IMAGE EVALUATION OF TRIPLE-ENERGY WINDOW SCATTER CORRECTED I-131 AND I-123 POSTSURGIGAL SPECT/CT IMAGES USING A NECK-THYROID PHANTOM WITH SMALL SIZES OF THYROID REMNANTS

Ioannis Petrou[1], Savvas Frangos[2], Ioannis Iakovou[3], Anastasia Hadjiconstanti[4], Konstantinos Michael[5,6], Christoforos Panagidis[1], Diogenis Kyprianou[7], Yiannis Parpottas[4,5]

[1]Department of Nuclear Medicine, Nicosia General Hospital, State Health Services Organisation, Cyprus; [2]Department of Nuclear Medicine, Bank of Cyprus Oncology Center, Cyprus; [3]Department of Nuclear Medicine, Aristotle University AHEPA Academic Hospital of Thessaloniki, Greece; [4]Frederick Research Center, Cyprus; [5]Department of Mechanical Engineering, Frederick University, Cyprus; [6]Department of Medical Physics, Bank of Cyprus Oncology Center, Cyprus; [7]Department of Nuclear Medicine, Limassol General Hospital, State Health Services Organisation, Cyprus

INTRODUCTION

Differentiated thyroid cancer treatment typically involves surgical removal of the whole or the largest part of the thyroid gland and a subsequent radioiodine therapy [1]. Diagnostic postsurgical thyroid I-131 or I-123 SPECT/CT imaging can provide information on the actual presence of remnants. It is important to determine the sizes of remnants for the implementation of individualized treatment for ablation.

PURPOSE

In this study, the non-scatter (NSC) and triple-energy window (TEW) scatter corrected I-131 and I-123 SPECT/CT images of a custom-made neck-thyroid phantom with small sizes of thyroid remnants were visually evaluated by physicians.

MATERIALS & METHODS

Anthropomorphic neck-thyroid phantom

SPECT/CT acquisitions were performed using a custom-made phantom, which encloses trachea, oesophagus, cervical spine and a removable section with thyroid remnants. Figure 1(a) shows a front view of the neck-thyroid phantom and thyroid-remnant section with two different sizes of thyroid remnants while figure 1(b) shows a coronal CT slice of the phantom, obtained with the Somaton Sensation Open (Siemens) with a slice thickness of 0.6 mm.

The hollow cavity of the neck phantom can be filled with water (4180 mL) to simulate the soft tissue. Diluted radiopharmaceutical can be injected within this cavity to simulate various thyroid background-to-remnant activity ratios.

For this study, remnants of 1.5- and 3 mL were inserted, at clinically relevance areas, to simulate thyroid remnants after thyroidectomy. Radiopharmaceuticals can be injected within the hollow cavities of the remnants (target).

The neck-thyroid phantom is made of a material with a density close to 1 g/cm^3. The ellipsoid hollow cavities of trachea and oesophagus are filled with air while the cylindrical hollow cavity of the cervical spine is filled with bone-equivalent material. All abovementioned parts are anatomical positioned within the phantom.

SPECT/CT acquisitions

All images were acquired with the SPECT/4-slice-CT system (Infinia Hawkeye 4, GE Healthcare) at the Department of Nuclear Medicine of the Bank of Cyprus Oncology Center and at the Nicosia General Hospital utilizing the custom-made phantom. The clinical protocols were followed for the acquisitions. Specifically, the High-Energy General-Purpose (HEGP) collimators were used for the I-131 acquisitions and the Low-Energy High-Resolution (LEHR) collimators for the I-123 acquisitions, in 180° (H-mode) orientation. Data were acquired in 60 projections over 180° of rotation, covering an angular range of 360°, with 35 sec/projection. An ± 10% energy window was centered over the 364 keV photopeak of I-131 and the 159 keV photopeak of I-123, respectively. For the TEW acquisitions, the widths of the lower and upper energy windows were set to 5 keV: 304.4-309.4 and 418.6-423.6 keV for I-131, and 127.5-132.5 keV and 177.2-182.5 keV for I-123.

