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ORIGINAL ARTICLE

Role of Different Imaging Modalities and Fine-needle Aspiration Cytology Correlation in Diagnosing Thyroid Gland Pathologies

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Abstract

Background: **Thyroid nodule, goiter, thyroiditis, and thyroid cancer are all common conditions that may have a negative effect on normal thyroid function.**

Objective: **To determine how fine-needle aspiration cytology correlation and various imaging modalities contribute to the diagnosis of thyroid gland diseases.**

Patients and methods: **A total of 100 participants who came for thyroid problems in the outpatient departments of Al-Hussein University Hospital were included in the research. All patients were screened with ultrasound (US), and based on the results of that examination, some were sent for further radiological testing.**

Results: **Of the 100 patients included in the study, US was able to classify thyroid diseases as focal (69 cases), diffuse (30 cases), and others (11 cases). A total of 48 thyroid nodules underwent fine-needle aspiration cytology and distributed based on the Bethesda score as three (6.2%) in category I, 30 (62.5%) in category II, five (10.4%) in category III, one (2%) in category IV, three (6.2%) in category V, and six (12.5%) in category VI. The sensitivity, specificity, positive and negative predictive values, accuracy, and likelihood ratios of US, and pathology were determined. Approximately 22 (22%) patients underwent a computed tomography scan mainly to evaluate retrosternal extension and for preoperative staging, and 22 (22%) patients underwent a radionuclide scan.**

Conclusion: **Patients with normal thyroid function (euthyroid) should first have an US. In the same way, US is the first line of diagnosis for a goiter's size and extent. Computed tomography without contrast is appropriate if there is any worry about effect on the trachea or if it is necessary to determine how deep the goiter sits.**

Keywords: Bethesda system, Computed tomography, Fine-needle aspiration biopsy, Thyroid gland pathologies

1. Introduction

Diseases of the thyroid gland are numerous and diverse. They may be neoplastic or non-neoplastic, symptomatic or asymptomatic, diffuse or localized. Thyroid imaging has long been recognized as a crucial part of the diagnostic process for patients with suspicious thyroid abnormalities.[1-3]

The use of ultrasound (US) is crucial in the investigation and treatment of conditions involving the thyroid. Thyroid nodule therapy has been greatly influenced by the widespread use of US as a primary diagnostic tool, both preoperatively and postoperatively.[3,4]

US is the go-to diagnostic tool because of its high spatial resolution, which is especially useful for assessing the thyroid. On the contrary, imaging techniques like computed tomography (CT) and MRI play a supportive role in diagnosing thyroid illness.[1,5]

When it comes to identifying benign and malignant thyroid abnormalities, US outperforms CT and

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MRI. Local tumor growth (especially in the trachea and esophagus) may be assessed, as can metastases to the lungs and liver. Patients who have increased blood thyroglobulin (Tg) levels after a thyroidectomy but who have a negative US should have CT or MRI to look for hidden metastases (mediastinal or retropharyngeal).[1,5]

Thyroid evaluations have included radionuclide imaging for a long time. Because it gives such great insight into the thyroid gland's functionality, it is crucial in the diagnosis and assessment of thyroid illness. Nuclear medicine imaging with 99mTc radionuclide focused thyroid nodules are graded as 'hot,' 'warm,' or 'cool' based on their proportional absorption of the radioactive isotope technetium pertechnetate and iodine. Additionally, iodine is used in the treatment of patients with thyroid cancer in the evaluation of residual/recurrent illness, the evaluation of distant metastases, and the follow-up of patients following thyroidectomy.[2,3,6]

The purpose of this research was to compare the accuracy of fine-needle aspiration cytology correlation with other imaging modalities for identifying diseases of the thyroid gland.

2. Patients and methods

The research was carried out on 100 patients who had been seen at Al-Hussein University Hospital's outpatient departments specializing in the treatment of a variety of thyroid conditions. These individuals had visible thyroid nodules (not goiters) with euthyroid status, suspected goiters, thyrotoxicosis, primary hypothyroidism, preoperative thyroid cancer assessment, or early imaging after therapy.

All patients included in the study were subjected to the following:

Complete history taking and complete physical examination.

