Iodine-123 SPECT of the Thyroid in Multinodular Goiter

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Iodine-123 single photon emission computed tomography (SPECT) imaging of the thyroid was performed in two patients with multinodular goiter and swallowing difficulty to provide the functional and anatomic orientation of the goiter in relation to the airway. Transaxial slices showed the retrolaryngeal extension of the enlarged thyroid and the tracheal compression by the goiter in both patients. Sagittal and coronal sections confirmed the posterior extension of the goiter. Tracheal displacement was confirmed by roentgenography of the neck in both patients. Vocal cord paralysis demonstrated by fiberoptic laryngoscope and esophageal compression shown by esophagography were found in a patient with toxic multinodular goiter with coexisting papillary carcinoma of the thyroid. In this patient, both the tracheal compression noted in SPECT imaging and the tracheomalacia suggested by the flow volume loop pattern in pulmonary function test were confirmed at the time of thyroidectomy. Our observation suggests that SPECT imaging of large multinodular goiter may be useful in preoperative delineation of the functional anatomy and the extension of goiter in relation to the airway.

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Clinical palpation and technetium-99m (^{99m}Tc) pertechnetate or iodine-123 (^{123}I) planar thyroid imaging frequently provide sufficient information in the management of patients with multinodular goiter. However, when one evaluates preoperative patients with large multinodular goiter and symptoms of local compression, tomography of the thyroid gland should be considered to assess the retrotracheal or substernal extension. Tomography of the thyroid has been performed by x-ray transmission computed tomography (*1,2*) and, recently, has also been evaluated by nuclear magnetic resonance imaging (*3,4*).

Radionuclide emission tomography of the thyroid, particularly transaxial and sagittal tomographic sections, had not been utilized in the management of patients with thyroid disease until recently when Frey et al. employed Iodine-124 to perform positron emission tomography (PET) of the thyroid (*5,6*). In this report, we present tomographic imaging of the thyroid, using (p,2n) ^{123}I and single photon emission computed tomography (SPECT), in two patients with multinodular goiter.

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MATERIALS AND METHODS

SPECT imaging of thyroid was performed 5 hr after oral administration of 400 μCi ^{123}I. A medical image processor, interfaced to a SPECT scanner using a slant hole collimator was employed. The slant hole collimator was used because it would allow the camera to rotate around the shoulders easily and thus move the detector close enough to the thyroid. Individual planar data acquisitions were collected at every 6° angle interval for 40 sec per sampling acquisition. The camera was rotated around the patient 180° starting from right lateral position to left lateral position. Each image was acquired in a 64 x 64 matrix. Projection data was corrected for camera nonuniformities without attenuation correction and smoothed prior to reconstruction. Reconstruction was performed through a combination of the convolution technique and the filtered backprojection technique utilizing the Shepp and Logan filter. Transaxial, sagittal and coronal tomographic slices were then reconstructed and displayed using a digital laser disc format. The entire computer processing time was 5 min.

Figure 1a-c shows transaxial, sagittal, and coronal tomographic sections of a normal thyroid gland, respectively. On the transaxial sections, slices are displayed from the cephalad to caudal aspect of the thyroid with the patient supine and the viewer looking cephalad, i.e., the patient's right thyroid lobe on the viewer's left. The tracheal space (arrow) can be well visualized between two lobes if the intensity is increased.

