. Both two-dimensional and three-dimensional data are acquired. For MCD study, the data is acquired with these parameters i.e., 32 steps per scan, 60 second per step, matrix size 128x128x16 and about 6 degree per step.

PET data are reconstructed by filtered backprojection with various parameters e.g. emission only, emission with transmission, emission with transmission post-scan utility and EM reconstruction. MCD data are reconstructed with Ramp filter and Butterworth filter for both with and without attenuation correction.

Hoffman phantom:

The phantom is filled with Ga-68 about 1.5 mCi (55.5 MBq). Several parameters are used for PET study and MCD study. The PET data are reconstructed with these parameters i.e., emission only, emission with transmission, emission with post-injection transmission, emission-transmission simultaneously (10 min.), emission-transmission simultaneously (15 min.) and EM reconstruction. MCD data are reconstructed with Butterworth filter and Wiener filters.

All of these data are used and calculated for comparison between each reconstruction. By drawing the Region of Interest (ROI) in each rod size area and average counts of background area (3 ROIs) for partial volume effect phantom. For Hoffman phantom, 12 ROIs including 4 background ROIs are used for quantitative study. The percent contrast and noise are defined as follows;

The percent contrast =

$$\frac{\text{target} - \text{background(average)}}{\text{target} + \text{background(average)}} \times 100$$

$$\text{noise} = (\text{standard deviation})^{1/2}$$

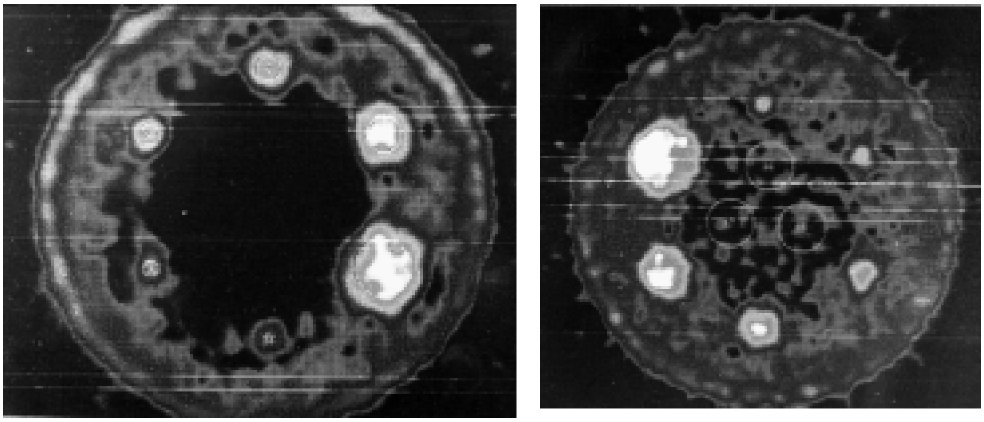

Fig. 1 *The Partial Volume Effect ROIs for rod and background, respectively.*

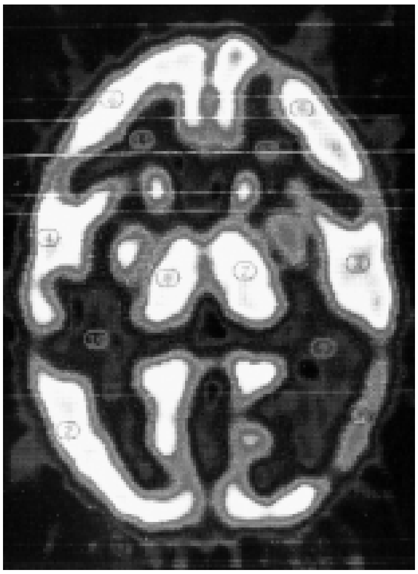

Fig. 2 *The Hoffman Phantom ROIs.*

From these calculated data and images, the selected parameter for both PET and MCD is compared.

Patient:

Patient data are displayed for demonstrating the comparison between two imaging. These patients are cerebral infarction, old myocardial infarction and lung cancer.

RESULTS

Based on percent contrast and noise level, the set of parameters from PET and MCD study are compared and selected. The selected parameters for PET and MCD are compared and shown in Figure 3 to 6. The comparison in patient data are displayed in figure 7 to 9.

