Original Article

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Role of Ultrasonography and Ultrasound Elastography in the Evaluation Thyroid Nodules

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Abstract

Background: Thyroid nodules are commonly encountered, and thyroid cancers are among the commonest head and neck malignancies. Early detection and accurate diagnosis are extremely important in the definitive management of such patients.Ultrasonography is widely used first line of investigation in a patients suspected with thyroid mass which will help to differentiate diffuse thyroid diseases from nodular thyroid disease,recent advances in ultrasound technology and the introduction of Ultrasound Elastography have reportedly improved the accuracy in the differentiation of benign from malignant thyroid nodules. **Subjects and Methods:** Based on the inclusion and exclusion criteria, 80 cases of thyroid lesions diagnosed by ultrasound were included in the study. The ultrasonography and ultrasound elastography examination was done in the department of Radiology. These 80 cases which were found to have thyroid lesion on ultrasound were subjected to FNAC for confirmation of ultrasound finding and establishment of final diagnosis. **Results:** Our study showed 37.5% (30) of cases were diffuse thyroid disease and 62.5%(50) were nodular diseases. Out of 30 diffuse thyroid disease 15% were colloid goiter, 17.5% were hashimoto's thyroiditis,5% were De Quervain's thyroiditis. Our study also showed 100% of the hyperechoic nodules were benign, 77.77% hypoechoic nodules were benign and 22.22% hypoechoic nodules were malignant, 100% isoechoic nodules were benign and 100% of cystic nodules were benign. **Conclusion:** Ultrasound helps us to know clearly whether the lesion is solitary or multiple. It helps to clearly differentiate between solid and cystic lesions. The diffuse heterogenous echotexture of the gland with characteristic hypoechoic nodules clearly helps us in diagnosing Hashimotos thyroiditis. In addition, ultrasound is very useful to differentiate benign lesions from malignant thyroid lesions in most of the cases.

Keywords: Elastography, Elasticity score, Thyroid nodules.

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Introduction

Disorders of thyroid gland are very common in clinical practice. Thyroid diseases are most common among all the endocrine diseases in India. Ultrasonography is relatively cheap, easily accessible, rapidly performed and has advantage of no exposure to ionizing radiation. Since the thyroid gland is superficially located, high resolution real time gray scale, sonography can demonstrate normal thyroid anatomy and pathologic conditions with remarkable clarity. As a result, this technique has come to play an increasingly important role in the diagnostic evaluation of thyroid diseases.[1,2]

Neoplasm of thyroid may be benign or malignant. USG of the thyroid helps in measuring the tumour size, diagnosing multinodularity and excluding contralateral disease. USG can also suspect malignancy in a lesion on the basis of certain sonographic characteristics and further categorize it into papillary, follicular, anaplastic. So the basic use of sonography for the evaluation of nodular thyroid is to:[3,4]

- Determine location of palpable neck mass example thyroid or extra thyroid.
- Characterize benign or malignant nodule features.
- Detect acute nodule in a patient with history of head and neck irradiation or

MEN II syndrome

- Determine extent of known thyroid malignancy.
- Determine residual or recurrent and metastatic carcinoma.
- Guide fine needle aspiration of thyroid nodule or cervical lymph node

US elastography differentiates lesions according to their elasticity score or colour map, the results may be operator-dependent and interobserver variability can occur in data acquisition and interpretation. Furthermore, the differences in colour map among the various commercial US units can cause confusion; some US units indicate that blue is hard and red is soft, whereas other units have the reverse code.[5,6] Therefore, this method is limited by a lack of standardization. Recent technological advances in US elastography have permitted quantitative analysis. However, there is a lack of evidence to evaluate the clinical performance of US units. Therefore, the present prospective study was performed to assess the diagnostic performance of colour mapping and strain ratio for characterizing malignant thyroid nodules using US elastography.

Subjects and Methods

These 80 cases which were found to have thyroid lesion on ultrasound were subjected to FNAC for confirmation of ultrasound finding and establishment of final diagnosis.