Laboratory tests: thyroid-stimulating hormone, or thyrotropin, is a marker of thyroid health. To determine the severity of a disease and the efficacy of therapy, T4 and T3 levels are measured. Autoimmune thyroid diseases including Graves' disease and Hashimoto's disease may be diagnosed with the use of thyroid antibodies such thyroid peroxidase antibodies, Tg antibodies, and the thyroid-stimulating hormone receptor. However, a definitive diagnosis cannot usually be made with only these tests. Creatinine levels and estimated glomerular filtration rate were measured recently (within a week) before intravenous contrast-enhanced CT or MRI was performed on any patient.

Thyroid US: US examinations were performed by Toshiba Aplio 500 (Toshiba Medical Systems Corporation, Otawara City, Tochigi Prefecture) Ultrasound Machine.

CT examination was performed using Toshiba 160 channels. We acquired CT scans of the neck both with and without intravenous contrast.

Using 1.5 T equipment, we conducted a neck MRI with and without intravenous contrast (Achieva 1.5-T Pulsar, Philips Healthcare). In our center, tracheal carina to skull base images were taken during MRI.

As some patients were allergic to the radiotracer, thorough assessment of the patient was taken into account when using radionuclide imaging, such as I-123 radionuclide or I-131 radionuclide uptake and Tc-99m pertechnetate scan neck. Patients were instructed to stop using antithyroid drugs such as methimazole and propylthiouracil for at least 5 days before the procedure. The radiotracer was injected into the patient's veins 30 min before the scan. The patient is positioned on the mobile exam table, and three serial pictures of the thyroid gland are captured by the gamma camera. The Discovery NM/CT 670 was used to get the images (GE Healthcare).

All biopsies were performed by a seasoned interventional radiologist using a needle-guided approach while under live sonographic guidance.

The ethics of medicine were taken into account. The patient was informed about and consented to the examination. Ethical considerations: this clinical study followed the rules for Good Clinical Practice set out by the International Conference on Harmonization (ICH) and the World Medical Association (18th, Helsinki, 1964).

2.1. Statistical analysis

16-channel Helical CT neck images without and with intravenous contrast (Sensation, Siemens Medical Solution) were taken.

The data were sorted, processed, and analyzed in SPSS, version 22 for Windows (IBM SPSS Inc., Chicago, Illinois, USA). The Shapiro–Wilk test was used to check for normal data distribution. Qualitative data were represented using frequencies and percentages. We used the χ^2 test to compare qualitative data types. Mean and SD were used to summarize data. Independent samples t test was used to compare two normal variable sets (parametric data). P value less than or equal to 0.05 is the level of significance.

3. Results

The patients included in our study represented 16 (16%) males and 84 (84%) females with mean age of 42.6 ± 13.2 years and age range of 13–90 years (Table 1).

Table 1. Demographic data of the studied patients.

	Number
Age	
>0 to ≤15	3
>16 to ≤25	4
>26 to ≤45	62
>46 to ≤65	26
>65	5
Range	13.0–90.0
Mean ± SD	42.6 ± 13.2
Sex	
Male	16
Female	84
Total	100

Table 2. Ultrasound findings of studied cases.

Focal thyroid lesion (subclassified according to TI-RADS)	69
Benign	9
Not suspicious	8
Mildly suspicious	16
Moderately suspicious	27
Highly suspicious	9
Diffuse thyroid disease (autoimmune)	30
Others	11
Reduced thyroid volume	2
Thyroid hematoma	2
Recurrent/remnant thyroid tissue	4
Parathyroid adenoma	2
Ectopic lingual thyroid	1

All patients included in the study underwent neck examination by US. A total of 30 patients showed diffuse thyroid disease, the most common being autoimmune thyroid disease (mainly Hashimoto's thyroiditis and Graves' disease). Overall, 69 patients showed focal thyroid lesions, which were subclassified according to TI-RADS classification as benign (nine cases), nonsuspicious (eight cases), mildly suspicious (16 cases), moderately suspicious (27 cases), and highly suspicious (nine cases). However, 11 patients could not be classified as one of the two aforementioned broad categories, so categorized as 'others' including reduced thyroid volume (two cases), thyroid hematoma (two cases), recurrent/remnant thyroid tissue postoperative (four cases), parathyroid adenoma (two cases), and ectopic lingual thyroid (one case) (Table 2).

Three (6.2%) of the 48 thyroid nodules that underwent fine-needle aspiration with or without follow-up or surgery were classified as Bethesda category I, 30 (62.5%) as category II, five (10.4%) as category III, one (2%) as category IV, three (6.2%) as category V, and six (12.5%) as category VI (Table 3).

