AJMB AN OPEN ACCESS JOURNAL
eISSN: 2600-8173
https://doi.org/10.37231/ajmb.2022.6.S1.507
https://journal.unisza.edu.my/ajmb

PENERBIT Universiti Sultan Zainal Abidin

Asian Journal of Medicine and Biomedicine

Optimization of Adaptive Threshold in Tumor Segmentation Based on I-124 PET/CT NEMA Phantom Study

Dhanessha Vijayarao[1], Marianie Musarudin[1]*, Aminudin Said[2]

1School of Health Sciences, Health Campus, Universiti Sains Malaysia, Kelantan, Malaysia
2Nuclear Medicine Department, Institut Kanser Negara, Putrajaya, Malaysia

Corresponding author: marianie@usm.my

Received: 25th July 2022 **Accepted: 23rd August 2022** **Published: 30th October 2022**

Abstract

Numerous methods have been introduced to segment the thyroid tumors in iodine-124 (^{124}I) Positron Emission Tomography/Computer Tomography (PET/CT) imaging. An adaptive threshold-based is preferable to a manual and fixed threshold-based approach for forecasting accurate and precise tumor volume in real-patient studies, as it was reported to be more resistant to noise and resolution. Manual segmentation was reported to be time-consuming, subjective, subject to inter- and intra-observer variability and prone to segmentation errors [1]. This study aimed to determine the optimal adaptive threshold for thyroid tumor segmentation in ^{124}I PET/CT imaging.

The objective of this study was firstly to determine the segmented volume using the standardized uptake value threshold method. Secondly, to compare the adaptive threshold and recovery coefficient (RC) value between the time of flight (TOF) and non-time of flight (non-TOF) PET/CT reconstructions in ^{124}I phantom studies. Finally, to determine the accuracy and RC for ^{124}I PET/CT studies. This study was done by placing NEMA 2012/IEC 2008 PET IQ Phantom and filled with 1 kBq/ml and 20 kBq/ml in its background and sphere each to model tumor background ratio (TBR) 20:1 of ^{124}I PET/CT imaging. The phantom was scanned using TOF and non-TOF PET at 3, 4 and 5 minutes per bed position and reconstructed using β600, 1200 and 2000 beta penalization factors. Image registration, contouring and segmentation were performed using MIM Encore Software. A set of different adaptive thresholds ($T_{adaptive}$: 10%-50%) was applied to each sphere in the TBR image of the phantom using the tri-dimensional automatic segmentation tool. The optimal $T_{adaptive}$ for each of the parameter assessed was defined based on the lowest goodness value calculated. The RC was calculated using mean value and known activity. Finally, the RC against the percentage of maximum was plotted to analyse the descending order of beta penalization factors for time per bed position.

Figure 1 shows the image of ^{124}I contoured VOIs on the spheres. The results showed that segmented volumes were not affected by the time per bed position in ^{124}I PET/CT imaging. Table 1 shows the descending order beta penalization factors for time per bed position. Beta penalization factors of 600 to 2000 resulted in either underestimation or overestimation of the measured volume. Comparing TOF to non-TOF PET/CT ^{124}I imaging, consistent and reproducible data were observed for the TOF PET for the three beta penalization factors. $T_{adaptive}$ of 28.0% consistently gave the lowest goodness value shown by the closest R^2 value to one, thus can produce lowest error if it is being used to reconstruct images.

eISSN: 2600-8173
https://doi.org/10.37231/ajmb.2022.6.S1.507
https://journal.unisza.edu.my/ajmb

Figure 1: Image of ^{124}I contoured VOIs on the spheres

Table 1: Descending order beta penalization factors for time per bed position

Descending order beta penalization factors for time per bed position			
Time per bed position (min)	Beta penalization factors, β /maximal %		
3	β 1200 (104%)	β 2000 (92%)	β 600 (120%)
4	β 600 (107%)	β 1200 (95%)	β 2000 (87%)
5	β 600 (106%)	β 1200 (94%)	β 2000 (86%)

As a conclusion, 28% $T_{adaptive}$ is suggested as the optimal threshold for ^{124}I TOF PET/CT imaging due to consistent data obtained for all beta penalization factors assessed in this study. The inconsistent data obtained by non-TOF PET thus requires further optimization.

Keywords
^{124}I, TOF, Adaptive threshold, Beta penalization factors, Non-TOF, PET/CT Imaging, Segmentation

Acknowledgement
Authors wish to acknowledge the support, succor and cooperation given by the staff at the Nuclear Medicine Department, IKN for the data information and also to Universiti Sains Malaysia, Kubang Kerian for supporting this research. This study reference NMRR ID-21-02347-WQF had not been funded by any organization. We would like to thank the Director of Health Malaysia for his permission to publish this article.

Reference

1. Popović, Z. B., & Thomas, J. D. Assessing observer variability: a user's guide. *Cardiovascular diagnosis and therapy*. 2017; *7*(3), 317.