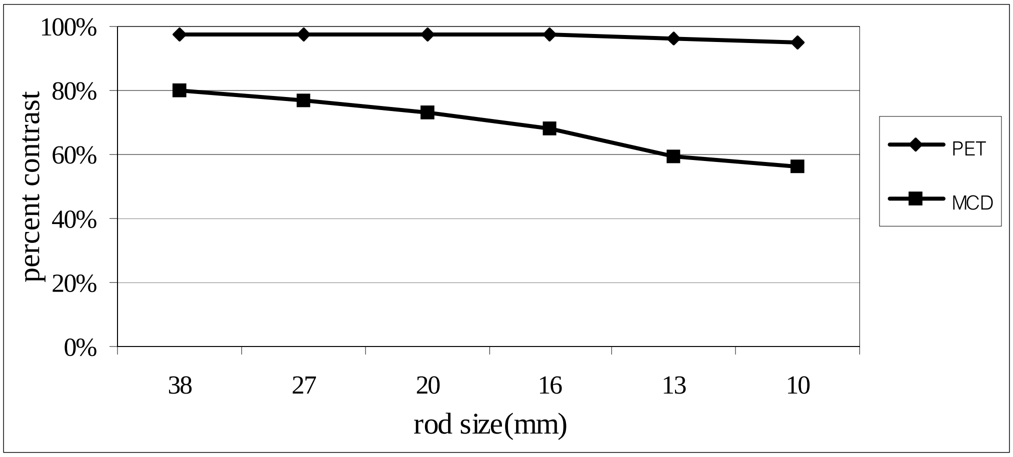

Fig. 3 *The comparison of percent contrast for PET and MCD partial volume effect phantom study*

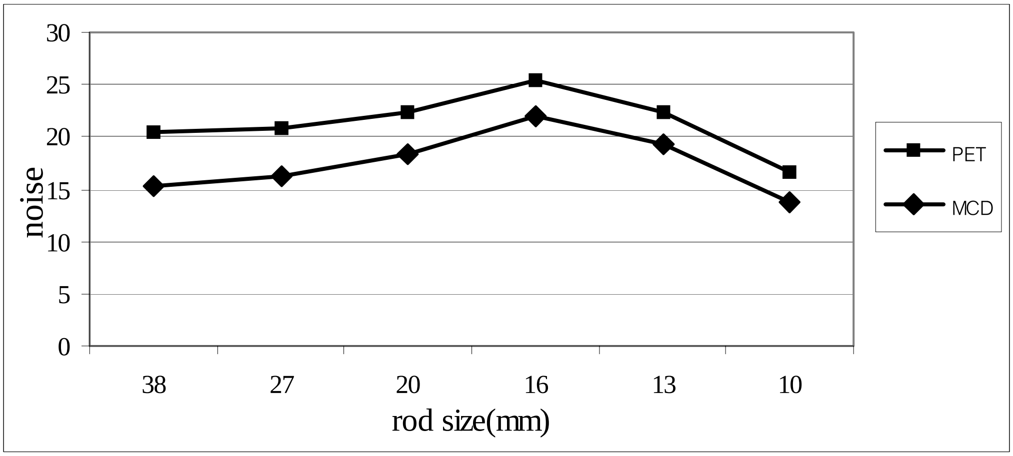

Fig. 4 *The comparison of noise for PET and MCD partial volume effect phantom study*

DISCUSSION

For Partial volume effect phantom (figure 3-4), PET study gives higher contrast with higher noise than MCD study. PET study still gives a good percent contrast though the lesion size is small. The lesion size has more effect on MCD than PET especially when the size is small, the MCD study give worse percent contrast. The relationship between rod size and noise level is the same for both PET and MCD study. The noise level in PET is higher than MCD for each rod size. The correlation (r) of percent contrast between MCD and PET is not so good (r = 0.918497) which means PET still gives a much better image than MCD.