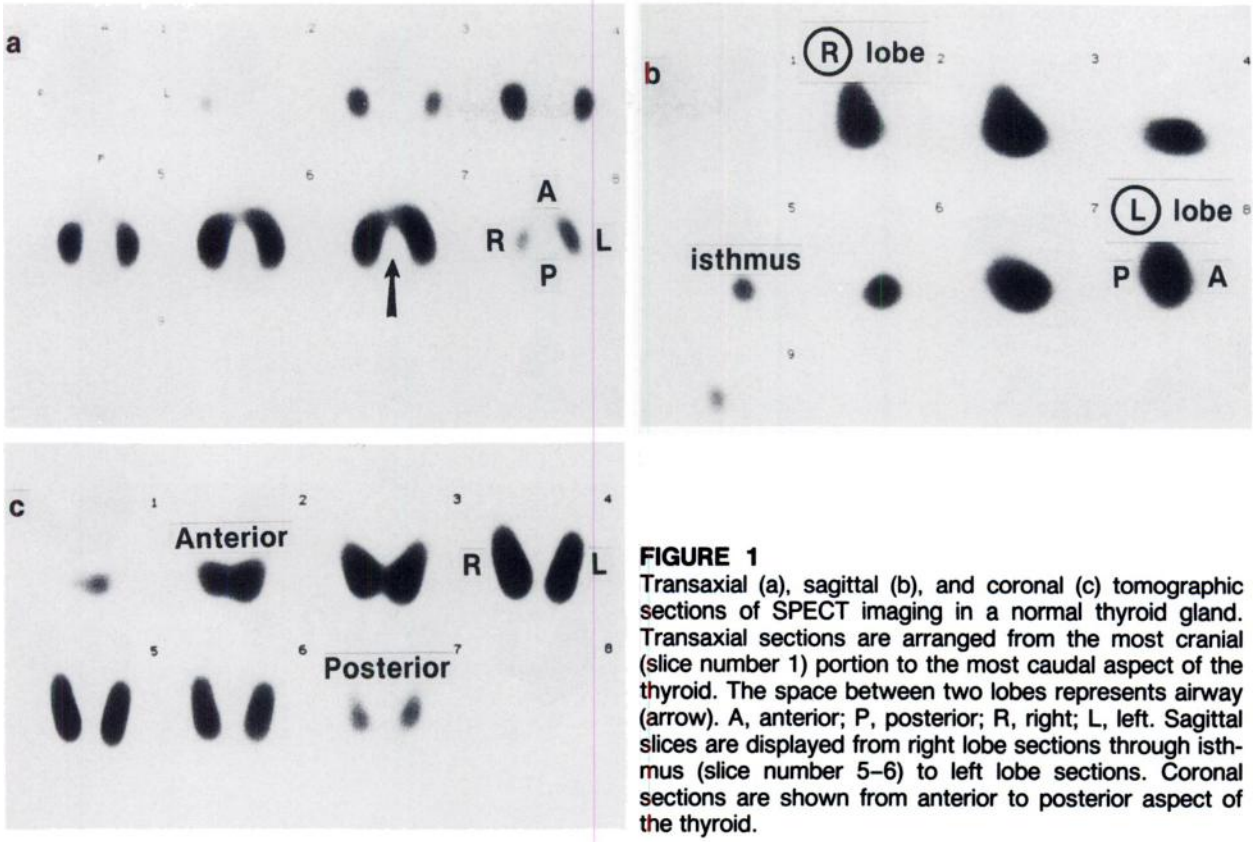

FIGURE 1
Transaxial (a), sagittal (b), and coronal (c) tomographic sections of SPECT imaging in a normal thyroid gland. Transaxial sections are arranged from the most cranial (slice number 1) portion to the most caudal aspect of the thyroid. The space between two lobes represents airway (arrow). A, anterior; P, posterior; R, right; L, left. Sagittal slices are displayed from right lobe sections through isthmus (slice number 5–6) to left lobe sections. Coronal sections are shown from anterior to posterior aspect of the thyroid.

Sagittal sections are arranged from right lobe through isthmus to left lobe with the anterior aspect of the patient on the viewer's right. Coronal cuts are demonstrated from anterior to posterior aspect of the thyroid with the thyroid orientation analogous to planar imaging, the viewer facing the patient.

CASE REPORTS

Case 1

A 69-yr-old female was found to have multinodular goiter 20 yr ago. The goiter had progressively enlarged since she first presented with clinical and chemical hyperthyroidism 3 yr ago. Despite treatment with methimazole 20 mg three times a day, hyperthyroidism persisted and difficulty in swallowing, especially solid food, had been noted for the past 2 yr. She had also suffered from exertional and resting dyspnea with choking sensation for 2 yr.

Physical examination revealed a massive multinodular goiter, ~200 g, extending posteriorly on both sides. She was clinically and chemically hyperthyroid. Planar pinhole ^{123}I thyroid scan showed multiple areas of increased and decreased tracer uptake, consistent with multinodular goiter. In order to define the extension of the goiter and its anatomic relation with the trachea, SPECT imaging of the thyroid was obtained immediately following the planar imaging.