Inclusion criteria:
Patients who presenting in the department of radiodiagnosis with a thyroid mass on ultrasonography and which are subsequently confirmed by FNAC will be included in the study

Exclusion criteria:
Patients who refused FNAC whom the final confirmatory diagnosis could not be established will be excluded
Imaging methods

Equipment
Thyroid sonography performed conventional B-mode US and US elastography using an iU22 (Vision 2010; Philips, Seattle, WA, USA) with a commercially available 7 to 12 MHz linear-array transducer). No additional pressure in terms of freehand compressions was required during scanning of US elastographic images. Although elastographic machine uses "strain" technology, physiological stimuli, such as patient respiration or carotid artery pulsation, caused the required strain in tissue deformation. Colour mapping and strain ratio for thyroid nodules were obtained without knowledge of the cytopathological results. Each nodule was assessed using 256-level colour mapping (red–green–blue) elastography: green indicated average stiffness of the tissue, blue indicated hard tissue, and red indicated soft tissue. In organizing the results, colour mapping was divided into two categories that were modified from a scale of 1–3 by Rago et al 59. The elasticity colour scale by Rago et al. was as follows: score 1, elasticity in the whole or in a large part of the nodule; score 2, elasticity only at the peripheral part of the nodule; and score 3, no elasticity in the nodule. In the present study based on the criteria of Rago et al., the lesion was categorized as "blue" when it was more than 50% blue, and it was categorized as "not blue" when it was less than 50% blue. However, when a nodule with a score of 2 with peripheral elasticity was problematic, a reference was used with less or greater than half of the radius of a nodule.

Positioning of the patient:
The patient is examined in the supine position with the neck hyperextended to identify the inferior margin of the gland, which may extend to the clavicle in some patients. A small pad may be placed under the shoulders to provide better exposure of the neck, particularly in patient with a short, stocky habitus. The examiner usually sits at the head of the table and can steady the transducer by resting an elbow of the forearm on the table next to the patient's head. The thyroid gland is scanned in both longitudinal and transverse planes. Imaging of the lower poles can be enhanced in some patients by asking them to swallow which momentarily raises the thyroid gland in the neck. The entire gland from upper to lower pole, including the isthmus is carefully examined. The examination is extended laterally to include the region of the carotid artery and jugular vein in order to identify the enlarged cervical lymph nodes. On transverse scans the upper, mid, and lower patterns of the thyroid gland is identified and on longitudinal scan, the lateral, mid, and medial portions of the thyroid are demarcated.
The oesophagus is normally seen posterior and medial to the left, adjacent to the trachea with swallowing it may be seen to respond with peristalsis. The carotid artery and the more lateral jugular view are just lateral to the thyroid gland relatively anterior in the neck but posterior to the strap muscles and anterior to the longus colli muscles. The gland was evaluated using the well-established criteria of solid, mixed and cystic pattern. Solid nodules were divided into homogeneous and heterogenous pattern, the homogeneous being subdivided into hyperechoic,isoechoic and hypochoic echotexture

Cytological examination
FNA was performed with a 23 G needle attached to a 2 ml syringe. Cytological results were reported according to the Bethesda classification, which is a uniform reporting system for thyroid FNA results. The six general diagnostic categories included are (I) non-diagnostic or unsatisfactory, (II) benign, (III) atypia of undetermined significance or follicular lesion of undetermined significance, (IV) follicular neoplasm or suspicious for a follicular neoplasm, (V) suspicious for malignancy, or (VI) malignant73

Results

Study showed 100% of the benign nodules were hyperechoic, 75% benign nodules were hypoechoic, 100% of benign nodules were isoechoic and 100% of anechoic nodules were benign.
Out of 25% of hypoechoic nodules were proven to be malignant

Table 1: Distribution of cases according to echo textures of the nodules

Echotexture	Benign	%Age	Malignant	%Age	Total
Hyperechoic	25	100	0	0	25
Hypoechoic	12	75	4	25	16
Isoechoic	15	100	0	0	15
Anechoic	4	100	0	0	4
Total	56	93.33	4	6.66	60

Our study showed among 25 hyperechoic nodules 20 were colloid nodule, 5 were adenoma
Among 15 isoechoic nodule 12 were colloid nodules, 3 were adenoma
Among 16 hypoechoic nodules 8 were colloid nodules, 3 were de Quervain's thyroiditis, 1 was adenoma and 4 were malignant. All the 4 anechoic nodules were colloid cysts.