SPECT data were reconstructed using the ordered-subset expectation-maximization (OSEM) algorithm with 2 iterations and 10 subsets. The image matrix size was 128x128 with a pixel size of 4.42 mm. A Butterworth filter (cut-off: 0.48 cycles/cm, power: 10) was applied to the reconstructed images. A CT scan was also acquired at 140 kV with 2.5 mA. The reconstructed slice thickness was 4.42 mm. The image matrix size was 512x512. Attenuation correction was applied to non-scattered corrected (NSC) and TEW scatter corrected SPECT data.

The first part of acquisitions was performed for different administered activities of I-131 and I-123 within the 1.5 and 3 mL thyroid remnants, ranged from 2.5-40 MBq for I-131 and 0.5-6 MBq for I-123, respectively. The second part of acquisitions was performed for different background activities of I-131 and I-123 to achieve different background-to-remnant activity ratios (5%, 10%). In this part of acquisitions, the administered activity within the remnants was 0.37 MBq/ml.

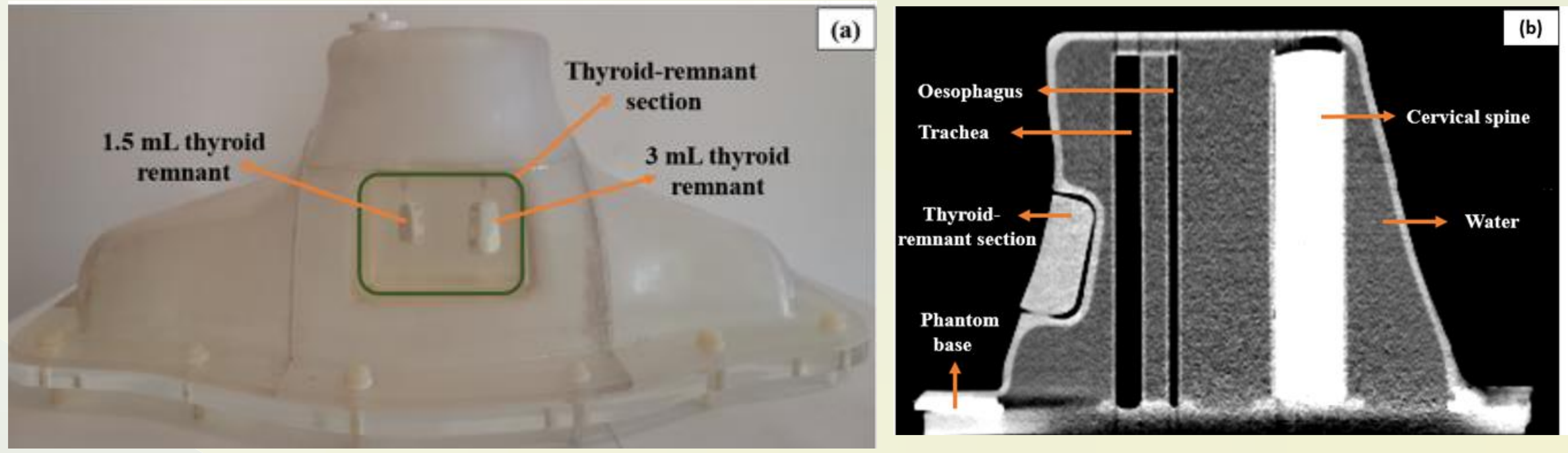

Figure 1: (a) Front view of the custom-made neck-thyroid phantom with two different sizes of thyroid remnants and (b) a coronal CT slice obtained with the Somaton Sensation Open (Siemens) with a slice thickness of 0.6 mm.

Scatter Correction

The TEW scatter correction [2] was performed by an algorithm developed in MatLab. TEW was applied to all projections prior reconstruction with the Xeleris workstation.

Image Evaluation

All acquired images were evaluated visually by experienced nuclear medicine physicians to decide the image that they could draw ROIs, with more confidence, for evaluation of the volume of each remnant, which is important for therapeutic decisions. Note that the physicians had no prior knowledge of the above imaging parameters when reading the images.

RESULTS

Figure 2 shows the NSC (top row) and the TEW (bottom row) scatter corrected SPECT/CT images with I-131 (left) and I-123 (right) for the 1.5 mL and 3 mL thyroid remnants, and without background activity. The administered activity within the remnants of this figure was 13 MBq. The physicians reported that they could not distinguish significant differences among the NSC and TEW images, however, they were more confident to evaluate the volume of each remnant from the TEW scatter corrected SPECT/CT images than the NSC ones. Comparing the I-131 and I-123 images, without background, the physicians considered that the quality of I-123 images is higher than the I-131 ones.

