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Radio-Diagnosis

Evaluation of Thyroid Nodules on B-Mode Ultrasonography, Color Doppler and Real Time Elastography- A Case Series

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Abstract **Original Research Article**

A prospective study of 50 patients was conducted on Aloka Arietta S 60 USG machine for Evaluation of Thyroid Nodules on B-Mode Ultrasonography, Color Doppler and Real-Time Elastography. Out of total 50 patients, 72 % were females and 28% were males. Malignant lesions were common in above 45 years age group, while benign lesions were common in 25-45 age groups. 95% of the thyroid lesions were benign and only 5% of the lesions were malignant. Aspect ratio of >1 was associated with malignant thyroid nodules. All the lesions with irregular margins were malignant. Majority of hypoechoic lesions were malignant. Majority of benign nodules showed either peripheral and central vascularity or peripheral vascularity. Majority of malignant nodules showed both peripheral and central chaotic vascularity and central vascularity. All mixed nodules were benign and all spongiform nodules were benign. Majority of benign nodules were solid and all malignant nodules were solid. All of the benign nodules showed peripheral thin and complete halo. None of the malignant nodules showed complete peripheral halo. All the cases showing punctate echogenic foci were malignant nodules. Benign nodules showed macro calcification, peripheral rim calcification and comet tail artifacts. All of the cases showing extra-capsular spread and regional lymph nodal metastases were malignant. TIRADS score 1-2 was suggestive of benign nodules. TIRADS score 3 and 4 was observed in both benign and malignant thyroid nodules, more in benign nodules. TIRADS score 5 was suggestive of malignant nodules. All of the lesions showing elasticity score of 4 were malignant. Elasticity score 3 was seen in both benign (90.9%) and malignant (9.1%) nodules. Elasticity score of 1 and 2 were seen in benign thyroid nodules. Mean strain ratio in malignant nodules was 4.9±1.5. Mean strain ratio in benign nodules was 1.5±0.9. The nodules which were characterized as malignant in ultrasound were confirmed as malignant on FNAC. Ultrasound can characterize the number of nodules, size of each nodule, margins of the nodule and contents of the nodule. Ultrasound can predict if the lesion is benign or malignant. Diagnostic accuracy of both elastography scoring and strain ratio was higher than TIRADS scoring.
Keywords: Ultrasound; Thyroid gland; Thyroid nodules; benign; malignant; ACR TI-RADS 2017; Real time elastography (RTE); elasticity score; strain ratio.

INTRODUCTION

The thyroid gland is largest of all the endocrine glands and due to superficial location of the thyroid gland; it is easily accessible to direct physical examination. Therefore it allows excellent visualization and evaluation of its normal anatomy and pathological condition by high resolution real-time grey scale sonography [1]. The thyroid gland has multiple important functions such as regulating the metabolic functions of the body like cardiac output, skeletal growth and thermogenesis. High-resolution sonography is the best imaging modality for the thyroid gland. By ultrasonography normal anatomical and pathological features such as size, margin number of nodules etc. can be demonstrated [2]. The thyroid gland is primarily evaluated clinically by palpation and determination of the levels of thyroid hormones. On ultrasonography thyroid, the nodules are easily evaluated. The size of nodule, location of nodule in the thyroid gland, echotexture of the nodule, margins of the nodule, presence of halo around the nodule, calcification within the nodule, vascularity of the nodule, accessory nodules and associated cervical nodes and contents of the nodule (cystic, solid or mixed) are characterized to differentiate between benign and malignant nodule [3]. Thyroid disorders are most commonly seen amongst all the endocrine diseases in India [4]. Thyroid diseases are most commonly seen in females than males. Sonographic ally thyroid masses are seen as diffuse enlargement of the thyroid gland, thyroid nodules and clinically they may be palpable lesions or non-palpable lesions. The patients may be symptomatic or asymptomatic. Multinodular goiter is the commonest pathology and is seen in 40% of the cases. The females are most commonly affected and constituted 90% of goiter cases. By high-frequency ultrasonography, even the smaller lesions which are not palpable can be identified.

MATERIALS AND METHODS

This is a prospective study of 50 patients conducted for a period of two years (July 2016 to September 2018) at "Dr.D.Y.Patil Medical College, Hospital and Research Centre, Pimpri, Pune". This study was carried out on Aloka Arietta S 60 USG machine. The aim of the study was to "Evaluation of Thyroid Nodules on B-Mode Ultrasonography, Color Doppler and Real-Time Elastography." The patients who were fulfilling the inclusion and exclusion criteria were included in the study and the study group comprised 50 patients. Institutional Ethical Committee (IEC) clearance was obtained before the start of the study. Informed and written consent was obtained from all the patients.

Patients of all age and both the sex group were included with physical clinical examination suggestive of palpable thyroid swelling in lower neck in the midline or on either side. Patients with solitary thyroid nodules or dominant nodule of multinodular goiter (MNG) which were referred for the ultrasound. Also patients with symptoms and signs suggestive of thyroid disorder (Hyperthyroidism/ Hypothyroidism) were also included. Patients with diffuse thyroid disease, patient already diagnosed and treated for thyroid lesion, undergone thyroidectomy or radiation therapy were excluded.

Also unsuitable nodules like very large coalescent or exophytic nodules could not be compared against normal thyroid parenchyma within elastography window, nodules that could not be penetrated by USG due to rim calcifications were not suitable for elastography. Purely Cystic lesion which was not suitable for elastography was excluded.

Thyroid Ultrasound and Real time elastography was performed using an ultrasound HITACHI-ALOKA ARIETTA S 60 Machine. Linear transducer L55 of frequency 7- 13 MHz was used. However, a 3.5–5 MHz convex probe was sometimes more convenient for measurements of large thyroids and for retrosternal extension of the gland.

The ultrasonographic examination was done in 3 steps. First B-mode ultrasound was conducted and then the Color Doppler along with power Doppler examination was done. Lastly, the third examination with Real-Time elastography was done by using the same ultrasound probe during the same examination.

The patient was positioned supine with the patient's neck was hyperextended over a pillow and the chin was raised. Lower poles of thyroid imaging were enhanced by asking the patient to swallow, so the gland moves upward. The examination was thoroughly done in the transverse and longitudinal planes. The probe was applied to the neck using a sufficient quantity of jelly. The first evaluation was started with B-mode imaging of thyroid gland in transverse plane. The thyroid gland lesions were identified and lesions were carefully evaluated using ultrasonographic parameters, then color and power Doppler examination were done. The standard proforma was used for the collection of data.

Real Time Elastography was done using qualitative analysis by using Asteria scores [5] (Figure-1) and Semi-quantitative analysis by using Strain ratio. The elastography was done by applying light compression by elastography probe. To minimize the motion of thyroid gland, the patient was asked to hold their breath and avoid swallowing. The repetitive compressions and decompressions were applied at the skin over the targeted lesion to obtain elastographic images, and then it was superimposed over the B-mode images. The tissue stiffness was seen as the color scale from red to blue. In our ultrasound machine color red represents tissue with greatest elastic strain (i.e. softest components) and the color blue for those with no strain (i.e. hardest components). The elastogram was obtained, which then used for classification according to the scores by Asteria *et al*. [5] (Figure-1). The elastography scores were classified on a scale of 1–4. The elastography is evaluated in two ways, first based on the elasticity score and then on the strain ratio. The stored dynamic real time elastography images are used to calculate the strain value of nodule and it is compared with the strain value of normal tissue. The strain ratio is determined by dividing the strain value of normal thyroid by the stain value of the region of interest in the nodule. Every nodule then evaluated minimum 3 times depending upon the different static images. Then the mean final value was taken.

$$\textbf{Strain ratio (SR)} = \frac{\textbf{Average strain in the reference area}}{\textbf{Average strain in the lesion}}$$

