Quantitative Analysis of Dynamic PET images in Cardiac patients using Patlak tool on GE PET workstation

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ABSTRACT

The purpose of this study was to evaluate the clinical application of Patlak tool on GE PET workstation for quantitative analysis of dynamic PET images in cardiac patients. Three patients including coronary artery disease (CAD), myocardial infarction (MI), and angina were studied. All subjects underwent dynamic cardiac PET scan using a GE Advance scanner. After 10 min transmission scan for attenuation correction using two rotating ^{68}Ge rod sources, three patients with cardiac disease were performed dynamic cardiac PET scan after the administration of approximately 370 MBq of FDG. The dynamic scan consisted of 36 frames with variable frame length (12×10s, 6×20s, 6 ×60s, 12 ×300s) for a total time of 70 min. Blood samples were obtained to determine the plasma substrate concentration. Region of interest of circular and rectangular shape to acquire input functions and tissue data were placed on left ventricle and myocardium. A value of 0.67 was used for lumped constant. Mean plasma substrate concentrations for three patients were 100 mg/dl (CAD), 100 mg/dl (MI), 132 mg/dl (angina), respectively. Regional MMRGlc values (mean±SD) at lateral myocardium area for CAD, MI, and angina were 8.43±0.24, 4.08±0.16, and 6.15±0.23 mg/min/100ml, respectively. Patlak tool on GE PET workstation appeared to be useful for quantitative analysis of dynamic PET images in cardiac patients, although further studies may be required for absolute quantitation.

Keywords: Positron emission tomography, Patlak method, myocardial metabolic rate of glucose.

1. INTRODUCTION

Positron emission tomography is a uniquely powerful diagnostic tool, which non-invasively provides information. Not only does the functional information provided by PET complement and clarify the anatomic information supplied by chest radiography, CT and MR imaging, but the superior sensitivity and negative predictive value of PET allow for improved accuracy in diagnosis, prognosis, staging, and monitoring the effects of treatment. Cardiac PET scans using ^{18}F-FDG is a useful diagnostic tool in the assessment of myocardial viability. Quantitative assessment of cardiac ^{18}F-FDG PET studies for determination of the myocardial metabolic rate of glucose (MMRGlc) is useful to accurate diagnosis, although it has been used qualitative interpretation of cardiac ^{18}F-FDG images to assess the in most clinical studies [1]-[9]. Quantitative analysis of cardiac ^{18}F-FDG PET, however, requires many cumbersome procedures such as serial blood sampling and complicated mathematical processes [2]. It is provided semi-automated Patlak tool for quantitation of metabolic rate of glucose on GE Advance PET workstation. The purpose of this study was to evaluate the clinical application of Patlak tool on GE PET workstation for quantitative analysis of dynamic PET images in cardiac patients.

2. MATERIALS AND METHODS

2.1. Patients

Three patients (3 men; 60 ± 12 y) with cardiac disease included in this study. Each of them has coronary artery disease (CAD), myocardial infarction (MI), and angina confirmed by other diagnostic tools.

2.2. Image acquisition

All patients were undergoing dynamic cardiac PET studies. After 10 min transmission scan for attenuation correction using two rotating ^{68}Ge rod sources, each 370 MBq ^{68}Ge, three patients with cardiac disease were performed dynamic cardiac PET scan using GE Advance scanner after the administration of approximately 370 MBq of FDG. The dynamic scan consisted of 36 frames with variable frame length (12×10s, 6×20s, 6 ×60s, 12 ×300s) for a total time of 70 min. Blood samples were obtained to determine the plasma substrate concentration.

2.3. Image analysis

2.3.1. Determination of blood and tissue time activity curves

Region of interest of circular shape to acquire blood time activity curve were placed on all planes of left ventricle. ROIs of rectangular shape to acquire tissue time activity curve were also placed on about 13 planes of myocardium for three patients (Fig. 1). The size of ROI used for blood and tissue time activity curve were approximately 4.9 cm^2 and 3.7 cm^2, respectively.