The proportions of US diagnoses, as benign (TI-RADS I and II), probably benign (TI-RADS III), indeterminate (TI-RADS IV), and malignant (TI-RADS V) in each Bethesda category, are listed in Table 4.

Statistical analysis was done by SPSS 17.0. The sensitivity, specificity, positive and negative predictive values, accuracy, and likelihood ratios of US, and pathology were determined for each site of involvement. The diagnostic performance was as follows: sensitivity 86.7%, specificity 53.3%, positive predictive value 48.1%, and negative predictive value 88.9%. Accuracy in evaluating malignant involvement of thyroid nodules in our study was 64.4% (Table 5, Figs. 1–5).

4. Discussion

In the current study, a CT scan was able to show the extent and linkages of the intrathoracic and mediastinal goiter, as well as show localized calcifications, cystic areas, and high attenuation with prolonged intravenous enhancement.

de Perrot et al.[7] reported that goiters were found to be placed prevascularly in 38% of cases, between the arteries and the trachea in 33% of cases, and retrotracheally in 27% of cases. Owing to a lack of MRI experience, CT is still vital to the process of developing a surgical strategy.

Pollard et al.[8] reported that the radiologist must be aware of the information the surgeon seeks to provide useful guidance for surgical planning, as radiologic evaluation plays a crucial role in the preoperative assessment of large goiters and other thyroid tumors. The effects of the tumor on the trachea, esophagus, and vascular systems, as well as its substernal extension, are described in detail by the radiologist. Imaging the patient with their arms above their head might also lead to an incorrect substernal localization of the goiter. When imaging a patient suspected of having a substernal thyroid goiter, it is best to have the patient hold their arms at their sides, as this is the posture they would be in following surgery.

Our study confirms and extends the results previously reported by Menconi et al.[9] on the ability of

Table 3. Distribution of Bethesda categories in the current study.

I	Nondiagnostic	3	6.2%
II	Benign	30	62.5%
III	Atypical	5	10.4%
IV	Suspicious score for follicular neoplasm	1	2%
V	Suspicious for malignancy	3	6.2%
VI	Malignancy	6	12.5%
	Total	48	100%

Table 4. The proportions of ultrasound diagnoses in each Bethesda category.

Bethesda category	Number of nodules ($n = 48$)	US benign ($n = 8$) (16.6%)	US probably benign ($n = 13$) (27%)	US indeterminate ($n = 21$) (43.7%)	US malignant ($n = 6$) (12.5%)
I	3	2	0	1	0
II	30	5	10	13	2
III	5	1	1	2	1
IV	1	0	1	0	0
V	3	0	1	1	1
VI	6	0	0	4	2

US, ultrasound.

Table 5. Statistical results of ultrasonography and pathology in detection of malignant thyroid nodules.

True positive	13
True negative	16
False positive	14
False negative	2
Sensitivity	0.867
Specificity	0.533
Positive predictive value	0.481
Negative predictive value	0.889
Accuracy	64.4

US with color-Doppler evaluation in the diagnosing of Graves' disease.

Our data showed that although scintigraphy was marginally more effective than US in diagnosing individuals with Graves' disease, it should be stressed that both methods were always capable of making a positive diagnosis, and that TRAb levels were always elevated.

In Hashimoto's thyroiditis, a kind of autoimmune thyroid disease, T and B lymphocytes invade the thyroid gland. Antithyroid autoantibodies are released by activated B lymphocytes. The destruction of the thyroid parenchyma, which causes thyrotoxicosis and thereafter hypothyroidism, is predominantly the work of cytotoxic T lymphocytes. Clinical manifestations of Hashimoto's thyroiditis include painless diffuse goiter, hypothyroidism, and autoantibodies.

Through our study, on US examination of the neck, we found cervical lymph nodes in patients with Hashimoto's thyroiditis, most often in the infrathyroidal and pretracheal regions.

Kim et al.[10] suggested that high sensitivity and specificity may be achieved in the diagnosis of diffuse thyroid illness by using a combination of at least three aberrant sonographic parameters (i.e. echogenicity, echotexture, vascularity, AP diameter, and glandular margin on real-time sonography). High sensitivity and accuracy were achieved in the present research when all parameters were used jointly to diagnose Hashimoto thyroiditis.