SR=1 the nodule is the same hardness/softness as the normal thyroid

RESULTS

Out of 50 patients ,72(%)were females and 28(%) were males. The majority of patients belonged to the age group of 25-45 years accounting for 72%. Malignant lesions were common in above 45 years age group, while benign lesions were common in 25-45 age groups. Malignant lesions were commonly observed in females than in males. Majority of malignant lesions were single and the majority of multiple lesions were benign. Thus an aspect ratio (i.e. anteroposterior diameter relative to transverse diameter) of >1 is associated with malignant thyroid nodules ($P < 0.001$). The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of shape taller than wider for malignancy were 38.5%, 100%, 100%, 82.2%, and 84% respectively. All the lesions with irregular margins were malignant. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of irregular margin for malignancy were 69.2 %, 100%, 100%, 90.2% and 92% respectively. Majority of hypoechoic lesions were malignant. Thus it is observed that hypoechogenicity is an as independent risk factor of malignancy with the sensitivity of 76.9%, specificity of 83.8%, the positive predictive value of 62.5% and accuracy of 82%. Thus the majority of benign nodules showed either peripheral and central vascularity or peripheral vascularity. Majority of malignant nodules showed both peripheral and central chaotic vascularity and central vascularity.

Thus the majority of benign nodules were solid and all malignant nodules were solid. The specificity of solid composition for malignancy was 86.5%. All of the benign nodules showed peripheral thin and complete halo. None of the malignant nodules showed complete peripheral halo. One malignant nodule showed incomplete peripheral halo. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of complete peripheral halo for a nodule to be benign were 100%, 73%, 56.5 %, 100%, and 80 % respectively. All the cases showing punctate echogenic foci were malignant nodules and all of them were papillary carcinoma. Thus benign nodules showed macrocalcification, peripheral rim calcification ad comet tail artifacts. The specificity, positive predictive value, negative predictive value, and accuracy of punctate echogenic foci for malignancy were 100%, 100%, 82.22% and 84 % respectively. All of the cases showing extra-capsular spread and regional lymph nodal metastases were malignant. In our study, by applying ACR TI-RADS [6] (Figure-2) we found that TIRADS score 1-2 suggestive of benign nodules. TIRADS score 3 and 4 was observed in both benign and malignant thyroid nodules, more in benign nodules. TIRADS score 5 suggestive of malignant nodules. The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of TIRADS criteria in our study were 92.3%, 70.3%, 52.2%, 96.3%,and 76%, respectively. All of the lesions showing elasticity score of 4 were malignant. Thus elasticity score 4 was seen in malignant thyroid nodules. Elasticity score 3 was seen in 11 thyroid nodules, out of them 90.9% were benign and 9.1% were malignant. Thus elasticity 1 and 2 were seen in benign thyroid nodules. The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of elasticity score for malignancy were 92.3%, 100%, 100%, 97.4% and 98 % respectively. In our study, we prospectively evaluated the elastographic appearance of 50 thyroid lesions and we found that strain ratio greater than 4 was the greater predictor of malignancy ($P < 0.001$). Mean strain ratio in malignant nodules was 4.9±1.5. Mean strain ratio in benign nodules was 1.5±0.9. Mean strain ratio in adenomatous nodule was 1.6±0.8, in follicular adenoma was 1.7±1.5 and for multinodular goiter was 0.8±1. For follicular carcinoma mean strain ratio was 4.5±1.4, for papillary carcinoma 5.3±1.7 and metastatic carcinoma from carcinoma of the breast was 4.5.

Thus both the elastography score and strain ratio was lower for benign nodules and higher for malignant nodules. The values of strain ratio were higher than 4 was in statistically significant relation with malignancy. After applying strain ratio criteria as 4, we found overall sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were 76.9%, 100%, 100%,92.5% and 94% respectively. In our study groups, papillary carcinoma was the most common malignant tumor to occur.

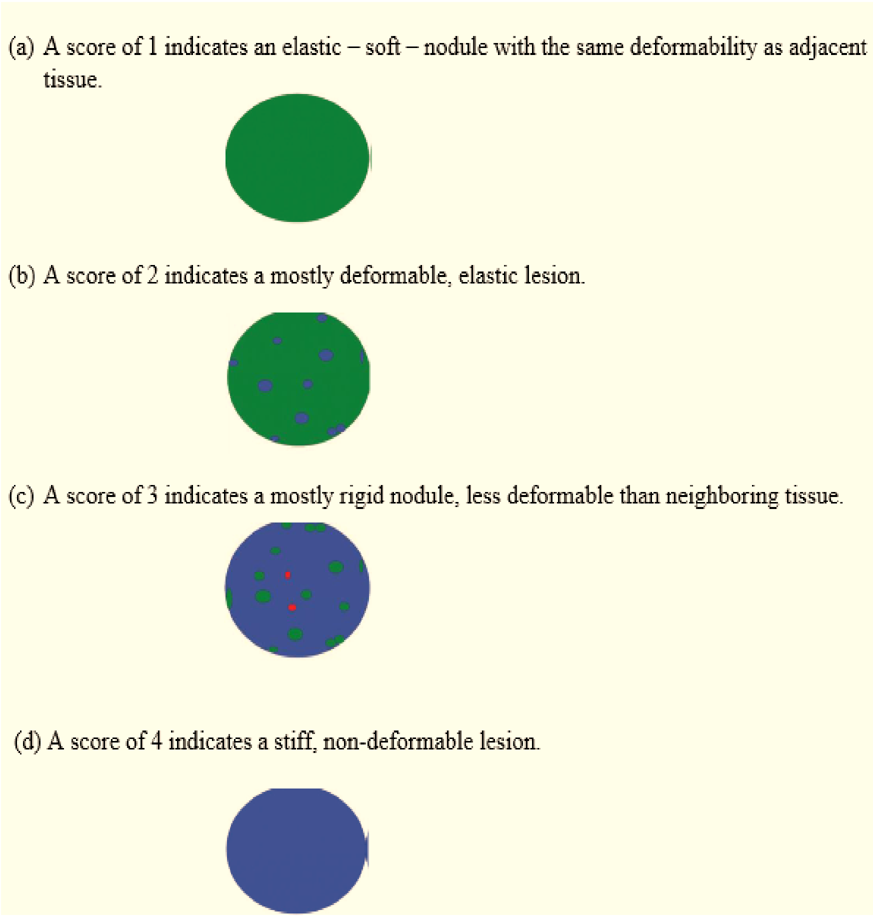
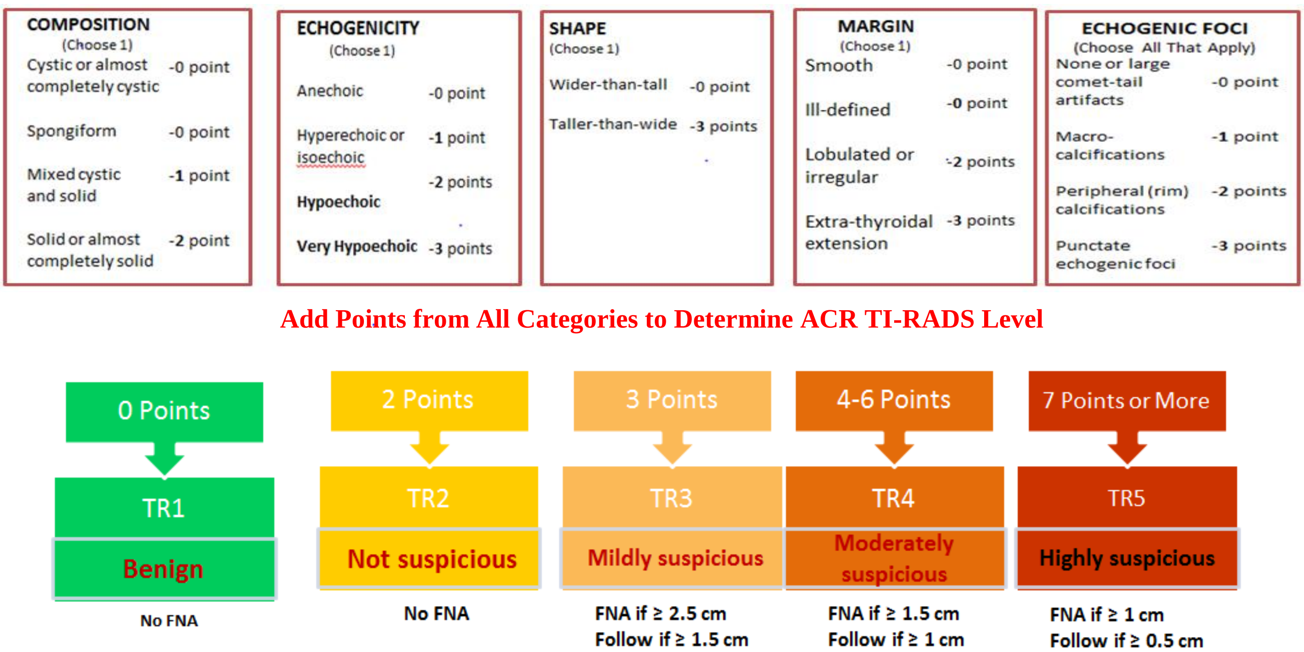