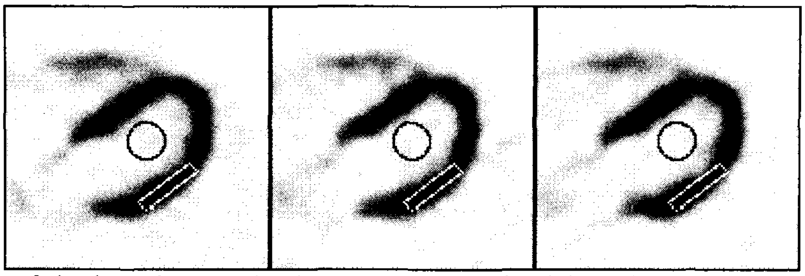

Fig. 1. Region of interest of circular and rectangular shape to acquire blood and tissue time activity curve were placed on the left ventricle and myocardium.

2.3.2. Generation of myocardial metabolic rate of glucose

Patlak tool on GE Advance PET workstation was used to generate the MMRGlc using blood and tissue time activity curves derived from cardiac dynamic PET images. A value of 0.67 was used for lumped constant. ROIs of elliptical shape to acquire MMRGlc were placed on about 7 planes of parametric images for three patients (Fig. 3).

3. RESULTS

Mean plasma substrate concentrations for three patients were 100 mg/dl (CAD), 100 mg/dl (MI), 132 mg/dl (angina), respectively. Figure 2 demonstrates the blood and tissue time activity curves for all patients. It showed that the equilibrium of blood time activity curves is generally reached very rapidly for all patients. Patlak plot indicated that the linear fit curves does line up well with the Patlak curve points for all patients (Fig. 3). The Example of the result images that are scaled in mg/min/100ml illustrating MMRGlc is showed in figure 4. The Regional MMRGlc values at lateral myocardium area are illustrated in table 1. The mean Regional MMRGlc values (mean±SD) at lateral myocardium area for CAD, MI, and angina were 8.43±0.24, 4.08±0.16, and 6.15±0.23 mg/min/100ml, respectively.

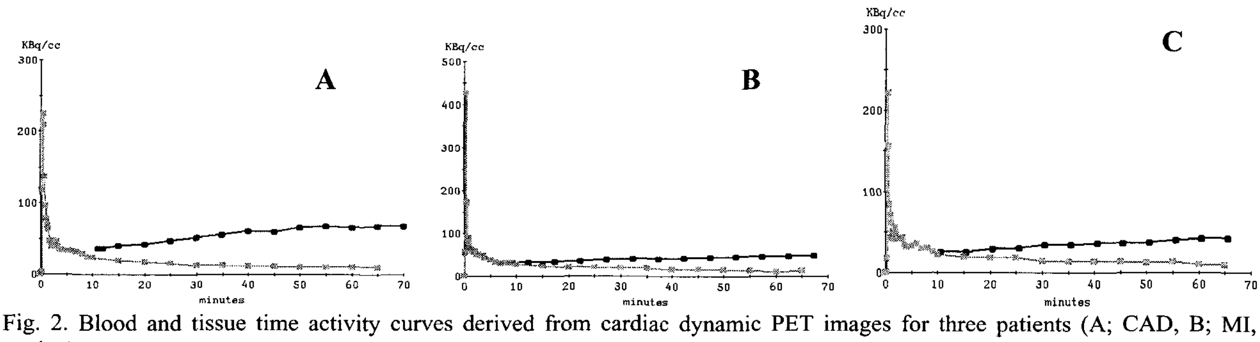

Fig. 2. Blood and tissue time activity curves derived from cardiac dynamic PET images for three patients (A; CAD, B; MI, C; angina).

