Estimation of organ motion for gated PET imaging in small animal using artificial tumor

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1. Introduction

The image quality is lowered by reducing of contrast and signal due to breathing and heart motion when acquire Positron Emission Tomography (PET) image of small animal tumor. Therefore motion correction is required for betterment of quantitative estimation of tumor. The gated PET using external monitoring device is commonly used for motion correction [1, 2]. But that method has limitation by reason of detection from the outside. Therefore, we had devised the in-vivo motion assessment. In-vivo motion has been demonstrated in lung, liver and abdomen region of rats by coated molecular sieve. In PET image analysis, count and SNR were drawn in the target region. The motion compensation PET image for optimal gate number was confirmed by FWHM. Artificial motion evaluation of tumor using molecular sieve suggests possibility of motion correction modeling without external monitoring devices because it estimates real internal motion of lung, liver, and abdomen. The purpose of this study was to assess the optimal gates number for each region and to improve quantitative estimation of tumor.

2. Methods and Results

2.1 In-vivo motion modeling and PET Imaging

The in-vivo motion model was prepared using 300g female Sprague Dawley rats in these experiments. We planted molecular sieve containing radioactive material in lung, liver and abdomen region of each rats for making internal motion model. Molecular sieve for in-vivo motion target were contained approximately 0.37 MBq Cu-64. We coated molecular sieve with Pluronic F-127 hydrogel for quantitative estimation by keeping the activity in the body.

The PET images in each region were obtained by a dedicated small animal PET scanner, Inveon^{TM} (Siemens, Knoxville, TN, USA) as list-mode data. The rats were injected with 37 MBq/0.2 mL of ^{18}F-FDG (fluoro-deoxy-glucose) via the tail vein. During whole experiments, the rats were under 2% isoflurane anesthesia. PET imaging studies was started 60 minutes after administration for 20 minutes. Breathing signals were collected and converted to trigger signals by the external motion monitoring system (BioVet, m2m Imag. Corp) and synchronized with the list mode acquisition. The trigger signals were simultaneously reflected motion of heart and breathing using dual-trigger method [3]. Each line of response in the list-mode data was converted to sinogram gated various frames (2~16 bin) by respiratory trigger event. The acquired 3D emission list-mode data were reconstructed to temporally framed sinograms using fourier rebinning (FORE) and ordered subsets expectation maximization 2D (OSEM 2D) algorithm with 4 iterations.

In PET image analysis for in-vivo motion assessment, count and signal-to-ratio (SNR) were measured from region of interest (ROI) drawn in the target region using AMIDE. Full width at half maximum (FWHM) were measured from drawn line profile in each image.

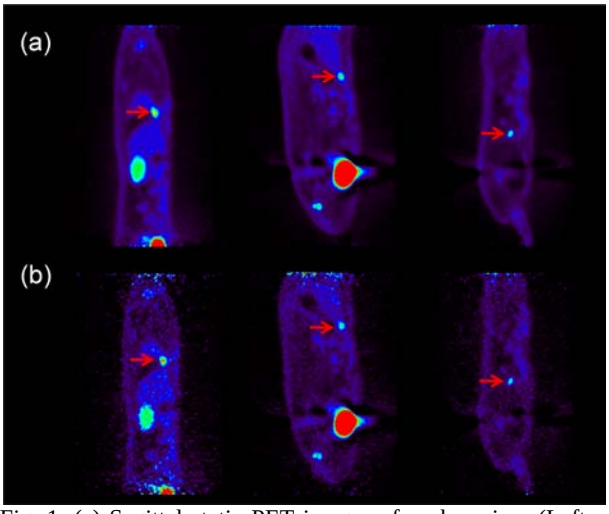

Fig. 1. (a) Sagittal static PET images of each region. (Left : lung, medium : liver, right : abdomen) (b) Sagittal gated PET images of each region. (The red arrows direct the target region.)

2.2 In-vivo motion Assessment

The acquired PET images revealed the artificial tumor placed each region, and also showed difference between gated image and un-gated image.

We performed in-vivo motion measurement in lower lung, liver, and lower abdomen region that organs have plenty of motion. Moving patterns of molecular sieve were different in each region. The variation of motion in the liver and lung was bigger than abdomen.