Fig-1: Elastography scores according to Asteria criteria [5]

(Figure-2) TIRADS

"The American College of Radiology (ACR) Thyroid Imaging Reporting and Data System (TI-RADS) i.e. ACR TI-RADS 2017 classification proposed by Tessler FN, Middleton WD, Grant EG, *et al*. [6]" was used to classify the nodules in terms of B-mode features

ACR TI-RADS classification [6]



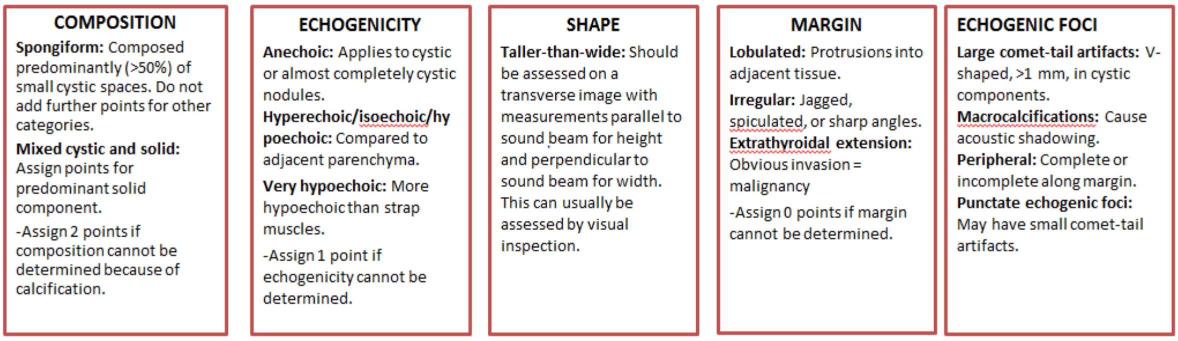


Fig-2

OBSERVATIONS AND RESULTS

Table-1: Age Distribution and association of age with malignancy

Age	N	Malignant	Benign	P value
25 – 45 Years	36 (72%)	7 (19.4)	29 (80.6)	0.09
Above 45 Years	14 (28%)	6 (42.9)	8 (57.1)	
Total	50 (100%)	13	37	

72 %(n=36) of patients were of the age group of 25-45 years and 28 %(n=14) of patients were above 45 age.

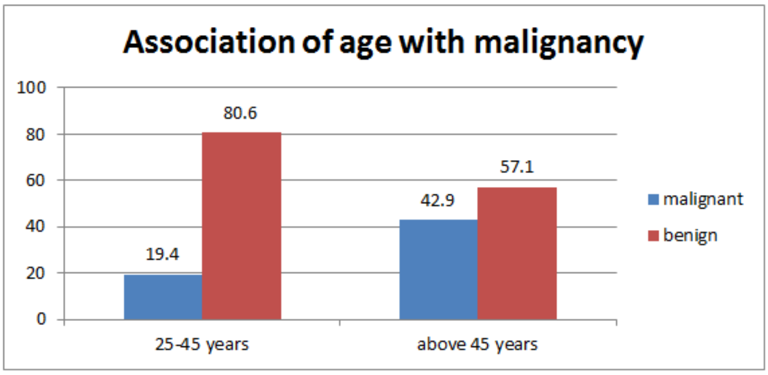


Fig-3: Bar diagram showing an association of age with malignancy in the study group

In the age group of 25-45 years numbers of patients with benign nodules were 29 (80.6%) and patients with malignant nodules were 7 (19.4%). In the age group of above 45 years numbers of patients with benign nodules were 8 (57.1%) and patients with malignant nodules were 6 (42.9%). Hence malignant lesions were common in above 45 years age group.

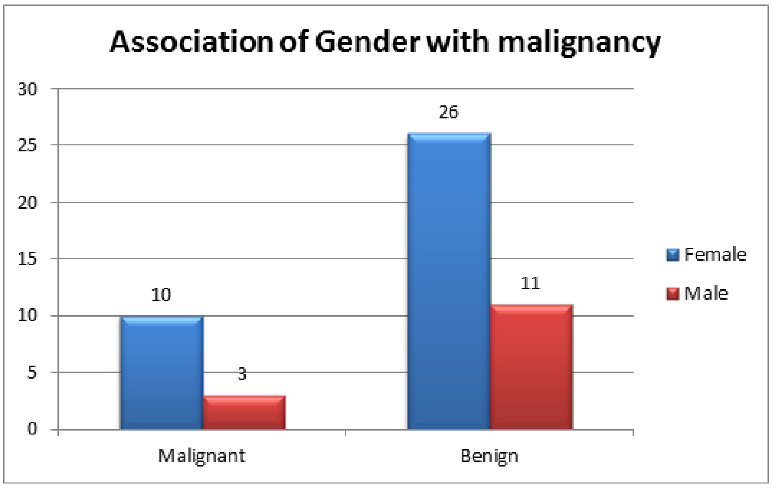


Fig-4: Bar diagram showing an association of gender with malignancy in the study group

36 lesions were seen in females out of which 26 (72.2%) were benign and 10 (27.8%) were malignant. 14 lesions were seen in males out of which 11 (78.6%) were benign, while 3 lesions (21.4%) were malignant. Malignant lesions were commonly observed in females than in males.

Table-2: Distribution of FNAC Findings

FNAC Findings	Frequency	Percentage
Adenomatous Nodule or Colloid nodule	30	60
Follicular Adenoma	5	10
Multinodular goiter	2	4
Papillary Carcinoma	8	16
Follicular Carcinoma	4	8
Metastasis from Breast carcinoma	1	2
Total	50	100

On histopathology 30 lesions (60%) were adenomatous nodule or hyperplastic or colloid nodules, 5 lesions (10%) were follicular adenoma, 2 lesions were (4%) multinodular goiter, 8 lesions were papillary carcinoma(16%), 4 lesions (8%) were follicular carcinoma and 1 lesion turn out to be metastasis from carcinoma breast(2%).

Out of 50 patients with thyroid nodules, there were 37 (74%) benign cases and 13 malignant cases (26%).

Table-3: Distribution of Malignancy in the study group.

