Detection of Myocardial Infarct Region Using PET and MRI Images

Sang-Keun Woo*, Yong Jin Lee, WonHo Lee, Min Hwan Kim, Ji Ae Park, In Ok Ko, Jin Su Kim, Jong Guk Kim, Young Hoon Ji, Joo Hyun Kang, Gi Jeong Cheon, Chang Woon Choi, Sang Moo Lim, Kyeong Min Kim
Laboratory of Nuclear Medicine Research, Molecular Imaging Research Center, Korea Institute of Radiological and Medical Sciences, 215-4 Gongneung-Dong, Nowon-Gu, Seoul, 139-706
**Corresponding author: skwoo@kcch.re.kr*

1. Introduction

Development of novel myocardial imaging techniques and preclinical testing of cardiovascular radiopharmaceuticals require an in vivo heart model of small animals such as rats [1]. Cardiac disease research relies increasingly on small animal models and non-invasive imaging methods such as PET/CT and MRI. PET is the most reliable non-invasive tool for the identification of myocardial viability and myocardial perfusion [2]. MRI provides high resolution anatomical images that allow accurate evaluation of ventricular structure. However, a direct comparison among multimodal image for characterization of perfusion, viability, and infarct size is lacking. The aim of this study was to improve quantitative assessment of rat myocardial infarct (MI) size using attenuation corrected PET polar map with gated CT image and MRI polarmap.

2. Methods and Results

2.1 PET/CT and MRI Imaging

Rat myocardial infarction model was induced by ligation of the left circumflex artery. The PET/CT images obtained with a small animal PET/CT scanner (Inveon^{TM}, Siemens). The experimental conditions were feeding, warming, and 2% isoflurane anesthesia. Gating was realized with the help of an external trigger device (BioVET). PET imaging was started 60 min after the administration of 30 MBq of ^{18}F-FDG via tail vein injection. The three bed CT images for attenuation map were acquired with following settings: X-ray voltage of 70 kVp, anode current of 400 μA, an exposure time of 200 milliseconds for each of 360 rotational steps.

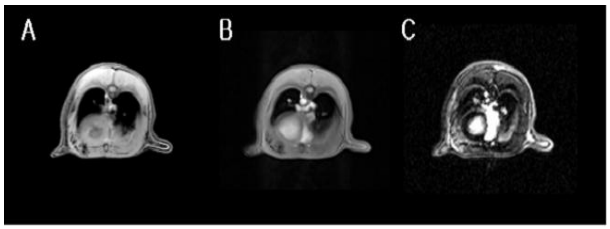

Fig. 1. Clinical MRI image (A) FLASH 2D sequence image (B) Contrast enhanced FLASH 2D sequence image (C) Inversion recovery cine FLASH image after contrast enhanced.

Contrast enhanced CT images of heart were obtained at second bed after injection of contrast agent using catheter. Contrast enhanced FLASH sequence MRI image was acquired with a 3-T clinical MRI scanner (MAGNETOM Tim Trio) using ECG triggering (Fig. 1) [3]. Fused image (Fig. 2) showed a good correlation of images from both small animal PET/CT and PET/MRI image.

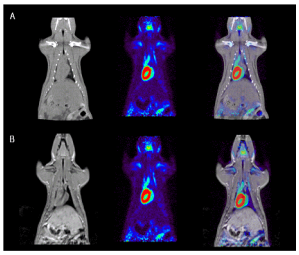

Fig. 2. Multimodal rat fusion image. (A) Fused small animal ^{18}F-FDG PET/CT image (B) Fused small animal PET and clinical MRI image.

2.2 Polarmap generation using QGS software

The pixel size of PET/CT and MRI image was being converted to automated myocardial wall detection by the QGS software used to process the gated image series (Fig. 3). The SUV PET image pixel size was Percent variation was calculated anterior wall (ANT), septal wall (SEP), inferior wall (INF) and lateral wall (LAT) in polar map. Homogeneity was calculated no corrected PET (NC), attenuation corrected PET with CT image (AC-CT), attenuation corrected PET with gated CT image (AC-gCT) and attenuation corrected gated PET with gated CT image (gAC-gCT) [4].