Our findings corroborate those of earlier research efforts. A retrospective multicenter study by Moon et al.[11] showed that the sensitivity values for most US traits were found to be poor after an evaluation of 831 individuals with thyroid nodules. The sensitivity of the hypoechogenicity result was 87.2%. Microcalcification and macrocalcification, as well as a taller-than-wide form, showed a high specificity for malignancy in the same research (90.8–96.1%, respectively).

Popowicz et al.[12] furthermore discovered poor sensitivity values for most US characteristics for

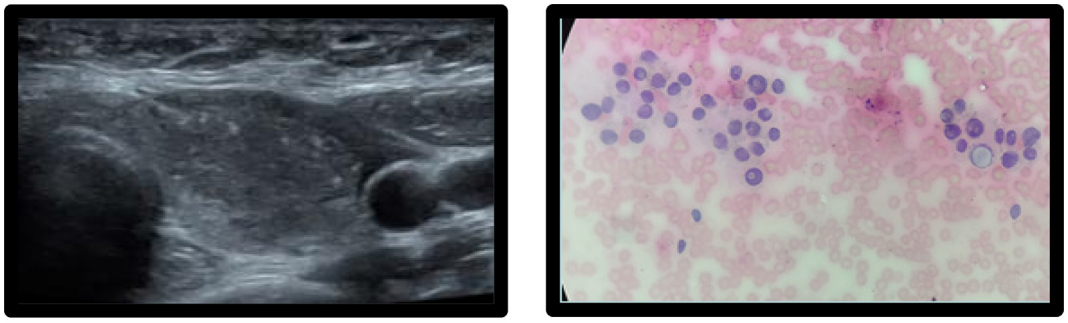

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Fig. 1. Classical papillary thyroid carcinoma. (a) Linear probe sonographic image, shows a circumscribed hypoechoic nodule with microcalcifications in the left thyroid gland, (b) shows colloid, papillaroid and papillae with core of connective tissue, foamy and hemosiderin laden macrophages.

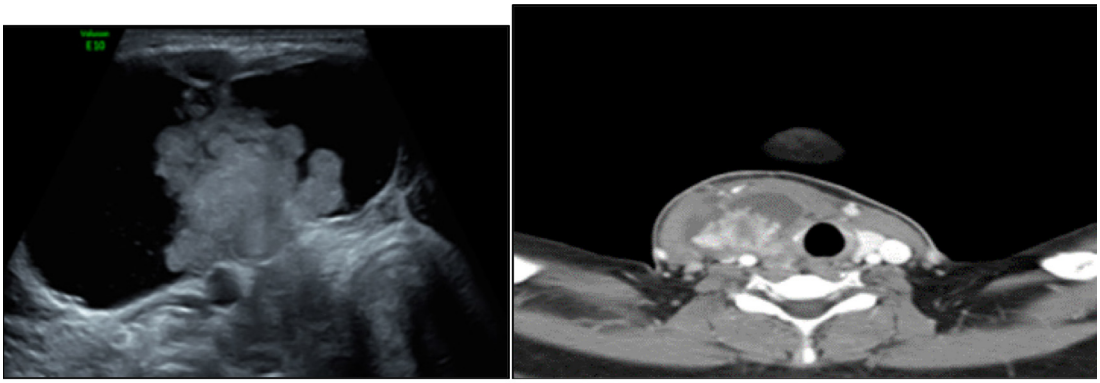

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Fig. 2. Tumors of the papillary thyroid. (a) Interior projecting eccentric solid location has several echogenic foci indicating microcalcifications, and curved images indicate a mainly cystic nodule with a smooth edge. (b) The axial CECT picture reveals a right lobe thyroid nodule that is both complicated and mostly intracystic.

cancer. On the contrary, microcalcifications and a taller than broad form provided excellent specificity.

Microcalcifications have a sensitivity of 89.3% for malignancy, as was demonstrated in a study of 550 patients with multinodular goiter conducted by Salmaslioglu et al.[13]

Thyroid cancer is staged using CT, and metastases may be found with this technique. CT is the technique of choice when a primary thyroid lesion has spread substernally or when there is concern for airway impairment. MRI is often employed in a second-line context for tumor characterization in questionable areas because of its high cost and restricted availability compared with other modalities.