Malignancy	Frequency	Percentage
Malignant	13	26
Benign	37	74
Total	50	100

Table-4: Distribution and Association of number of Lesions with malignancy

Number of Lesions	Frequency	Percentage	Malignant	Benign	P value
Single	14	28	10 (71.4)	4 (28.6)	<0.001
Multiple	36	72	3 (8.3)	33 (91.7)	
Total	50	100	13	37	

Out of 14 single lesions, 10 lesions (71.4%) were malignant, while 4 (28.6%) were benign. Amongst 36 multiple lesions, 33 (91.7%) lesions were benign and 3 (8.3%) were malignant. Hence the majority of malignant lesions were single and the majority of multiple lesions were benign.

Table-5: Distribution of Locations and Association of Locations with malignancy

Location	Frequency	Malignant	Benign	P value
Right	28 (56%)	6 (21.4)	22 (78.6)	0.47
Left	18(36%)	5 (27.8)	13 (72.2)	
Bilateral	4(8%)	2 (50)	2 (50)	
Total	50(100%)	13	37	

22 (78.6%) benign lesions were seen in the right lobe. 6 (21.4%) malignant lesions were seen in right thyroid lobe. 13 (72.2%) benign lesions were seen in left thyroid lobe. While 5 malignant lesions (27.8%) were seen in left thyroid lobe. 4 lesions involved both thyroid lobe out of which 2 were benign and 2 were malignant.

Table-6: Distribution of Shape and Association of Shape with Malignancy

Shape	Frequency	Malignancy		P Value
		Malignant N (%)	Benign N (%)	
Wider than taller	45(90%)	8 (17.8)	37 (82.2)	<0.001
Taller than wider	5(10%)	5 (100)	0	
Total	50(100%)	13	37	

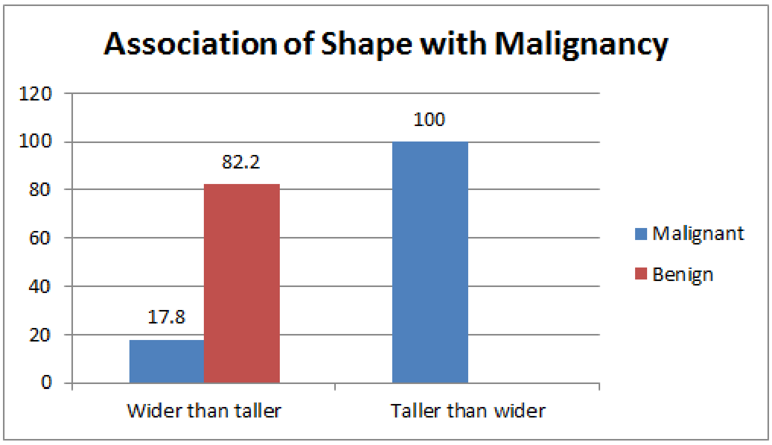


Fig-5: Bar diagram showing an association of shape with malignancy in the study group

37 (82.2%) benign lesions were wider that taller, while 8 (17.8%) malignant lesions were wider than taller. Out of total 50 nodules, 5 nodules were showing taller than wider appearance and they all were malignant. It was not seen in benign nodules.

Table-7: Distribution of Margin and Association of Margins with Malignancy

Margins	Frequency	Malignancy		P Value
		Malignant N (%)	Benign N (%)	
Irregular	9(18%)	9 (100)	0	<0.001
Smooth	41(82%)	4 (9.8)	37 (90.2)	
Total	50(100%)	13	37	

Out of 41 lesions showing smooth margins, 37(90.2%) lesions were benign and 4(9.8%) lesions were malignant. All the lesions with irregular margins were malignant

Table-8: Distribution of Echogenicity and Association of Echogenicity with Malignancy

Echogenicity	Frequency	Malignancy		P value
		Malignant N (%)	Benign N (%)	
Hyperechoic	23 (46%)	1 (4.3)	22 (95.7)	<0.001
Hypoechoic	16(32%)	10 (62.5)	6 (37.5)	
Isoechoic	11(22%)	2 (18.2)	9 (81.8)	

Out of 23 hyperechoic lesions, 22 (95.7%) were benign and 1 lesion (4.3%) was malignant. Out of 16 hypoechoic lesions, 10 (62.5%) were malignant, while 6 (37.5%) lesions were benign. Out of 11 isoechoic lesions, 9 (81.8%) were benign while 2 (18.2 %) lesions were malignant. Thus the majority of benign lesions were hyperechoic or isoechoic. Majority of hypoechoic lesions were malignant.

Table-9: Distribution and Association of Calcification with Malignancy

Calcification	Frequency	Malignancy		P value
		Malignant N (%)	Benign N (%)	
Yes	12(24%)	5 (41.7)	7 (58.3)	0.23
No	38 (76%)	8 (21.1)	30 (78.9)	

12 nodules showed the presence of calcification out of which 7 (58.3%) were benign and 5(41.7%) were malignant. 38 cases showed lack of calcification out of which 30 (78.9%) were benign and 8 (21.1%) were malignant.

Table-10: Association of Calcification with Malignancy

Calcification	Frequency	Malignancy		P value
		Malignant N (%)	Benign N (%)	
Punctate Echogenic foci	5 (10%)	5 (100)	0	0.33
Macrocalcification	4(8%)	0	4 (100)	
RIM calcification	1(2%)	0	1 (100)	
Comet Tail Artifacts	2(4%)	0	2 (100)	
Absent*	38(76%)	8 (31.1)	30 (78.9)	

Out of 5 cases showing punctate echogenic foci, all 5 cases were malignant nodules and all of them were papillary carcinoma. 4 cases of thyroid nodules showing macrocalcification were benign nodules. 1 case of peripheral rim calcification was benign nodule. 2 cases showing comet tail artifacts were benign nodules. 38 nodules showed an absence of calcification, out of which 30(78.9%) were benign and 8 (21.1%) were malignant.

Table-11: Distribution and Association of Composition with Malignancy

Composition	Frequency	Malignancy		P value
		Malignant N (%)	Benign N (%)	
Mixed	3(6%)	0	3 (100)	0.38
Solid	45(90%)	13 (28.9)	32 (71.1)	
Spongiform	2(4%)	0	2 (100)	

45 lesions (90%) were solid, 3 lesions (6%) were mixed (both solid and cystic component), while 2 lesions (4%) were spongiform. Purely cystic lesions were excluded in this study. Hence the majority of lesions were solid. 32 (71.1%) of benign nodules and 13 (28.9%) of malignant nodules were solid. All 3 mixed nodules were benign. All 2 spongiform nodules were benign.

Table-12: Distribution of Peripheral Halo

Peripheral Halo	Frequency	Malignant N (%)	Benign N (%)	P value
Present and complete	27 (54%)	0	27 (100)	<0.001
Incomplete	1(2%)	1 (100)	0	
Absent	22(44%)	12 (54.6)	10 (45.4)	

28 lesions showed the presence of peripheral halo, out of which 27 lesions (54%) showed complete halo and 1 lesion (2%) showed incomplete peripheral halo.

Table-13: Distribution and Association of Vascularity with Malignancy

Vascularity	Frequency	Malignancy		P value
		Malignant N (%)	Benign N (%)	
Central	4(4%)	2 (50)	2 (50)	0.6
Peripheral	17(34%)	3 (17.7)	14 (82.4)	
Both	25(50%)	7 (28)	18 (72)	
No	4(8%)	1 (25)	3 (75)	

Out of 17 cases of thyroid nodules showing peripheral vascularity 14 (82.4%) were benign and 3(17.7 %) were malignant. 18 (72%) benign nodules and 7 (28%) malignant nodules showed both peripheral and central vascularity. 2 (50%) of benign nodules and 2 (50%) malignant nodules showed central vascularity. No vascularity was seen in 3 (75%) benign nodules and 1 (25%) of malignant nodules. Thus the majority of benign nodules showed either peripheral and central vascularity or peripheral vascularity. Majority of malignant nodules showed both peripheral and central chaotic vascularity and central vascularity.