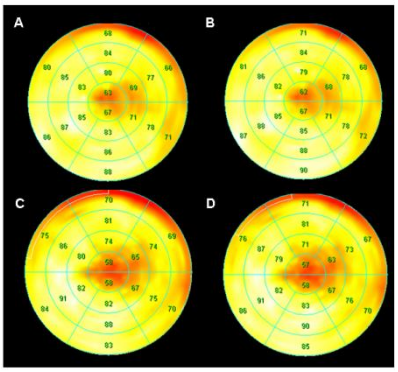

Fig. 3. PET image polarmap (A) Attenuation corrected (AC) end systolic state polarmap using free breathing CT image (B) AC end systolic state polarmap using gated CT image (C) AC end diastolic state polarmap using free breathing CT image (D) AC end diastolic state polarmap using gated CT image.

2.3 MI region assessment

Triphenyltetrazolium chloride (TTC) staining measures tissue viability used to evaluate real infarct size in Fig. 4. The reference infarct size was defined by infarction area percentage of the total left myocardium. Infarct sizes were defined by defects area percentage of the mid portion area in polar map.

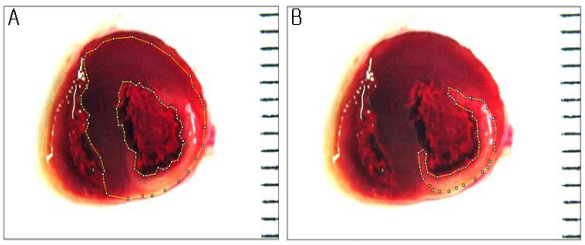

Fig. 4. Triphenyltetrazolium chloride (TTC) staining measures tissue viability used to evaluate real infarct size. The reference infarct size was defined by infarction area percentage of the total left myocardium. (A) Total left myocardium size (B) Infarction size.

The infarct size for optimal size was repeated varying threshold values (PET polar map: higher threshold 70%, 80%, 90% and 100%, MRI polar map: lower threshold 40%, 50%, 60% and 70%). The measured infarct sizes were evaluated by correlation in comparison with reference infarct size. The infarction area was confirmed by histologic analysis with TTC staining, and measured ratio was 20.7% (Fig. 5).

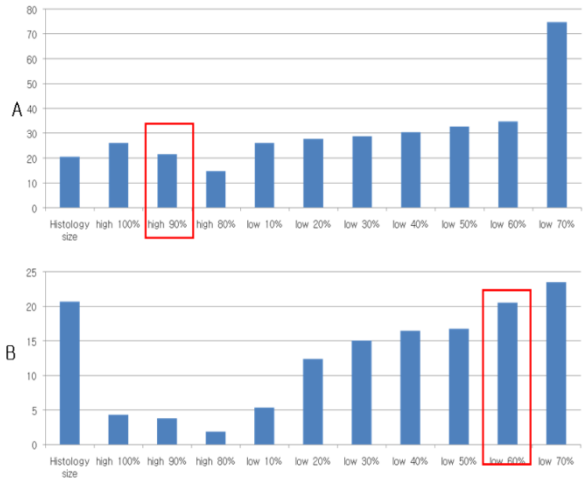

Fig. 5. Estimated value with various threshold using PET and MRI image polarmap (A) Case of PET image polarmap (B) Case of MRI image polarmap.

3. Conclusions

The gated CT attenuation corrected gated PET polar map homogeneity was improved myocardial activity in anterior, inferior and lateral region. MRI based polar map with FLASH sequence at threshold lower 60% provide good result of infarct size measurement. Integrated myocardial analysis technology of high sensitive PET and high resolution MRI images may potentially facilitate the improvement of volume and attenuation correction information in cardiology. The hybrid PET/MRI images for detecting molecular targets may extent the application of these modalities to the characterization of atherosclerotic plaques and to the evaluation of angiogenetic or stem cell therapies

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