For Hoffman phantom (figure 5-6), in each

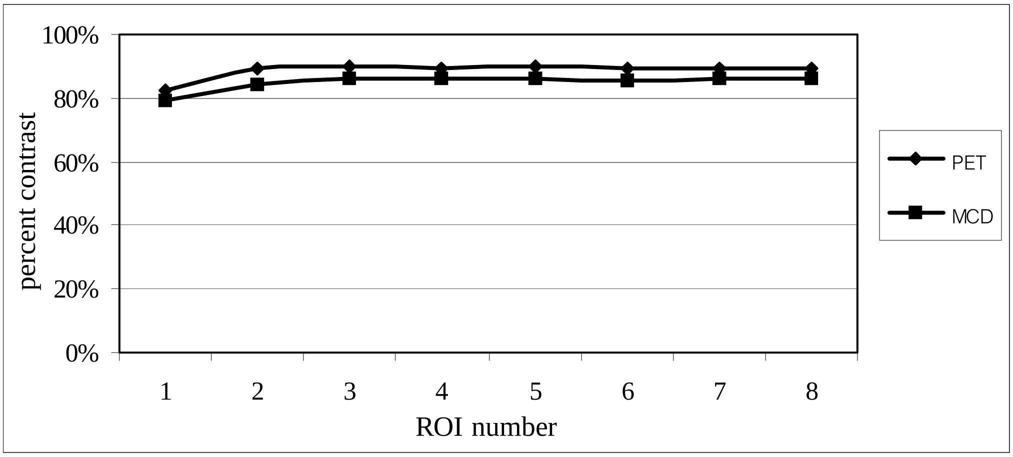

Fig. 5 *The comparison of percent contrast for PET and MCD Hoffman phantom study*

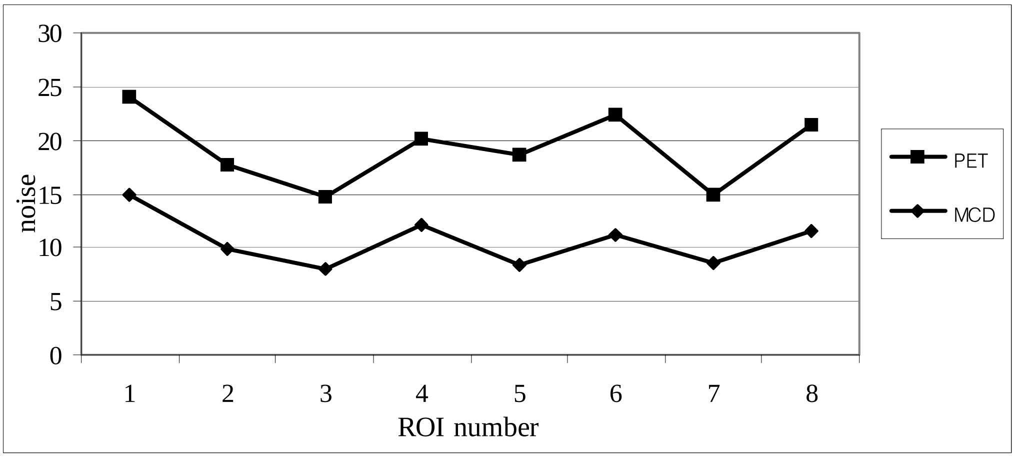

Fig. 6 *The comparison of noise for PET and MCD Hoffman phantom study*

ROI number, MCD gives a very close percent contrast to PET study. The noise level in PET study still higher than MCD study. But the correlation of the percent contrast between PET and MCD is good (r = 0.963108). This means that MCD gives a good result when compared with PET.

From figure 7 to 9, some patient data are demonstrated. MCD gives worse images than PET but gives the same lesion site. This means MCD gives useful data the same as PET study. At the present time, the government of Japan doesn't allow the hospital to use external radioactive source in SPECT so it can not use transmission data to get an accurate correction. But it will be considered in the near future.

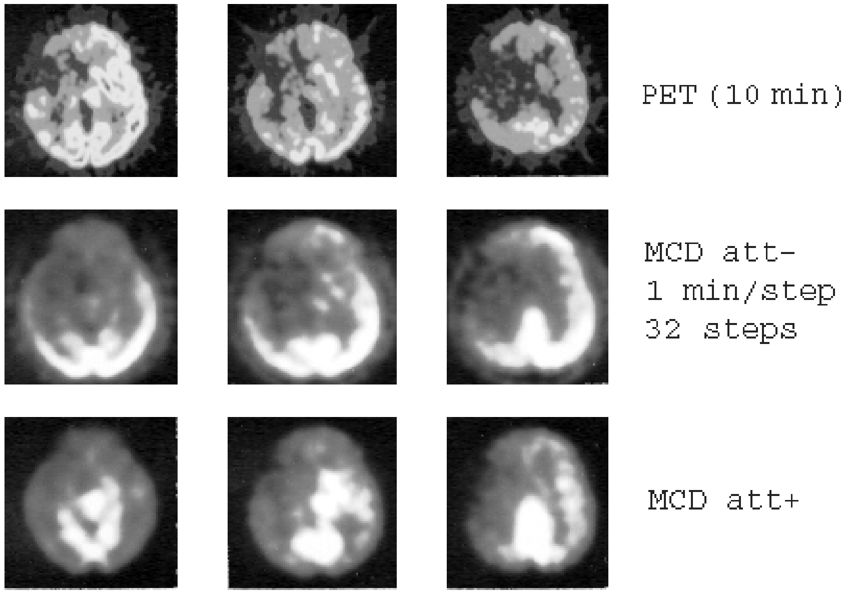

Fig. 7 *The comparison of PET and MCD in cerebral infarction patient in Osaka University Hospital*