Table-14: Distribution and Association of Extra capsular Invasion with Malignancy

Extra capsular Invasion	Frequency	Malignancy		P value
		Malignant N (%)	Benign N (%)	
Present	5(10%)	5 (100)	0	<0.001
Absent	45(90%)	8 (17.8)	37 (82.2)	

All of the 5 cases showing extra capsular spread were malignant. Out of 45 cases which were not showing extra capsular spread, 37 cases were benign and 8 cases were malignant.

Table-15: Association of TIRADS with Malignancy

TIRADS	Frequency N (%)	Malignancy		P value
		Malignant N (%)	Benign N (%)	
1	1(2%)	0	1 (100)	<0.001
2	4(8%)	0	4 (100)	
3	22(44%)	1 (4.5)	21 (95.5)	
4	14(28%)	3 (21.4)	11 (78.6)	
5	9(18%)	9 (100)	0	

Table-16: Distribution and Association of TIRADS with Malignancy

TIRADS	Frequency	Malignancy		P value
		Malignant N (%)	Benign N (%)	
4-5	23(46%)	12 (52.2)	11 (47.8)	<0.001
1-3	27(54%)	1 (3.7)	26 (96.3)	

TIRADS score of 1-3 were observed in 27 thyroid nodules of which 26 (96.3%) were benign and 1 (3.7%) was malignant. TIRADS 4-5 were observed in 23 thyroid nodules of which 11 (47.8%) were benign and 12 (52.2%) were malignant. Thus TIRADS score 1-3 were commonly observed in benign nodules. TIRADS score 5 was observed in 9 nodules, out of which all of them were malignant nodules.

Table-17: Distribution and Association of Elasticity Score with Malignancy

Elasticity Score	Frequency N (%)	Malignancy		P value
		Malignant N (%)	Benign N (%)	
4	12 (24)	12 (100)	0	<0.001
1-3	38(76)	1 (2.6)	37 (97.4)	

Table-18: Association of Elasticity Score with Malignancy

Elasticity Score	Frequency N (%)	Malignancy		P value
		Malignant N (%)	Benign N (%)	
1	5 (10%)	0	5 (100)	<0.001
2	22(44%)	0	22 (100)	
3	11(22%)	1 (9.1)	10 (90.9)	
4	12(24%)	12 (100)	0	

12 thyroid nodules showed an elasticity score of 4, all of which were malignant. 38 of thyroid nodules showed elasticity score of 1-3 out of which 37(97.4 %) were benign and 1 case (2.6%) was malignant.

Table-19: Distribution and Association of Strain Ratio with Malignancy

Strain Ratio	Frequency N (%)	Malignancy		P value
		Malignant N (%)	Benign N (%)	
>=4	10(20)	10 (100)	0	<0.001
<4	40 (80)	3 (7.5)	37 (92.5)	

Table-20: Mean Strain Ratio for benign and malignant lesions

Malignancy	Frequency	Strain Ratio Mean (SD)	Mean Difference	P Value
Malignant	13	4.9 (1.5)	3.5	<0.001
Benign	37	1.5 (0.9)		

Strain ratio of ≥ 4 was seen in 10 thyroid nodules, all of which were malignant. Strain ratio of < 4 was observed in 40 thyroid nodules. Out of which 37 (92.5 %) were benign and 3(97.5%) were malignant.

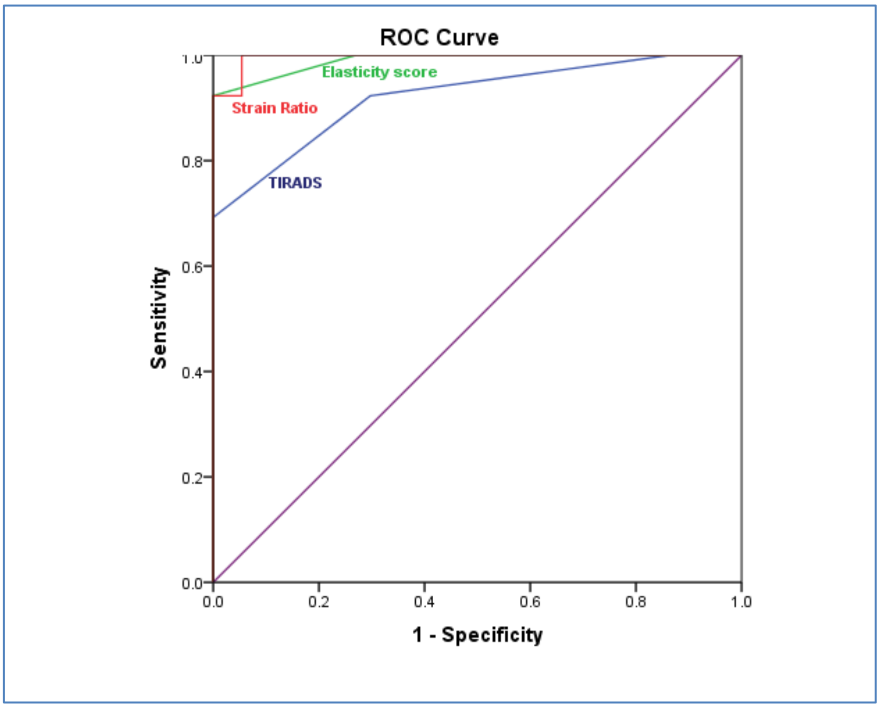


Fig-6: Comparison of Receiver Operating Characteristic (ROC) curve of the strain ratio, TIRADS score and elasticity score in the diagnosis of malignancy

Receiver operating characteristic curve analyses was done using the specificity and sensitivity of elastography scores, strain ratio and TIRADS scores to differentiate benign from malignant thyroid nodules. The AUC was 0.996 for strain ratio cut off value as 4. The AUCs of strain ratio was greater than elastography scores and TIRADS scores. Receiver operating characteristic (ROC) analysis demonstrated that the optimum strain ratio cut-off value for discriminating between benign and malignant lesions was 4.05 (at 100% specificity).

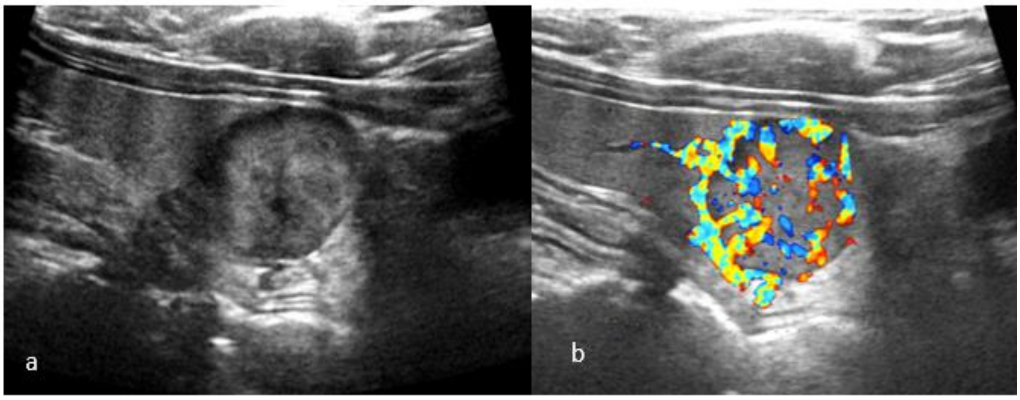
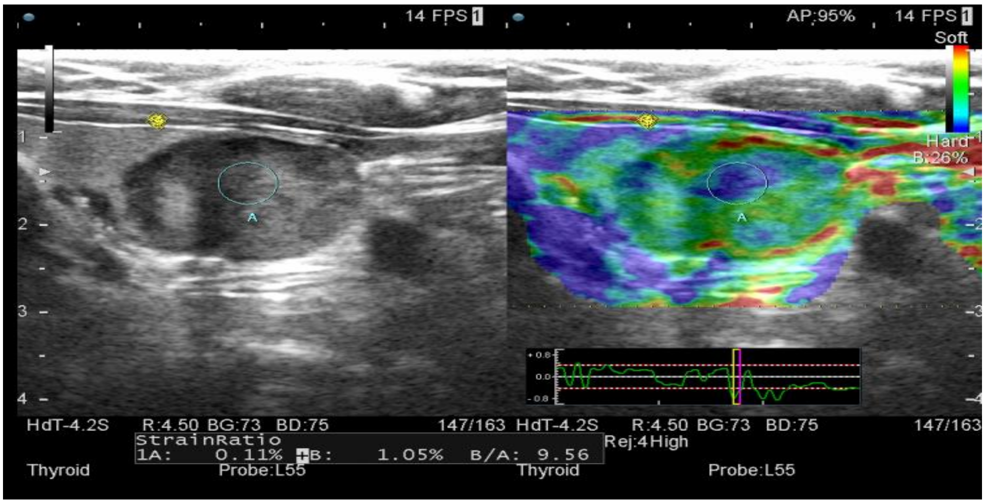