Figure 2 shows the SPECT imaging of Case 1. As shown on transaxial sections, there is retrolaryngeal extension of both lobes of the thyroid and paratracheal compression by the goiter. The normal tracheal space between two lobes is occupied and distorted by the enlarged thyroid tissue. Normally there is no tracer uptake posterior to the isthmus on the sagittal image. In contrast, posteriorly located thyroid tissue behind the isthmus is noted on the sagittal sections at the level of the isthmus (Figure 2), representing the posterior extension of the goiter around the trachea. These findings suggest the tendency of enlarged thyroid to grow posteriorly.

X-ray of the soft tissue in the neck showed displacement of trachea to the right and barium swallow esophagography revealed compression of distal hypopharynx and cervical esophagus for 5 cm. Pulmonary function tests showed a FEV1 of 65.8% predicted and a flow volume loop pattern consistent with variable extrathoracic airway obstruction, suggesting the presence of tracheomalacia. Fiberoptic laryngoscope was thus performed and right vocal cord paralysis was found. The patient then underwent a total thyroidectomy. Tracheal compression with tracheomalacia was confirmed. Meticulous dissection of retrotracheal mass from the trachea and protection of recurrent laryngeal nerves were undertaken. The surgical pathology showed multinodular goiter with multiple foci of follicular variant of papillary carcinoma of the thyroid. Dyspnea and dysphagia were markedly improved and the function of the right vocal cord normalized postoperatively.

Case 2

A 38-yr-old female presented with dysphagia and multinodular goiter 18 mo before she was referred to our clinic. Two months later, she went to a community hospital and underwent a partial thyroidectomy where only the superior portion of left lobe was removed and histologic examination revealed diffuse colloid goiter without evidence of Hashimoto's thyroiditis. The patient had noted persistent difficulty of swallowing and progressive enlargement of thyroid gland since surgery. Subsequently a 6-mo trial course of L-thyroxine (Synthroid