Figure 3a shows the NSC (top row) and TEW (bottom row) scatter corrected SPECT/CT images, with I-131 (left) and I-123 (right), for the 1.5 mL and 3 mL thyroid remnants, with 5% background-to-remnant activity ratio. The corresponding images for 10% background-to-remnant activity ratio are shown in figure 3b.

From this visual evaluation, for different background-to-remnant activity ratios, it was observed that the TEW scatter correction method improved the quality of I-131 and I-123 images. Also, the quality of I-123 images is higher than the I-131 ones.

The abovementioned comparisons are more profound in images with background activities, and in particular, for the 5% background-to-remnant activity ratio.

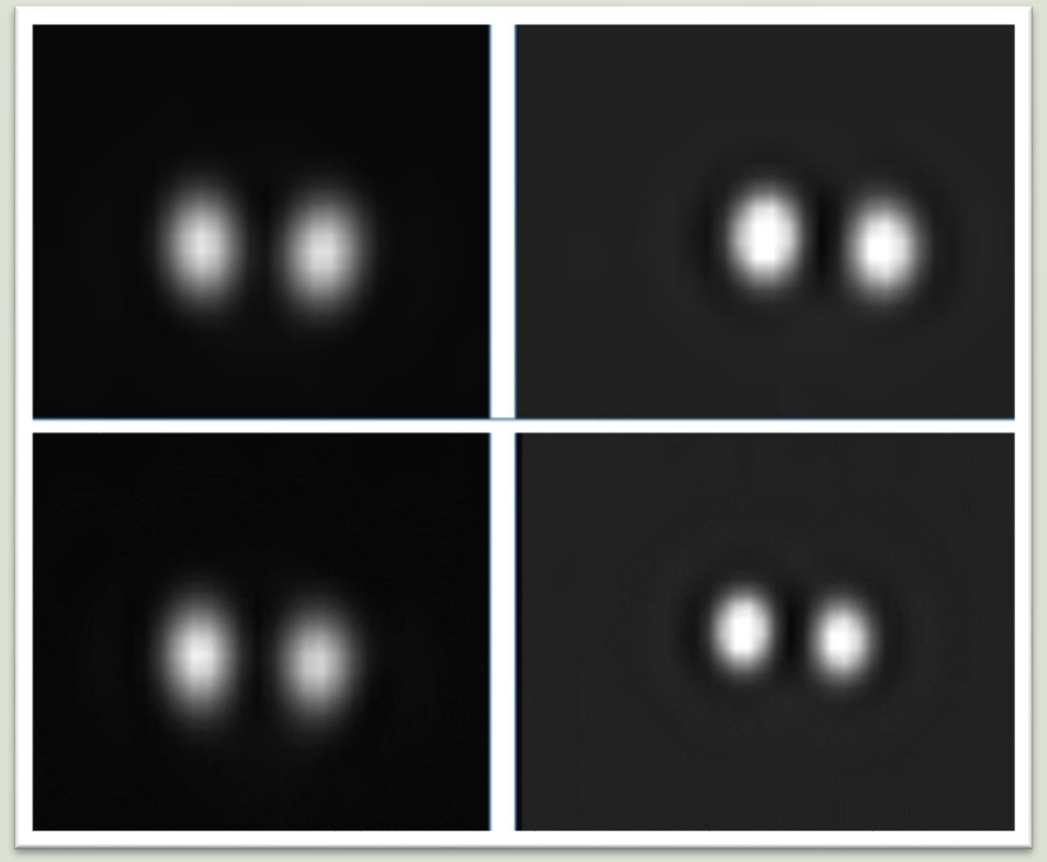

Figure 2: NSC (top row) and TEW (bottom row) scatter corrected SPECT/CT images with I-131 (left) and I-123 (right) for the 1.5 mL and 3 mL thyroid remnants without background activity.

