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Assessment of PET and MRI Polar Map using Gaussian Mixture Model

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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 Gaussian mixture model (GMM).

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.

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 two thresholding methods (predefined threshold and GMM). Predefined threshold method was commonly used in other studies. We applied threshold value form 10% to 90% in step of 10%. GMM is statistically matures methods for clustering and image segmentation. 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]. A histogram of polar map can be represented two component (infarct and normal) gaussian mixture model.

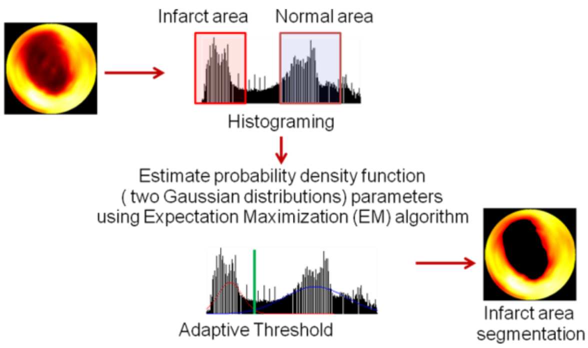

Fig. 1. The process of Gaussian Mixture Method.

2.4 Correlation analysis between histology and PET

GMM and 30% predefined threshold value showed a high correlation with TTC staining. 40%, 50% and 60% threshold value also showed high correlation with TTC staining (Fig. 2, Table 1). GMM is showed smaller mean difference and variance than predefined threshold method (Fig. 3).

Table 1. The comparison of correlation coefficient predefined threshold method and GMM method

	GMM	**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

(a)

(b)

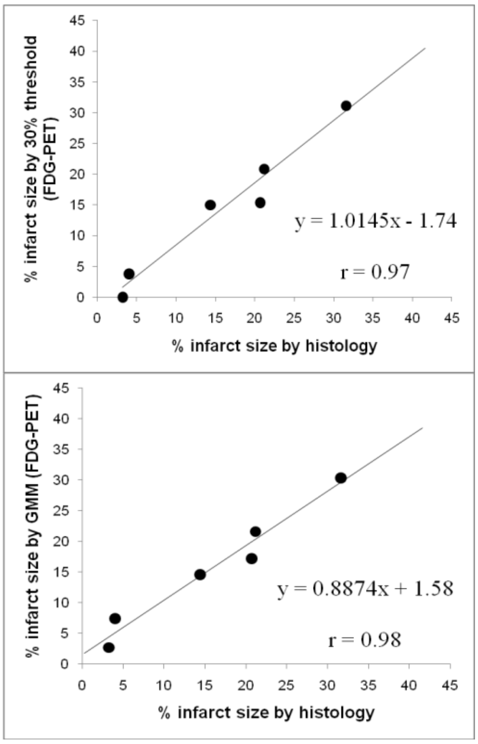

Fig. 2. The result of correlation analysis between histological infarct size and PET polar map infarct size driven from 30% predefined threshold (a) and GMM (b)

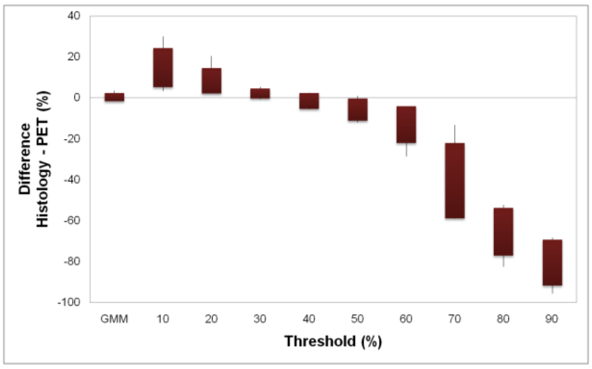

Fig. 3. The distribution of the differences between TTC staining and PET polar map

2.5 Measurement infarct size from MRI polar map

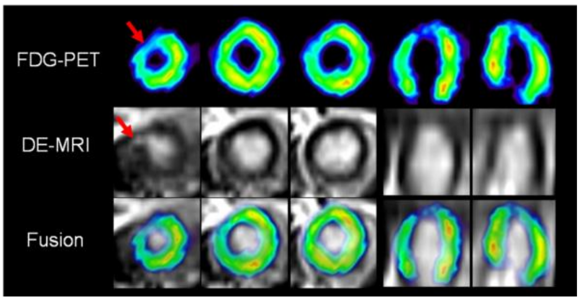

Fig. 4. Short-axis images from apex (left) to base (right) and long-axis images. FDG PET shows an uptake defect, and DE-MRI demonstrates hyperenhanced area (red arrows).

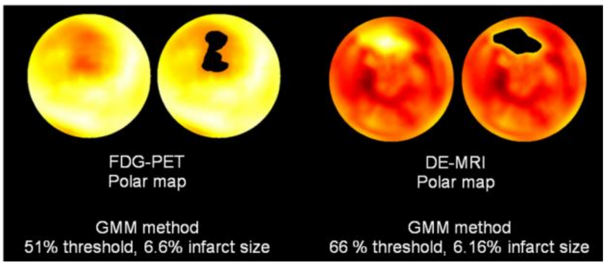

Fig. 5. PET and MRI polar map, GMM threshold value is 51% and 66%, infarct size is 6.6% and 6.16%, respectively

3. Conclusions

Infarct size was measured using PET and MRI polar map. GMM showed the highest correlation and the lowest mean difference with histological sections. GMM 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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