Fig-8: 45year old female patient with complaints of left paramidline neck swelling

(a) On sonography, a solitary hypoechoic solid lesion with irregular margins was noted in the left lobe of thyroid. It was showing incomplete peripheral halo. The TIRADS score was 5.

(b) On color Doppler examination this lesion was showing peripheral and central chaotic vascularity.

(c) On elastography, it appeared hard (blue in colour) with elastography score of 3. The strain ratio was 9.56. On FNAC this lesion was diagnosed as follicular carcinoma.



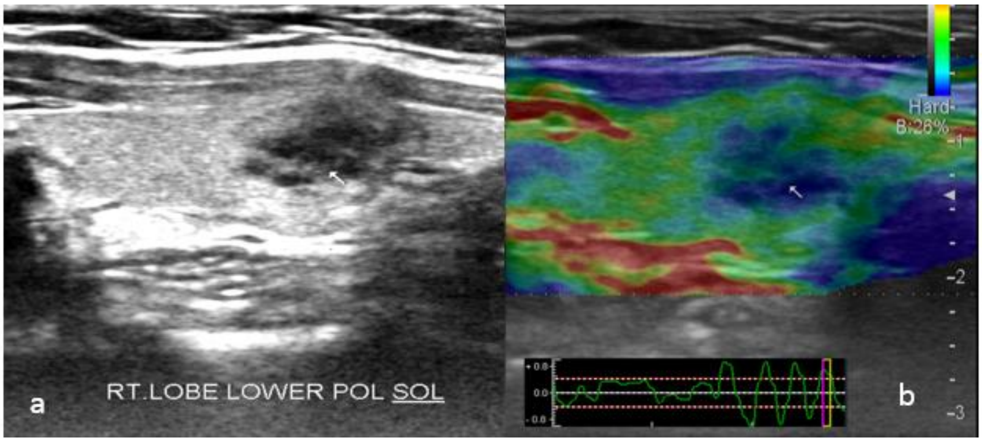


Fig-9: 45 year old female patient with complaints of swelling in the right side of the neck

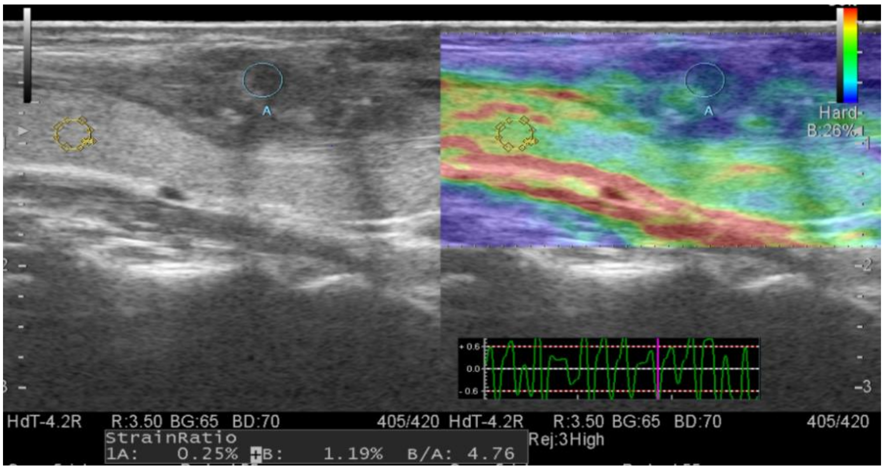
(a) An irregularly marginated, markedly hypoechoic solid lesion was noted in the lower pole of the right lobe of the thyroid which was showing extracapsular extension. The TIRADS score was 5.

(b) On elastography, it appeared hard (blue in colour) with elastography score of 4. The average strain ratio was 4.44. On FNAC this lesion was diagnosed as papillary carcinoma.

Fig-10: 45-year old female patient with complaints of neck swelling in the right side of the midline

(a) An irregularly marginated, taller than wider, hypoechoic solid lesion was noted in the upper pole of the right lobe of the thyroid which was showing extracapsular extension. The lesion was showing micro calcifications like punctate echogenic foci. The TIRADS score was 5.

(b) On elastography, it appeared hard with elastography score of 4. The strain ratio was 4.76. On FNAC this lesion was diagnosed as papillary carcinoma.



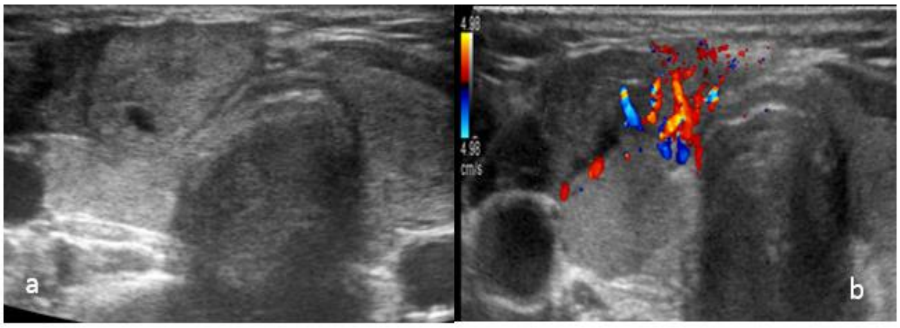
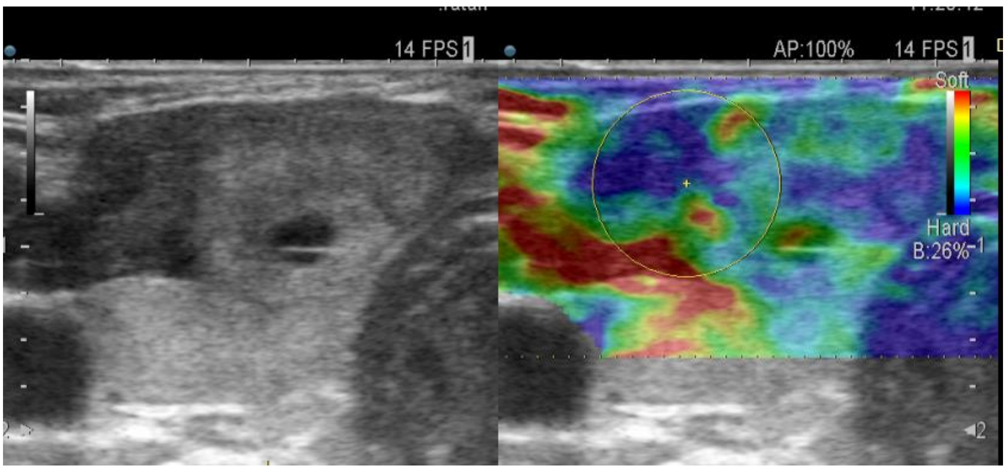


Fig-11: 42-year old female patient with complaints of neck swelling in the right side of the midline

(a) A lobulated, hypoechoic solid lesion was noted in upper pole of the right lobe of the thyroid.