If a tumor recurrence is suspected, the first step in the imaging process is a sonogram of the neck,

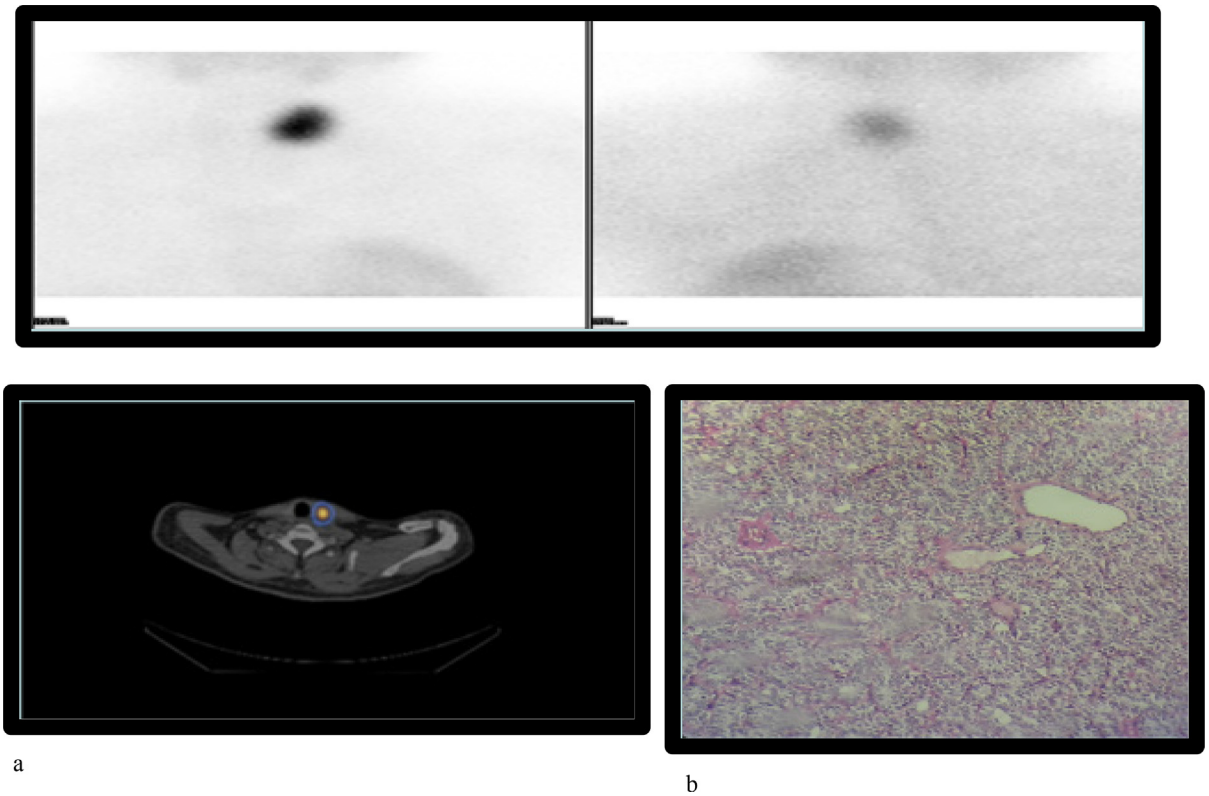

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Fig. 3. Parathyroid adenoma, (a) Sestamibi NM late 2 h. (b) SPECT/CT. (c) Parathyroid adenoma showing multiple fat vacuoles in histopathology section on the corresponding case (H and E, × 40).