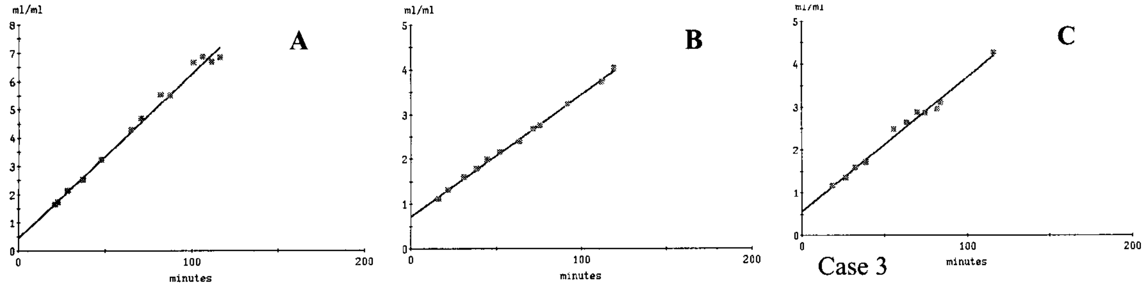

Fig. 3. Patlak plot for three patients (A; CAD, B; MI, C; angina).

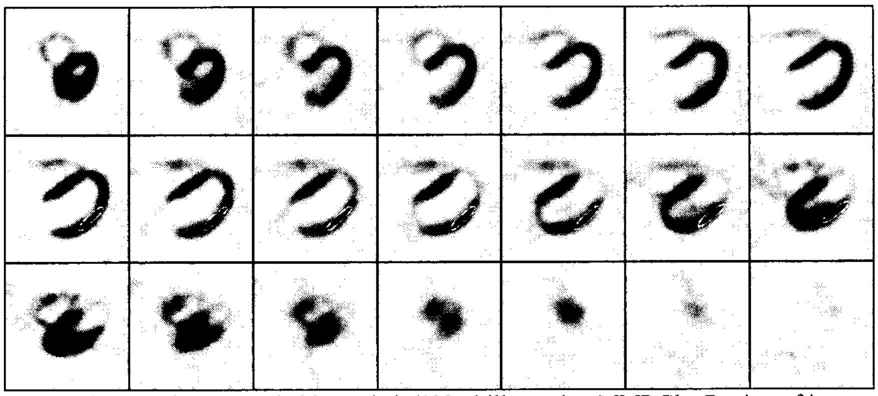

Fig. 4. Examples of the result images that are scaled in mg/min/100ml illustrating MMRGlc. Region of interest of elliptical shape to acquire MMRGlc were placed on the lateral myocardium area.

Table. 1. Regional MMRGlc values of three cardiac patients.

(mg/min/100ml)

	CAD	MI	Angina
ROI 1	8.56	4.14	6.26
ROI 2	8.25	4.29	6.34
ROI 3	8.43	4.16	6.03
ROI 4	8.62	4.14	5.94
ROI 5	8.29	4.08	6.27
ROI 6	8.08	3.82	6.40
ROI 7	8.75	3.90	5.80
Mean (SD)	8.43 (0.24)	4.08 (0.16)	6.15 (0.23)

4. DISCUSSION

The myocardial metabolic rate of glucose can be measured with dynamic ^{18}F-FDG PET using a Patlak method [2]-[6]. These quantitative values offer more detailed information about myocardial metabolism and it is also useful to accurate diagnosis in clinical situations. Quantitation of the MMRGlc, however, requires many cumbersome procedures such as serial blood sampling and complicated mathematical processes [2]. It is provided semi-automated Patlak tool for quantitation of metabolic rate of glucose on GE Advance PET workstation. In this study, we evaluated the clinical application of Patlak tool on GE PET workstation for quantitative analysis of dynamic PET images in cardiac patients. We could acquire the quantitative MMRGlc using a Patlak tool on GE PET workstation and simple one blood sampling and acquisition protocol. The mean Regional MMRGlc values (mean±SD) at lateral myocardium area for CAD, MI, and angina were 8.43±0.24, 4.08±0.16, and 6.15±0.23 mg/min/100ml, respectively. There are some limitations in this study by no comparing the results of MMRGlc values for CAD, MI, and angina with normal MMRGlc values or other indices to validate of this value. It is also excluded correction for spillover or partial volume effect in this study. Then, further studies may need to address the effect of spillover or partial volume for quantitation of MMRGlc.

5. CONCLUSION

Patlak tool on GE PET workstation appeared to be useful for quantitative analysis of dynamic PET images in cardiac patients, although further studies may be required for absolute quantitation.

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