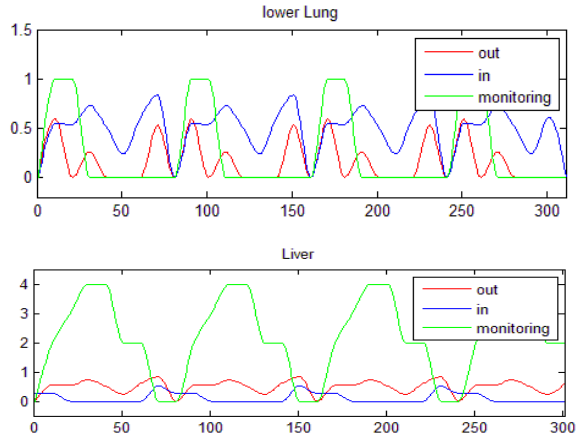

Fig. 2. Internal motion data and external motion data measured from molecular sieve in each region. External monitoring data as reference measured by BioVet. (Top: lower lung, Bottom: liver).

2.3 Gated Image Analysis

We had additionally analyzed whole gated PET images by comparing count, SNR, FWHM. The count and SNR of lung region were higher in gate number 8(count: 5.59 and SNR: 3.94) compared with gate number 7(4.99 and 3.94). Similarly, vertical and horizontal FWHM were improved in upper gate number 8 in lung (7bin: 3.38, 1.65 and 8bin: 3.16, 1.59).

The result of liver region showed great improvement of vertical and horizontal FWHM as the growth in gate number, especially upper gate number 9(8bin: 3.22, 2.72 and 9bin: 2.99, 1.38). The count and SNR of liver region were higher in gate number 9(count: 4.72 and SNR: 4.31) compared with gate number 8(4.50 and 4.16).

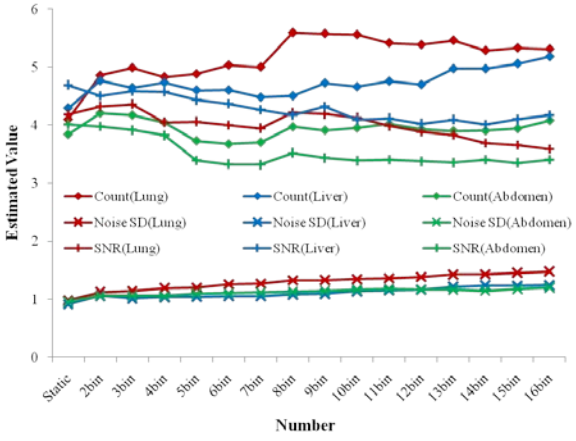

Fig. 3. Count, SNR, and noise standard deviation to gate number graph measured from ROI drawn in each region. (Red line : Lung, Blue line : Liver, Green line : Abdomen)

In case of abdomen region having fewer motion variances, there was not highly significant change. But the count and SNR were decreased in gate number 5 to 7 range (count: 3.72, 3.67, 3.70 and SNR: 3.34, 3.32, 3.31). The FWHM was also worsened in same range (vertical: 2.94, 3.24, 3.58 and horizontal: 2.35, 2.44, 2.69). Contrariwise, the results in gate number 4 indicated appropriate count value and FWHM with low signal loss (count: 4.04 / SNR: 3.82 / FWHM: 3.18, 2.06).

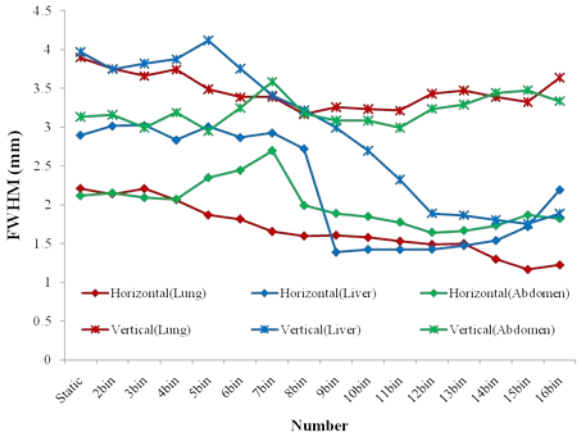

Fig. 4. The vertical and horizontal FWHM to gate number graph measured from drawn line profile in each image. (Red line : Lung, Blue line : Liver, Green line : Abdomen)

3. Conclusions

The PET images show that variation of count, SNR, FWHM following gate number and region. The gate number for motion correction should be set differently depending on the organ because motion level vary as each organ. Thus, we should determine the optimal gate number in accordance with motion characteristic of the organ. This study revealed that the optimal gate number of lung, liver, and abdomen region in the rat were 8, 9, and 4, respectively. The artificial tumor evaluation study is a way to assess accurately internal organ motion. This method demonstrates possibility of motion conjecture modeling without external monitoring device.

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