(b) On color Doppler examination this lesion was showing peripheral and central chaotic vascularity. The TIRADS score was 5.

(c) On elastography, it appeared hard with elastography score of 4. The average strain ratio was 4.6. On FNAC this lesion was diagnosed as papillary carcinoma.



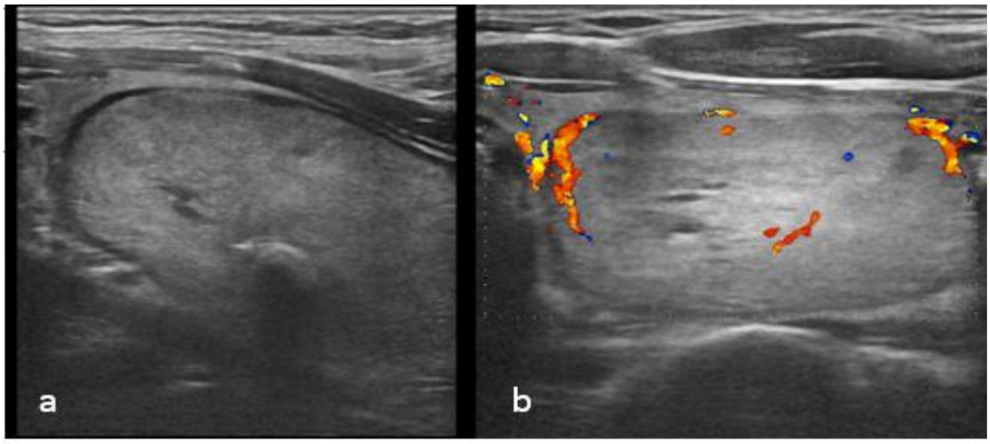
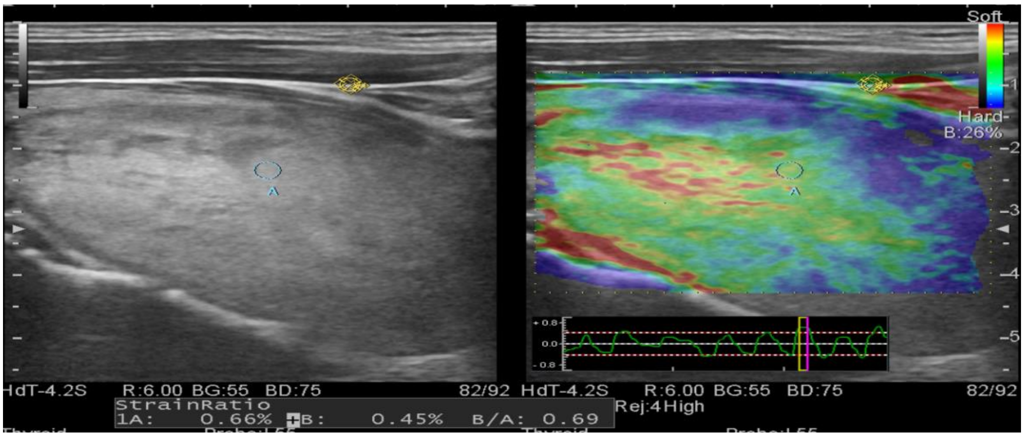


Fig-12: 26-year old male patient with complaints of neck swelling in the left side of the midline

(a) On sonography, a large well-defined, isoechoic solid lesion was noted in the left lobe of the thyroid. The lesion was wider that taller, showing smooth margins and complete peripheral halo. The lesion was showing macro calcification with posterior acoustic shadow. The TIRADS score of 4 was given.

b) On color Doppler examination it was showing mixed with predominant peripheral vascularity.



(a) On elastography, it was showing mixed with predominant soft pattern, which was given as elastography score of 2. The strain ratio was 0.69.On FNAC this lesion was diagnosed as benign follicular adenoma.

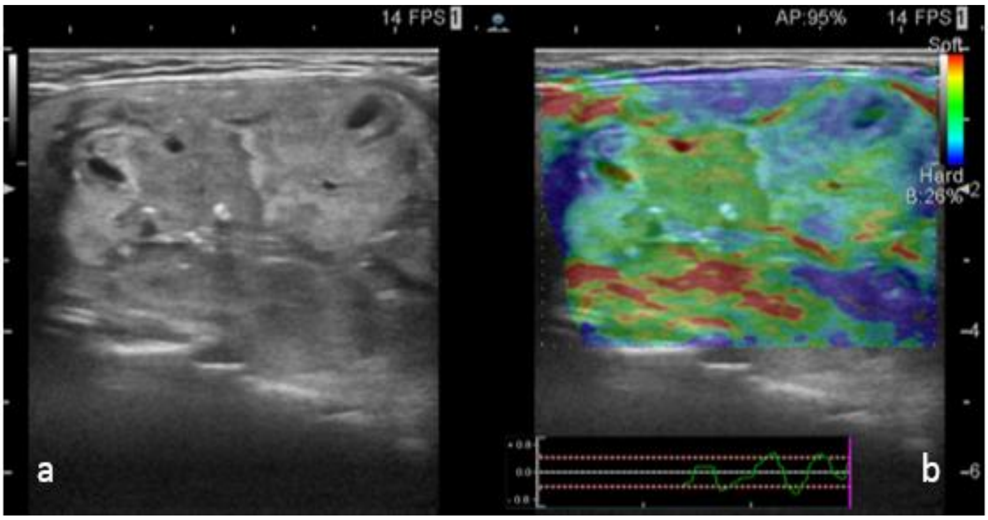


Fig-13: Year old female patient with complaints of neck swelling

(a) On sonography a multiple well-defined lesion with few tiny cystic spaces were noted in right lobe of thyroid. The lesion was wider that taller, showing smooth margins, macro calcifications and complete peripheral halo. The TIRADS score of 2 was given.

(b) On elastography it was showing mixed with predominant soft pattern which was given as elastography score of 2. The strain ratio was 1.3.On FNAC this lesion was diagnosed as colloid nodule.

Discussion

Our study was done on 50 patients with thyroid nodules. Total 50 thyroid nodules were evaluated, out of which there were 14(28%) males and 36 (72%) females (all age groups), and most of the cases (n=36) were present in the age group of 25-45 years (72%) and there were 37 (74%) benign cases and 13 malignant cases (26%).

Age Distribution

In our study, 72 %(n=36) of patients were of the age group of 25-45 years and 28 % of patients were above 45 age. 25 year old female was the youngest patient in the study and 71 year old male was the oldest patient in the study group. In our study, in age group of 25-45 years numbers of patients with benign nodules were 29 (80.6%) and patients with malignant nodules were 7 (19.4%). In the age group of above 45 years numbers of patients with benign nodules were 8 (57.1%) and patients with malignant nodules were 6 (42.9%). Hence malignant lesions were common in above 45 years age group, while benign lesions were common in 25-45 age groups (Table-1 and Figure-3). Diana G, Evans RM, Ivanac G. [7] showed that thyroid malignancy was more common in patients who were under 20 years or above 60 years of age than in patients between 20 and 60 years of age and more commonly seen in females. Our study correlates well with Diana G, Evans RM, Ivanac G [7].

Gender Distribution

36 lesions were seen in females out of which 26 (72.2%) were benign and 10 (27.8%) were malignant. 14 lesion were seen in males out of which 11 (78.6%) were benign, while 3 lesions (21.4%) were malignant. Malignant lesions were commonly observed in females than in males (Figure -4).