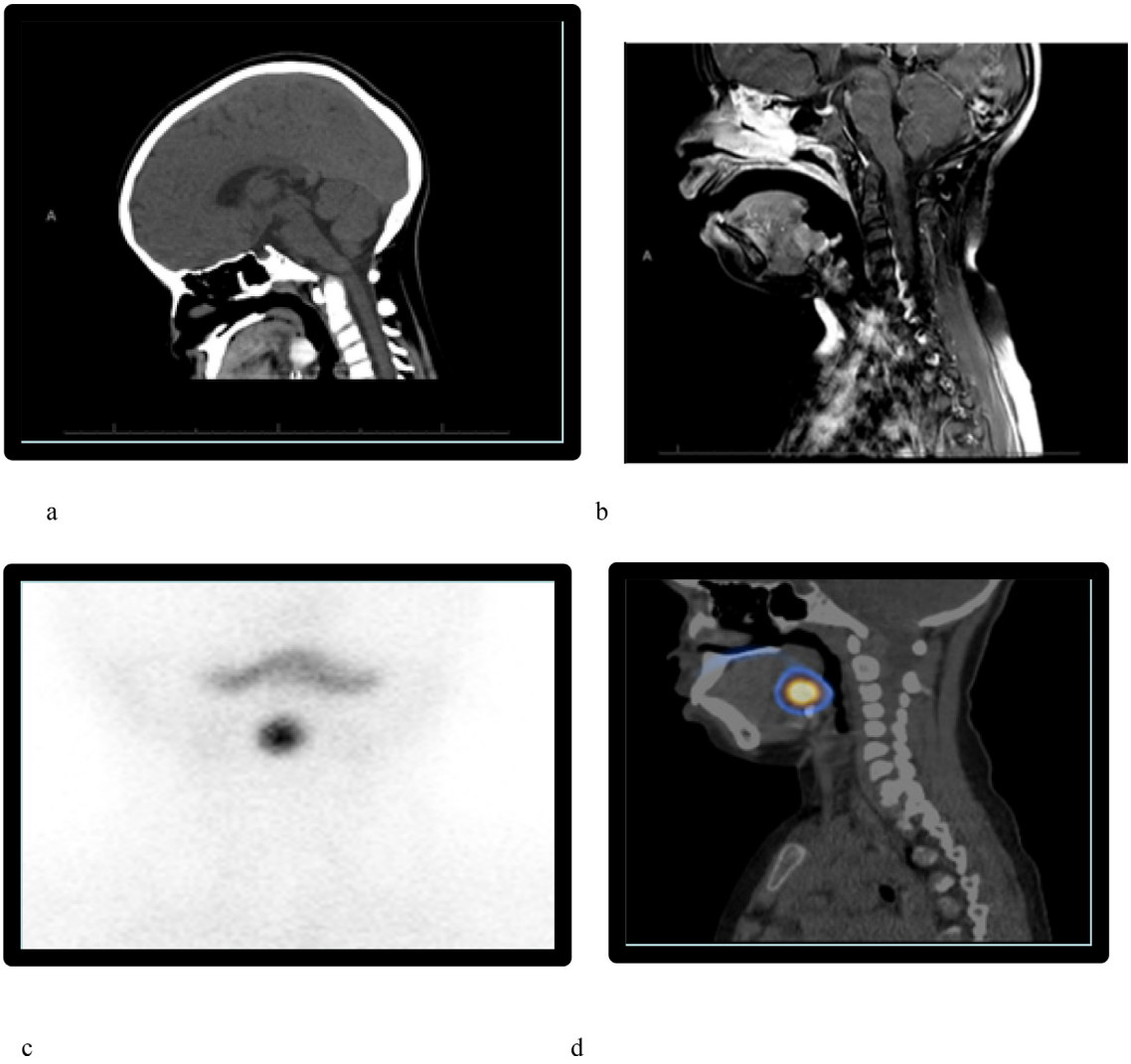

Fig. 4. An 8-year-old patient with absent thyroid gland by neck US. (a) Sagittal NECT showing rounded, well-defined, homogeneous hyperdense ectopic thyroid tissue seen at the base of the tongue. (b) Sagittal T1 post-GAD, the ectopic tissue shows homogeneous enhancement. (c, d) Thyroid TC 99 m with SPECT/CT images, confirmed the diagnosis of lingual ectopic thyroid. US, ultrasound.

during which the thyroid bed and cervical nodes are inspected for signs of cancer. Whole-body scintigraphy using radioiodine is used to diagnose Differentiated thyroid carcinoma (DTC) if US is negative. Patients at high risk for DTC, such as those who present with macroscopic invasion, gross residual disease, or distant metastases, may also benefit from whole-body scintigraphy as a first line of study. Multiple researchers have reported on the US features of metastatic thyroid cancer lymph nodes.[14,15]

Kamaya et al.[16] concluded that the US observation of a hypoechoic lesion in the thyroidectomy bed that is larger than 6 mm and with internal vascularity is a very sensitive predictor of recurrence. The sensitivity of serum Tg levels to identify recurrence in the thyroidectomy bed was lower than that of US.