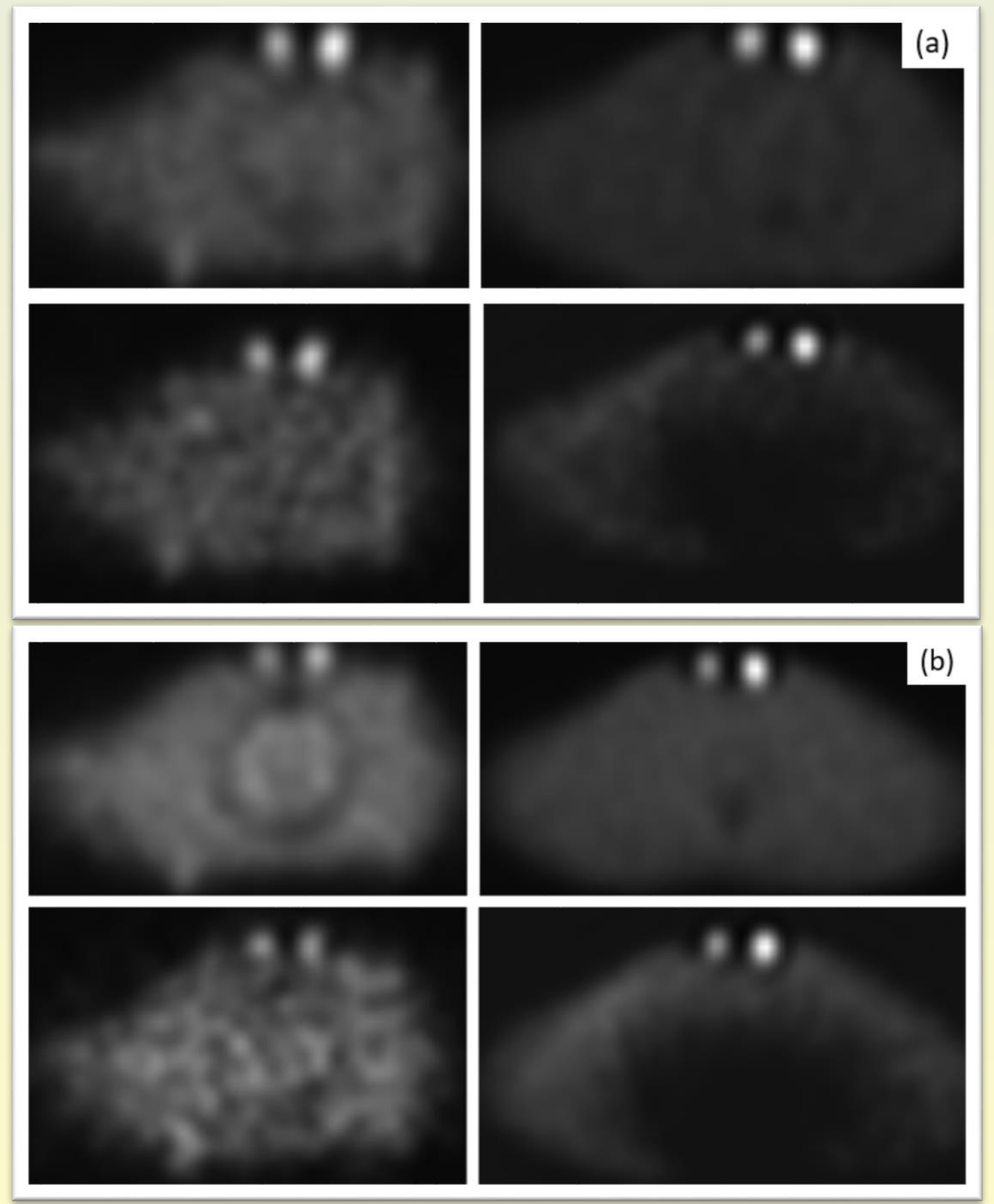

Figure 3: (a) NSC (top row) and TEW (bottom row) scatter corrected SPECT/CT images, with I-131 (left) and I-123 (right), for the 1.5 mL and 3 mL thyroid remnants, with 5% background-to-remnant activity ratio. (b) The corresponding images for 10% background-to-remnant activity ratio.

CONCLUSION

Diagnostic postsurgical thyroid SPECT/CT images from a custom-made phantom were visually evaluated by three experienced nuclear medicine physicians. The quality of the TEW images is higher than the NSC ones, for both I-131 and I-123. In all cases, the quality of I-123 images is superior than the I-131 ones.

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