Quantitative assessment of small animal cardiac 18F-FDG PET and MRI image

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1. Introduction

Cardiac disease research relies increasingly on small animal models and non-invasive imaging methods such as positron emission tomography (PET) and magnetic resonance imaging (MRI) [1, 2]. Delayed enhancement magnetic resonance imaging (DE-MRI) using gadolinium-based contrast agents appear to be a visualizing infracted myocardium with high spatial resolution [2, 3]. Polar map (or bull's-eye image) was used to determination of the myocardial infarction area. Polar map is a comprehensive interpretation of the left ventricle [4]. The infarct size was computed as the fraction of the total polar map areas. The threshold was computed as the percentage of mean intensity of the normal region. In other study, 50% predefined threshold value in varying range (30~70%) was most commonly use [2, 5, 6]. However, predefined threshold value isn't acceptance in all case. The purpose of this study was to investigate methodological approach for automatic measurement of rat myocardial infarct size using PET and MRI polar map with adaptive threshold value driven from Multi gaussian mixture model (MGMM).

2. Methods and Results

2.1 PET Imaging

PET was performed using small animal PET scanner (Inveon, Siemens). PET images were obtained after intravenous injection of FDG. Each animal was scanned for 20 min with list-mode data format. PET data were reconstructed using fourier rebinning and ordered subset expectation maximization (OSEM) 2D reconstruction with 4 iterations. Trans-axial PET images were reoriented into short axis slices.

2.2 MR Imaging

MRI was performed using a 3-T clinical MRI system (MAGNETOM Tim Trio, Siemens). Delay enhancement images were obtained 10 min after injection of GD-DTPA-BMA (Omniscan) 0.5 mol / kg. Short-axis images were acquired using T1-weghted turboflash phase sensitive inversion recovery (PSIR) sequence (parameter: repetition time = 529 ms, echo time = 1.83 ms, flip angle = 20°, interpolated in-plane resolution = 0.47 × 0.47, 8 short axis slices and slice thickness = 2.5 mm) with ECG triggering and a human wrist coil. The optimal inversion recovery time was used for nulling myocardium intensity.

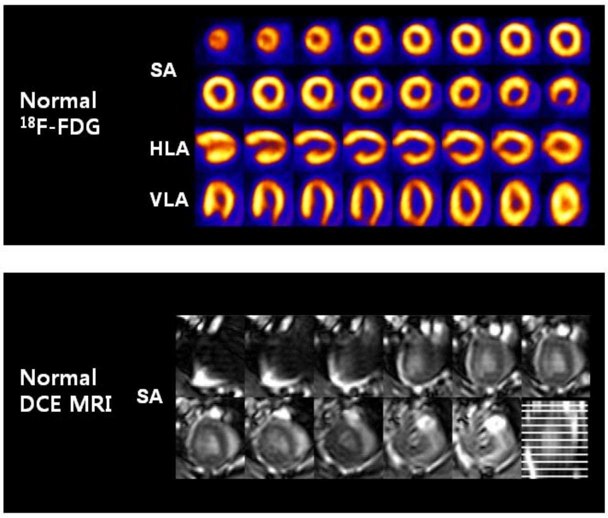

Fig. 1. Cardiac FDG PET and DCE MRI short axis image.

2.3 Evaluation of Infarct Size

To automatically make the myocardial contour and generate polar map, we used QPS software (Cedars-Sinai Medical Center). The infarct size in polar map was calculated as the percentage of lower threshold area in polar map from the total polar map area. To calculate infarct size, we used three thresholding methods (predefined threshold, Otsu and MGMM). Predefined threshold method was commonly used in other studies. We applied threshold value form 10% to 90% in step of 10%. Otsu algorithm calculated threshold with the maximum between class variance. MGMM method estimated the distribution of image intensity for adaptive threshold calculation. The histogram can be used to represent the statistical character of probability density function and the Gaussian mixture is used to estimate the image's probability density function [7].