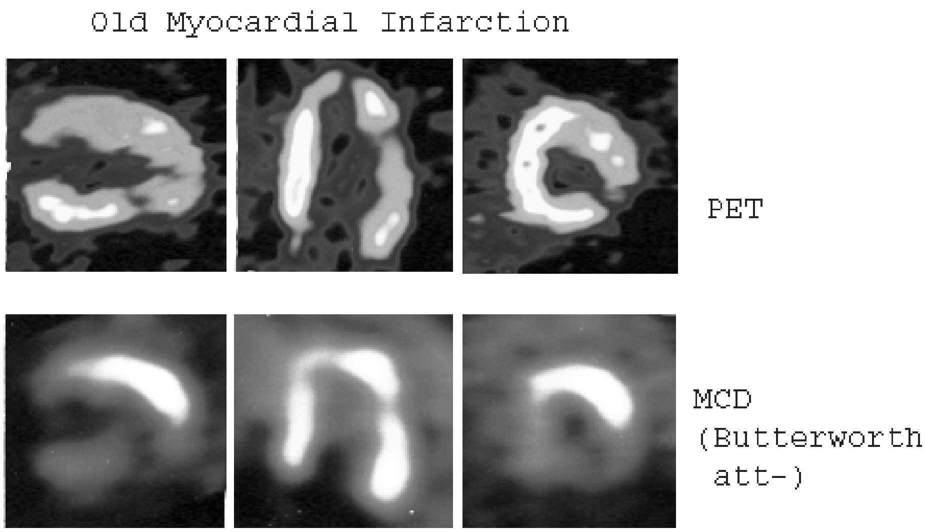

Fig. 8 *The comparison of PET and MCD in old myocardial infarction patient in Osaka University Hospital*

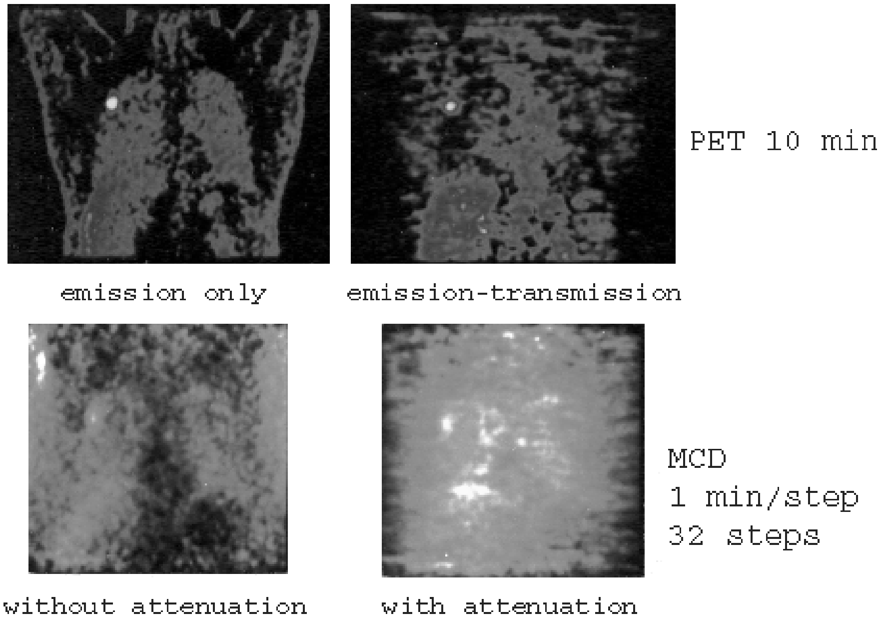

Fig. 9 *The comparison of PET and MCD in lung cancer patient in Osaka University Hospital*

CONCLUSION

MCD study can give percent contrast and image quality as close to PET study. Also, MCD study gives useful information especially for metabolic study with standard SPECT system. By using this technique, we can reduce the expense for PET system and it makes some metabolic study possible for the hospital that has only SPECT system.

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