In agreement, Zini et al.[17] stated that when it comes to detecting a recurrence of differentiated thyroid carcinoma in the neck, sonography is more sensitive than serum Tg levels and iodine 131 whole-body scanning. Sonography may also reveal a tumor recurrence in individuals who have had negative follow-up findings.

The results of this research indicate that calcification, cystic alteration, loss of echogenic fatty hilum, hyperechogenicity, round form, and aberrant vascularity are all strong US indicators of nodal metastasis of thyroid cancer. Rosario et al.[18] showed that calcification and cystic alteration are not seen in normal or reactive lymph nodes, making them highly specific and positive predictive values for lymphoma.

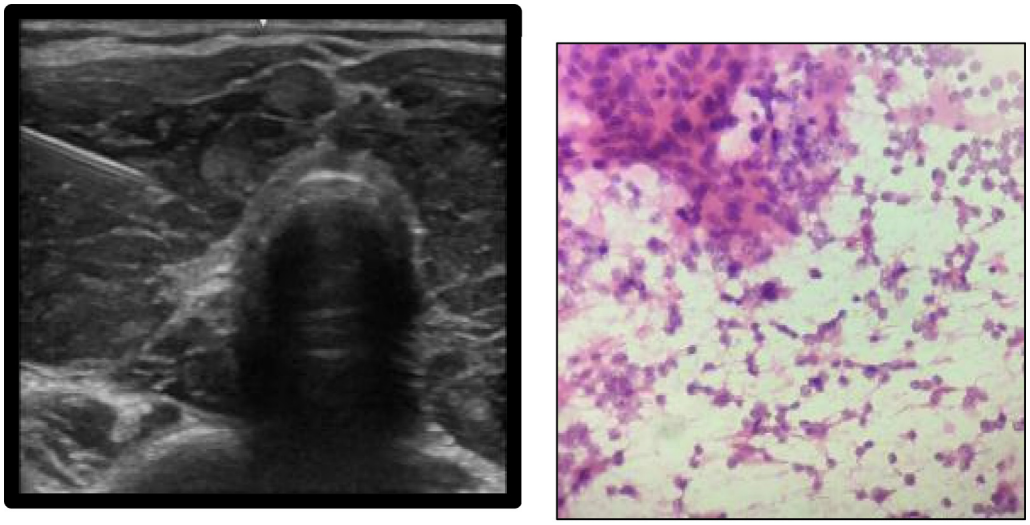

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Fig. 5. A 42-year-old female patient, known case of celiac disease and hypothyroidism. (a) Ultrasound-guided fine needle of the right thyroid lobe. (b) Hashimoto's thyroiditis cytology, a cellular background with numerous lymphocytes and follicular groups.

Lamartina et al.[19] have reported that owing to lymph node cystic degeneration, lymph node metastases are linked to thyroid cancer and head-and-neck squamous cell carcinoma. Cystic lymph node metastases from papillary thyroid cancer are prevalent. US shows cystic alterations as distinct cystic regions, cyst clusters around the node's border, or a total cystic node replacement. This research showed that cystic change is highly specific for diagnostic US characteristics and has a strong positive predictive value.

The three-tiered method for Incidental thyroid nodules (ITNs) identified on CT, MRI, and PET include the patient's age, the size of the nodule, and any questionable imaging findings as official criteria for further workup. The goal of this classification system is to improve cancer detection while decreasing the overdiagnosis of benign nodules. Two more trials using the three-tiered technique found that no malignancies were missed, and that the workup rate was reduced by 30% compared with standard biopsy procedures and by 45% compared with the usage of a size cutoff of 1 cm.[20,21]

From what we found, it is possible that fewer patients would have needed fine-needle aspiration if fewer nodules had been documented in radiology reports according to the three-tiered system guidelines.

5. Conclusion

US should be the first line of treatment for euthyroid individuals. US may also be used to assess the extent of a goiter. CT without contrast is appropriate if there is any risk of effect on the trachea or if it is necessary to determine how deep the goiter sits. Choosing between US (in which case Doppler may be useful) and radionuclide uptake and scan is needed in situations of suspected thyrotoxicosis. Patients with advanced cancer may benefit from CT or MRI with intravenous contrast for staging purposes.

Conflict of interest

Authors declare that there is no conflict of interest, no financial issues to be declared.

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