2.4 Correlation Analysis Between Histology and PET Image

The comparison of correlation coefficient predefined threshold method and MGMM method in table 1.

Table 1. Correlation coefficient of two threshold method

	MGMM	10%	20%	30%	40%
Correlation Coefficient (*r*)	0.98	0.38	0.81	0.97	0.96
	50%	**60%**	**70%**	**80%**	**90%**
	0.96	0.94	0.07	0.07	0.18

MGMM and 30% predefined threshold value showed a high correlation with TTC staining (Fig. 2).

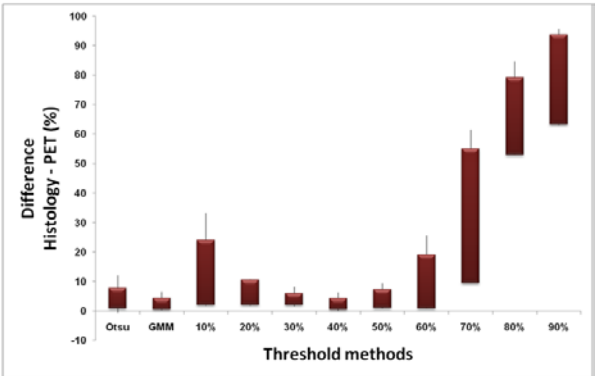

Fig. 2. The distribution of the differences between TTC staining and PET polar map

In the 14.38% infarct region of staining image, predefined thresholds method 20%, 30%, and 40% were 0.46%, 3.74% and 6.84%, respectively. Otsu method was 5.45%. Adaptive thresholds value with MGMM method was 11.84%. MGMM method correlation with TTC staining was 0.006% and predefined threshold was 0.59%.

2.5 Measurement Infarct Size from PET and MRI Image

MGMM threshold value of PET and MRI image was 51% and 66%. PET and MRI infarct size was 6.6% and 6.16%, respectively.

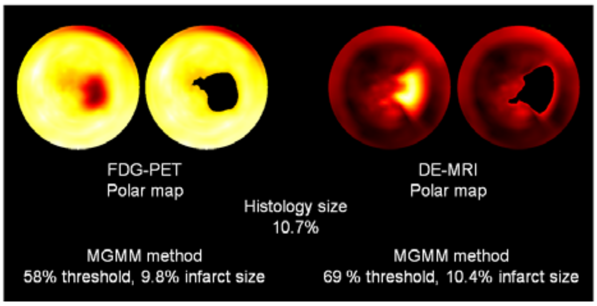

Fig. 3. PET and MRI polar map, GMM threshold value was 58% and 69%, infarct size is 9.8% and 10.4%, respectively

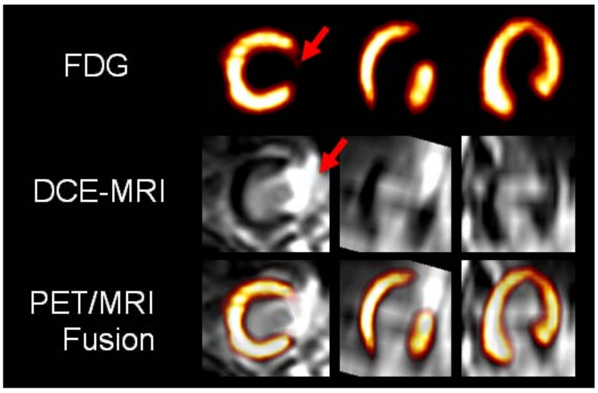

Fig. 4. Short-axis images from apex (left) to base (right) and long-axis images. FDG PET shows an uptake defect, and DE-MRI demonstrates hyperenhanced area (red arrows).

3. Conclusions

Infarct size was measured using PET and MRI polar map. MGMM showed the highest correlation and the lowest mean difference with histological sections. MGMM method was provide adaptive threshold in each subject and will be a useful for automatic measurement of infarct size. High spatial resolution MRI polar map will be an attractive method for infarct size measurement.

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