Table 2: Diffuse Thyroid swelling according to echotexture

Echotexture	Colloid Nodule	Colloid Cyst	De Quervain Thyroidits	Adenoma	Malignancy	Total
Hyperechoic	20	0	0	5	0	25
Isoechoic	12	0	0	3	0	15
Hypoechoic	8	0	3	1	4	16
Anechoic	0	4	0	0	0	4
Total	40	4	3	9	4	60

Our study out of 23 calcifications 3 were micro calcification, 20 were macro calcification

All the micro calcifications were proved to be malignant

Table 3: Distribution of nodules cases according to calcification

Calcification	No. Of Cases	Percentage
Micro	3	13.01
Macro	20	86.9
Total	23	100

Study showed 100% of benign nodules had Elasticity Score of 1 and 2, none of the nodules were malignant.80% of the benign nodules showed Elasticity Score of 3 and 20% of cases were malignant.100% of the malignant nodules were Elasticity score of 4 and none of the benign nodules showed Score 4.

Table 4: Elasticity scores of 50 thyroid nodules

Elasticity Score	Benign		Malignant	
	No Of Cases	%Age	No Of Cases	%Age
Score 1	28	100	0	0
Score 2	24	100	0	0
Score 3	4	80	1	20
Score 4	0	0	3	100
Total	56	93.3	4	6.6

Discussion

Dr. Maria Cristina Chammas and colleagues from the Medical University of São Paulo in Brazil evaluated 177 nodules by B-mode scanning, power Doppler, and spectral analysis. They related the results to the cytological findings of ultrasound-guided fine-needle aspiration.[7]

Nodular analysis with color Doppler was classified in four vascular patterns:

- I: no vascularization
- II: perilesional vascularization
- III: perilesional vascularization greater than or equal to central vascularization
- IV: only central vascularization

Dr. Rafal Z. Slapa and colleagues from the Center of Oncology in Warsaw used volume-rendered 3D power Doppler to establish features characteristic for thyroid carcinoma. They presented three conclusions at the ECR:

- Papillary thyroid carcinoma can present with different patterns of vessels — in most cases peripheral-central and only rarely peripheral or central.
- There is a large overlap of vascularity patterns between papillary carcinomas and benign nodules.
- Thyroid nodule vascularization can be used in conjunction with other criteria to determine the need for fine-needle aspiration.[8]

In our study 40 0f the colloid nodules 50% (20) were hyperechoic, 30% (12) isoechoic and 20% (8) were hypoechoic. These Cystic components frequently develop from necrosis or haemorrhage and eventually some of these lesions become purely cystic. In our study 28% of the colloid nodules had honeycomb pattern and 40% of ohe nodules had papillary projections within the cystic component. These nodules showed peripheral calcification in 14 nodules few showed classical egg shell calcification. Most of the lesions showed type 2 and type 3 vascularity on doppler study.

In our study all the 4 malignant nodules were taller than wide (with height-to-width ratio >1) and subsequently confirmed by FNAC/Histopathology. Most of the benign nodules showed wider than tall that is (with height-to-width ratio <1)

The shape of the nodule has also been studied as a marker of malignancy. The width of the nodule on a transverse scan corresponds to the natural growth planes. Malignant tumors have a tendency for centrifugal growth and show expansion perpendicular to the natural growth plane.[9] The appearance at USG is of a nodule that is taller than wide (i.e., anteroposterior diameter > transverse diameter on transverse scan). In 2006, Cappelli et al. in their series concluded that a taller-than-wide shape was a useful criterion for identifying a malignant lesion. Popowicz et al. indicated hypoechogenicity, the presence of microcalcifications, and the shape (with height-to-width ratio >1) to be independent features suggestive of malignant lesions, irrespective of their size. In the present study, we measured the anteroposterior (AP) and transverse (T) diameters and found AP≥T to have a moderately high specificity and sensitivity.[10]

Our study showed 4 (6.6%) of the nodules showed colloid cysts these were anechoic in nature with echogenic foci within suggestive of comet tail artifacts are seen in all the cases. Doppler study showed no evidence of vascularity with and around the cyst.