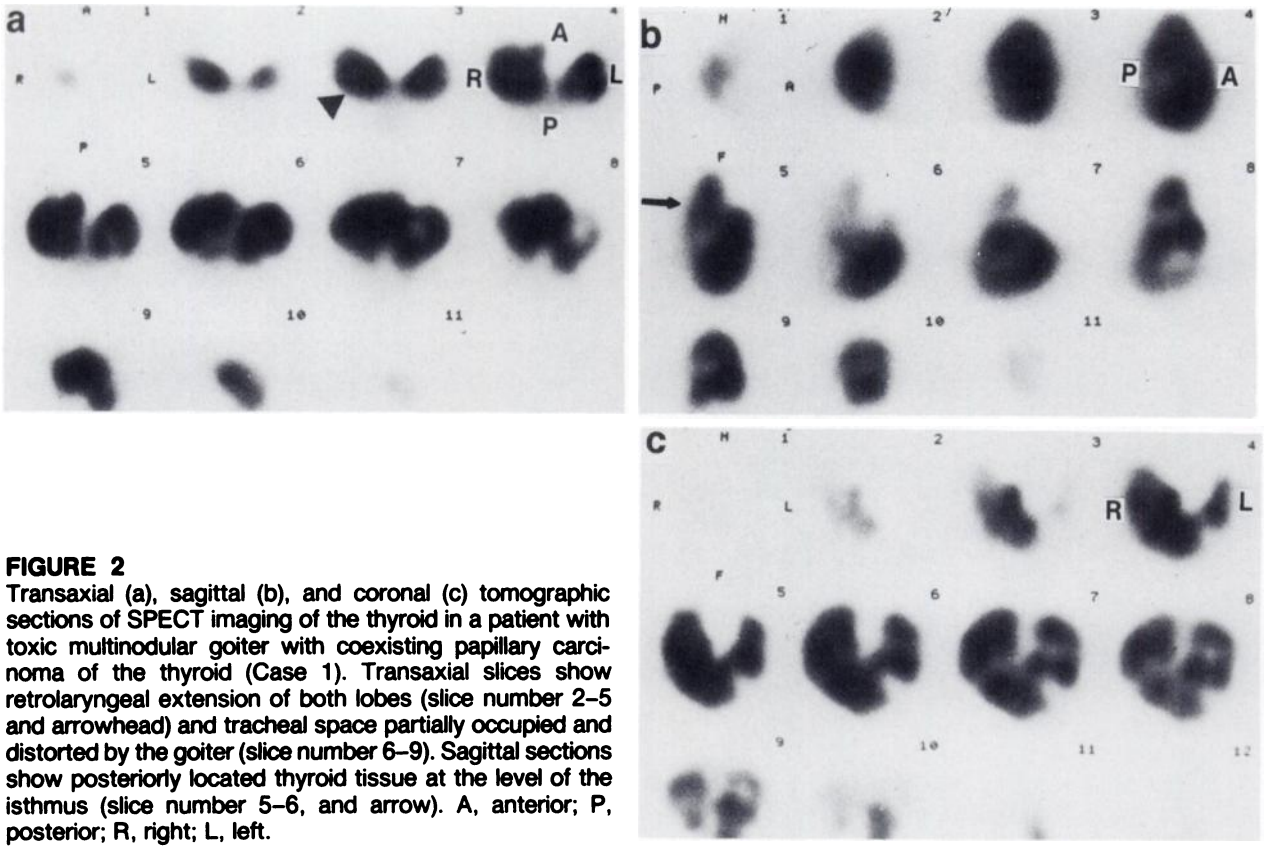

FIGURE 2
Transaxial (a), sagittal (b), and coronal (c) tomographic sections of SPECT imaging of the thyroid in a patient with toxic multinodular goiter with coexisting papillary carcinoma of the thyroid (Case 1). Transaxial slices show retrolaryngeal extension of both lobes (slice number 2–5 and arrowhead) and tracheal space partially occupied and distorted by the goiter (slice number 6–9). Sagittal sections show posteriorly located thyroid tissue at the level of the isthmus (slice number 5–6, and arrow). A, anterior; P, posterior; R, right; L, left.

