Evaluation of tumor motion effect in canine model for diagnostic and radiotherapy

Sang-Keun Woo [a*], Taewon Nam [a], Nohwon Park [c], Seungwoo Park [b], Suchul Han [b], Kyeong Min Kim [a], Joo Hyun Kang [a], Kidong Eom [c], Young Hoon Ji [b]
[a]Molecular Imaging Research Center, [b]Division of Radiation Cancer Research, Korea Institute of Radiological and Medical Sciences, Gongneung-Dong, Nowon-Gu, Seoul, 139-706
[c]Department of Veterinary Radiology and Diagnostic Imaging, Konkuk University, Neungdong-Ro, Gwangjin-Gu, Seoul, Korea, 143-701
[*]Corresponding author: skwoo@kcch.re.kr

1. Introduction

Organ motion caused by respiration has a negative effect on diagnosis and treatment. The internal organs move up to 35mm maximum and it provides information and uncertainty that has been distorted in the diagnosis and treatment [1-3]. Previous most studies for the effect of respiration have been performed with external monitoring systems but it cannot represent internal organ motion such as liver, pancreas, and lung. Positron emission tomography (PET) is more influenced by motion than computed tomography (CT) and magnetic resonance imaging (MRI) since measurement time for image acquisition is longer than CT and MRI. Thus, count of tumor is to be underestimated and region of tumor is to be overestimated [4]. The first aim of this study was developing the artificial pulmonary nodule which can be performed non-invasive transplant into thorax of dogs and second is to assess the effect of respiratory motion on PET image with evaluating the applicability of the artificial model using dogs for diagnosis and treatment.

2. Methods and Results

2.1 Developing the Artificial Pulmonary Nodule

Artificial pulmonary nodule was developed by using 8 Fr disposable gastric feeding tube and developed for two kinds of purpose, one was for injection of ^{18}F-FDG and the other was for insert of glass dosimeter. Anesthetized dogs were underwent implantation of the nodule and the location of implanted nodule was ascertained by fluoroscopic images.

2.2 PET Imaging with Phantom and dog

PET image was acquired from Biograph Truepoint PET scanner (Siemens Preclinical Solutions, Knoxville, TN, USA). ^{18}F-FDG was absorbed to the nodule. The nodule was mounted on the phantom representing the respiration motion of 10 rpm and 15 rpm and inserted into the anesthetized dogs. PET listmode data was acquired using the phantom under the condition of static, 10 rpm, and 15 rpm longitudinal round motion. Static PET image was reconstructed using 2 mm Gaussian filter and ordered subset expectation maximization (OSEM) algorithm with 6 iterations. Respiratory signal was collected using sensor for the pressure during acquisition time and respiratory gated image was acquired based on trigger signal transferred to PET scanner by AZ-733-V (Anzai medical Co., LTD, Japan) through histogramming the listmode data.

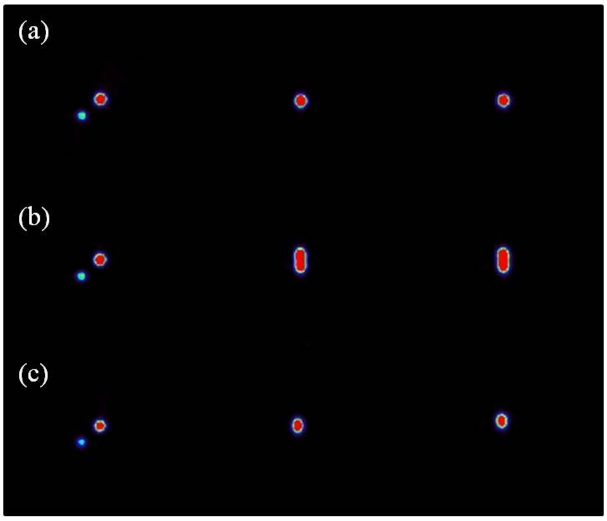

Fig. 1. Acquired PET images of the artificial pulmonary module; left, transverse images; middle, coronal images; right, sagittal images; (a) reference images, (b) static images, (c) respiratory gated images