Ahuja et al in their study showed the comet-tail artifact is commonly encountered in a variety of clinical conditions; however, its presence and significance in a thyroid nodule has not been documented before. They documented presence in 100 patients who underwent ultrasound examinations of the neck and thyroid. None of the thyroid nodules showed any evidence of malignancy on repeated fine-needle aspiration cytology (FNAC). In 85% of patients with the artifact, abundant colloid was seen on FNAC, suggesting that the artifact may be related to the presence of colloid.[11]

In our study 15% (9) of the cases were follicular adenomas. Out of thsese 9 nodules 5 (55.5%) of the cases were hyperechoic in echotexture, 3 (33.33%) were isoechoic in echotexture 11% had hypoechoic echotexure. Most of the adenomas in our study showed peripheral hypoechoic halo which was later confirmed to be a vessels around the adenoma on doppler.[6] adenomas showed peripheral calcification in our study. Scheible W et al studied large series of over 200 patients, the solitary hyper echoic ultrasound pattern was the most frequent, seen in 66% of the adenomas and the halo in about 60% of these lesions. Calcification of adenomas is the common ring like calcification around the periphery of the nodule producing posterior shadowing from the anterior margin and is quite specific for adenoma.[12]

Our study showed considerable overlap in diagnosing follicular adenoma and colloid goiter when adenoma goes for necrosis and hemorrhage. USG is not so sensitive in detecting accuretly from adenoma form colooid goiter hence there was mismatch between USG and FNAC.in our study 8 cases showed adenomatous nodule in follicular adenoma.

In our study 5% of the cases showed de Quervain's thyroiditis, all these nodules were presented with acute pain and fever and showed hypoechoic echotexture, irregular margins, prominent echogenic septae and showed decreased vascularity on Doppler.

Sun Young Park et al studied de Quervain's thyroiditis in 36 patients and they showed that thyroid gland was found to be enlarged in five patients, it was normal size in 20 patients and it was smaller in two patients. All the lesions had focally ill-defined hypoechogenicity. Hypervascularity was not noted in any of the lesions. Painful neck swelling was present in 18 patients. An accompanying fever was documented in nine of the 18 patients. Twelve patients showed disappearance (n = 3) or a decreased size (n = 9) of their lesions on follow-up US.[13]

In our study 6.6%(4) of the nodules were malignant .All the malignant nodules were (100%) hypoechoic in echotexure, none of the malignant nodules were hyper or isoechoic. 3 of the nodules showed microcalcification, 2 nodules showed surrounding lymph node involvement, all were irregular in outline. 75% of the malignant nodules showed type 4 vascularity, 25% showed type 3 vascularity

Real-time US-E is a newly developed diagnostic tool that evaluates the degree of distortion of ultrasound beam while an external force is applied. It is based on the principle that the softer parts of the tissues deform more easily than the harder parts under compression. Thus, a semi-quantitative determination of tissue elasticity is observed. Thus far, elastography has been evaluated in two ways, namely, based on the elasticity score and on the strain ratio. Malignant thyroid nodules such as papillary thyroid carcinoma, which is the most common histotype, displayed lower elasticity compared with benign lesions.[14]

The elasticity score evaluation was based on the color distribution, which was superimposed on the B-mode image. Previous reports found this method to be efficient 59 60. However, information about the stiffness of the target mass is limited. In the present study, the benign and malignant lesions of the elasticity score had a greater extent of overlap, and the sensitivity and specificity were lower.

Our study showed that, when the nodules showed Elasticity score 1 and 2 in US-E all the nodules were benign none of the nodules were malignant. When the nodules showed Elasticity score of 3 on US-E, 80% of the cases were benign and 20% were malignant .When the Elasticity score of 4 in the US-E, 100% of the nodules were malignant.

Conclusion

Ultrasound clearly helps to detect micro and macro calcification and lymphnode involvement. Micro calcification and lymph node involvement are most commonly scen in most of thyroid carcinoma.

Being a safe, simple, repeatable and without radiation exposure to the patient, it is worthy of being included in routine diagnostic work up.

Elastography with ultrasound is a quick and easy method of obtaining additional information when examining the thyroid and will probably reduce the number of cytological samples taken in the future. It increases confidence in the decision for benign versus malignant when assessing thyroid nodules. It also helps in the choice of nodule(s) for biopsy and reduces number of FNAC procedures.

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