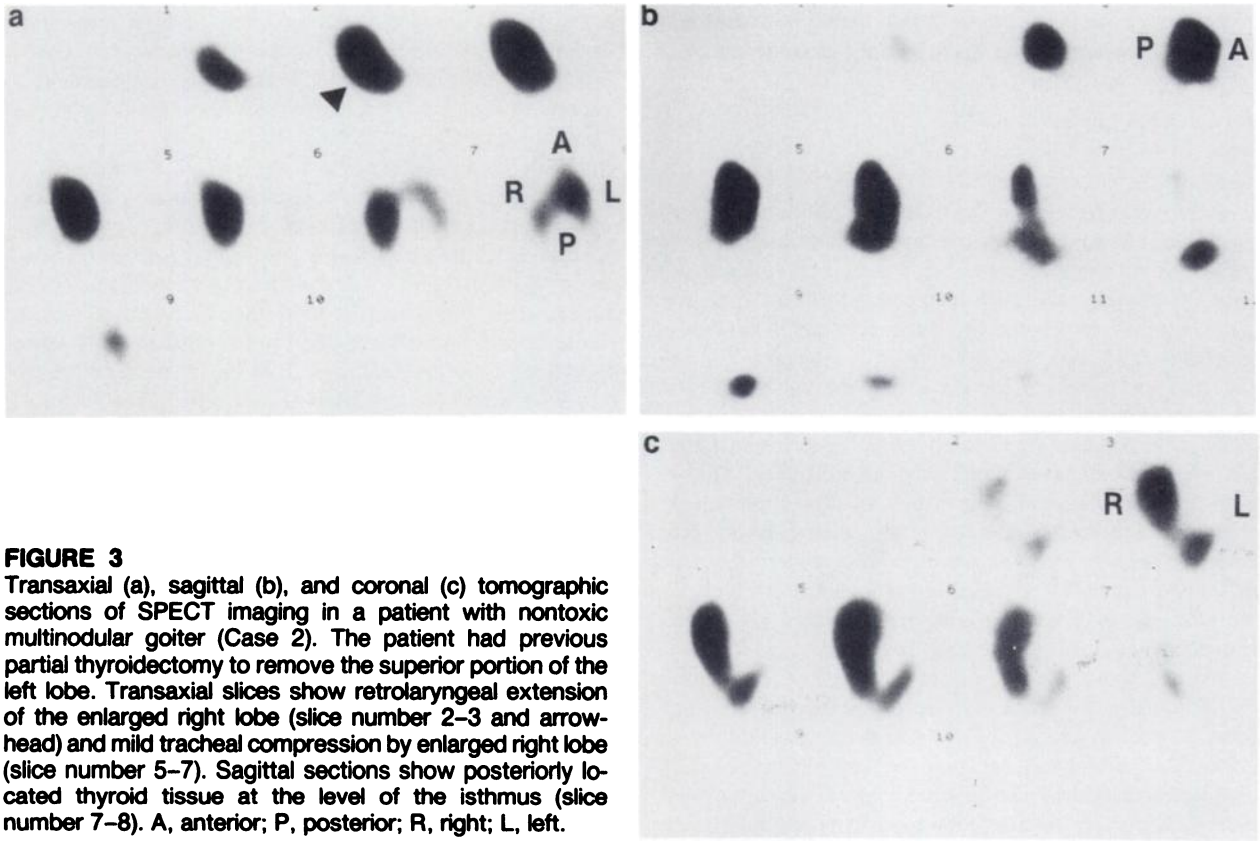

FIGURE 3
Transaxial (a), sagittal (b), and coronal (c) tomographic sections of SPECT imaging in a patient with nontoxic multinodular goiter (Case 2). The patient had previous partial thyroidectomy to remove the superior portion of the left lobe. Transaxial slices show retrolaryngeal extension of the enlarged right lobe (slice number 2–3 and arrowhead) and mild tracheal compression by enlarged right lobe (slice number 5–7). Sagittal sections show posteriorly located thyroid tissue at the level of the isthmus (slice number 7–8). A, anterior; P, posterior; R, right; L, left.

0.2 mg daily) as an attempt to suppress the gland was initiated. However, the gland remained enlarged and Synthroid was discontinued 7 mo before she was referred to our nuclear medicine clinic for further evaluation.

Family history was remarkable for thyroid disease. Her mother had a goiter and her 16-yr-old son had a thyroglossal duct cyst removed at age of 10 yr. The patient was clinically euthyroid and on palpation, her left lobe of thyroid was slightly enlarged with multiple small nodules while the right lobe was markedly enlarged with cephalad extension to the level of lower larynx. Planar pinhole thyroid scan using ^{123}I confirmed the clinical palpation findings and showed marked enlargement of right lobe.

Figure 3 demonstrates tomographic sections of Case 2. As shown on the transaxial slices, there is retrolaryngeal extension of superior portion of the enlarged right lobe at the level of lower larynx (arrowhead) and paratracheal compression of upper trachea by the enlarged right lobe. Narrowing of the patient's tracheal space can also be seen. On the sagittal sections, posteriorly located thyroid tissue, that most likely represents the extension of enlarged right lobe around the trachea, is also noted behind the isthmus. X-ray of the soft tissue in the neck showed displacement of trachea and larynx to the left. She was instructed to resume thyroid hormone and will be considered for thyroidectomy if she continues to be symptomatic.

DISCUSSION

Using coded-aperture imaging and [^{99m}Tc]pertechnetate, Resinger et al. reported a frontal tomography of the thyroid and concluded that the tomography offered advantages over conventional pinhole imaging if the computer processing time could be sufficiently reduced (*7*). The computer processing time was 2 hr in their report.

This report demonstrates the application of SPECT imaging in delineating the functional anatomy of the thyroid and the extension of the goiter in relation to the airway. Patients with multinodular goiters frequently complain of difficulty of swallowing or breathing. Dyspnea and dysphagia are subjective symptoms that may or may not be a result of local compression of the trachea or esophagus. Planar thyroid imaging does not always provide objective evidence of airway compression when evaluating patients with multinodular goiters and symptoms of local compression. As illustrated, SPECT imaging may delineate the functional and anatomic orientation of the goiter in relation to the airway.

Symptomatic patients with SPECT evidence of airway compression may be treated with thyroid hormone suppression, or in severe cases such as Case 1, with thyroidectomy. The knowledge of the extension of the goiter shown by SPECT assisted in preoperative workup and planning in this patient.

The presence of normal tracheal space on SPECT provides objective reassurance for the subjectively symptomatic patient with multinodular goiter. Further study with other correlative diagnostic modalities is needed to assess the role of SPECT imaging in the management of asymptomatic multinodular goiters.

The simplicity of SPECT imaging and the short data acquisition and computer processing time are advantageous as compared to nuclear magnetic resonance imaging (MRI). SPECT imaging provides more functional information and involves lower cost when compared to transmission computed tomography. Iodine-123 and SPECT facilities are generally more available than MRI, while PET utilization in the management of patients with thyroid disease is not cost effective or routinely available at this time.

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