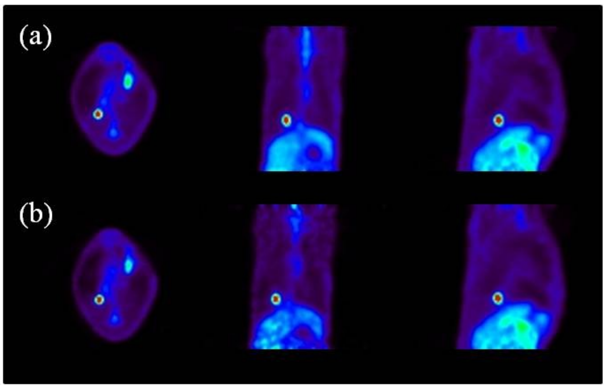

Fig. 2. Acquired PET images of the dog; left, transverse images; middle, coronal images; right, sagittal images; (a) static images, (b) respiratory gated images

PET images of the nodule mounted on the phantom are shown in Fig. 1. Blurring caused by motion was observed in Fig. 1(b) and blurring of the nodule was decreased by gating minimizing the effect of respiratory motion in Fig. 1(c). PET images of the nodule inserted into dog are shown in Fig. 2 and blurring was decreased also by gating.

Signal to noise ratio (SNR) was used for quantitative analysis in accordance with the nodule motion. SNR for evaluating the difference of sensitivity was calculated into percentage with drawing region of interest (ROI) on the nodule as a target region and background. SNR was 10.15 and 8.57 (15% decreased) in case of reference and 15rpm of phantom. Respiratory motion effect was corrected quietly and gated image came close to reference image by gating but there was decreasement of SNR and count in accordance with gating image.

2.3 Raditation irradiation

Calibration of glass dosimeter was operated with source to surface distance (SSD) of 80 cm using Co-60 irradiation equipment (Theratron 780, AECL, Canada). Reference dose was determined by using ion chamber (TN30006, PTW Freiburg, Germany). The nodule including glass dosimeter was mounted on the phantom moving 10 rpm and 15 rpm, respectively, and exposed to 1Gy Co-60 for 90 sec. Radiation dose rate was 75.19 cGy/min and SSD was 80 cm.

Table I: Radiation dose of glass dosimeter and ion chamber of phantom and dog

	Glass dosimeter (Gy)		Ion chamber (nC)
	Phantom	Dog	Phantom
Reference	0.91	-	13.91
10 rpm	0.91	0.654	13.91
15 rpm	0.90	0.643	13.87

The radiation dose estimated using glass dosimeter and ion chamber is described in Table I above. Radiation dose was decreased about 1.1% 0.3% in case of moving phantom of 15 rpm estimated by glass dosimeter and ion chamber, respectively.

3. Conclusions

The developed artificial pulmonary nodule showed reproducibility and motion effect as respiratory cycle and it was verified in PET images. Radiation dose estimated was not changed and was reduced slightly of 10 rpm and 15 rpm, respectively, in both of glass dosimeter and ion chamber. SNR and count also showed downward tendency according to increasing of rpm. The developed artificial pulmonary nodule will be useful tool for evaluating respiratory motion and better research performance for diagnosis and treatment will be expected with performing simulated experiment using the nodule conducted in this study.

REFERENCES

[1] P. J. Bryan, S. Custar, J. R. Haaga, and V. Balsara, Respiratory movement of the pancreas: an ultrasonic study, Journal of Ultrasound in Medicine, Vol.3, No. 7, pp.317-320, 1984.
[2] C. S. Ross, D. H. Hussey, E. C. Pennington, W. Stanford, and J. F. Doornbos, Analysis of movement of intrathoracic neoplasms using ultrafast computerized tomography, International Journal of Radiation Oncology, Biology, Physics, Vol. 18, Iss. 3, pp.671-677, 1990.
[3] S. C. Davies, A. L. Hill, R. B. Holmes, M. Halliwell, and P. C. Jackson, Ultrasound quantitation of respiratory organ motion in the upper abdomen, The British Journal of Radiology, Vol. 67, No. 803, pp.1096-1102, 1994.
[4] S. A. Nehmeh and Y. E. Erdi, Respiratory Motion in Positron Emission Tomography/Computed Tomography: A Review, Seminars in Nuclear Medicine, Vol. 38, Iss. 3, pp.167-176, 2008.