Nodularity

In our study 14 cases (28%) lesions were single, while in 36 cases (72%) lesions were multiple. Hence multiple lesions in thyroid were common than single lesions. Out of 14 single lesions, 10 lesions (71.4%) were malignant, while 4 (28.6%) were benign. Amongst 36 multiple lesions, 33 (91.7%) lesions were benign and 3 (8.3%) were malignant. Hence the majority of malignant lesions were single and the majority of multiple lesions were benign (Table-4). Mary C. Frates *et al.* [8] did a retrospective cohort study and compared the risk of cancer in patients with single and multiple nodules. They found that solitary nodule has a higher risk of malignancy than multiple nodules. The study also showed that the possibility of thyroid cancer in patient is not dependent on the number of thyroid nodules, also the possibility of thyroid cancer in a patient decreases as the number of nodules increases. Our findings corroborate with findings of Mary C. Frates *et al.* [8]

Region

Right thyroid lobe was involved in 28 cases (56%), left thyroid lobe was involved in 18 cases (36%), while both lobes were involved in 4 cases (8%). Hence the involvement of right lobes was commonly observed in our study.22 (78.6%) benign lesions were seen in the right lobe. 6 (21.4%) malignant lesions were seen in right thyroid lobe. 13 (72.2%) benign lesions were seen in left thyroid lobe. While 5 malignant lesions (27.8%) were seen in left thyroid lobe. 4 lesions involved both thyroid lobe out of which 2 were benign and 2 were malignant (Table-5).

Shape

45 lesions (90%) were wider that taller (aspect ratio 1. All the nodules were malignant. 37 (82.2%) benign lesions were wider that taller with aspect ratio 1 and they all were malignant. It was not seen in benign nodules. Thus an aspect ratio (i.e. anteroposterior diameter relative to transverse diameter) of >1 is associated with malignant thyroid nodules ($P < 0.001$) (Table-6 and Figure -5). The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of shape taller than wider for malignancy were 38.5%, 100%, 100%, 82.2% and 84% respectively. Kim *et al.* [9] found that a solid thyroid nodule that is taller than it is wider has 93% specificity for malignancy. Hong *et al.* [10] found that for detection of malignancy taller than wider feature was the better predictor. They concluded that for the prediction of malignancy 3 meaningful ultrasonography features were the presence of microcacifications, marked hypogenecity and a taller than wide appearance. Our study correlates well with Kim *et al.* [9] and Hong *et al.*[10].

Margins

41 lesions (82%) showed smooth margins, while 9 lesions (18%) showed irregular margins. Out of 41 lesions showing smooth margins, 37(90.2%) lesions were benign and 4(9.8%) lesions were malignant. All the lesions with irregular margins were malignant (100%) (Table-7). The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of irregular margin for malignancy were 69.2 %, 100%, 100%, 90.2% and 92% respectively. Papini *et al.* [11] conducted a prospective study on 494 consecutive patients with nonpalpable thyroid nodules. They found that irregular margins as an independent risk factor of malignancy with the sensitivity of 77.5%

and specificity of 85%. Our study is in accordance with Papini *et al*. [11].

Echogenicity

23 lesions (46%) were hyperechoic. 16 lesions (32%) were hypoechoic and 11 lesions (22%) were isoechoic. Hence hyperechoic lesions were most common and isoechoic lesions least common. Out of 23 hyperechoic lesions, 22 (95.7%) were benign and 1 lesion (4.3%) was malignant. Out of 16 hypoechoic lesions 10 (62.5%) were malignant, while 6 (37.5%) lesions were benign. Out of 11 isoechoic lesions, 9 (81.8%) were benign while 2 (18.2 %) lesions were malignant (Table-8). Thus the majority of benign lesions were hyperechoic or isoechoic. Majority of hypoechoic lesions were malignant. Thus it is observed that hypoechogenicity is an as independent risk factor of malignancy with the sensitivity of 76.9%, specificity of 83.8%, and positive predictive value of 62.5% and accuracy of 82%. Papini *et al*.[11] in their study they could predict malignancy in thyroid nodules using hypoechogenicity as criteria with the sensitivity of 87.1%, specificity of 43.4% and positive predictive value of 11.4%. Koike *et al*. [12] compared Ultrasound features with pathological results and they got the sensitivity of 95% and specificity of 51.4% for hypoechogenicity in malignant nodules. Our study correlates well with Papini *et al.* (11) and Koike *et al*.[12].

Vascularity

25 lesions (50%) showed both peripheral and central vascularity, 17 lesions (34%) showed peripheral vascularity, 4 lesions (8%) showed central vascularity, while 4 lesions (8%) were avascular. Thus the majority of lesions either showed combined central and peripheral vascularity or peripheral vascularity. Out of 17 cases of thyroid nodules showing peripheral vascularity 14 (82.4%) were benign and 3(17.7 %) were malignant. 18 (72%) benign nodules and 7 (28%) malignant nodules showed both peripheral and central vascularity. 2 (50%) of benign nodules and 2 (50%) malignant nodules showed central vascularity. No vascularity was seen in 3 (75%) benign nodules and 1 (25%) of malignant nodules (Table-13). Thus the majority of benign nodules showed either peripheral and central vascularity or peripheral vascularity. Majority of malignant nodules showed both peripheral and central chaotic vascularity and central vascularity. Diana G, Evans RM, Ivanac G. [7] found that malignant thyroid nodules show intranodal vascularity with chaotic arrangement with or without peripheral vascularity and benign nodules show either absent or peripheral vascularity. Frates *et al*. [13] found out if color Doppler can aid in the prediction of malignancy of thyroid nodules, they found that solid hypervascular thyroid nodules better predictor of malignancy (nearly 42% in their series). The color characteristics of a thyroid nodule, however, could not be used to exclude malignancy confidently, because 14% of solid non-hypervascular nodules were malignant. Our study correlates well with Diana G, Evans RM, Ivanac G. [7] and Frates *et al*. [13].

Composition

45 lesions (90%) were solid, 3 lesions (6%) were mixed (both solid and cystic component), while 2 lesions (4%) were spongiform. Purely cystic lesions were excluded in this study. Hence majority of lesions were solid. 32 (71.1%) of benign nodules and 13 (28.9%) of malignant nodules were solid. All 3 mixed nodules were benign. All 2 spongiform nodules were benign (Table-11). Thus majority of benign nodules were solid and all malignant nodules were solid. The specificity of solid composition for malignancy was 86.5%. Koike *et al*. [12] got 81.8% specificity for solid composition. Our study is in accordance with Koike *et al*.[12]

Peripheral Halo

28 lesions showed the presence of peripheral halo, out of which 27 lesions (54%) showed complete halo and 1 lesion (2%) showed incomplete peripheral halo. 27 (100%) of benign nodules showed peripheral thin and complete halo. None of the malignant nodules showed complete peripheral halo. 1 malignant nodule showed incomplete peripheral halo. None of the benign nodules showed the incomplete peripheral halo (Table-12). The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of complete peripheral halo for the nodule to be benign were 100%, 73%, 56.5 %, 100%, and 80 % respectively. Hoang JK, Lee WK, Lee M, Johnson D, Farrell S [14] found that complete and uniform peripheral halo was most commonly found in benign nodules with a specificity of 95%. It is absent in more than 50 % of nodules. Incomplete halo can be found in malignant nodules. Our study is in accordance with Hoang JK, Lee WK, Lee M, Johnson D, Farrell S [14].

Calcification

Calcification was seen in 12 lesions (24%), while 38 lesions (76%) showed a lack of calcification. Majority of cases showed a lack of calcification. Punctate echogenic foci were seen in 5 lesions (10%), macrocalcification was seen in 4 lesions (8%) and peripheral rim calcification was seen in 1 lesion (2%), while comet tail artifacts were seen in 2 lesions (4%). 12 nodules showed the presence of calcification out of which 7 (58.3%) were benign and 5(41.7%) were malignant. 38 cases showed lack of calcification out of which 30 (78.9%) were benign and 8 (21.1%) were malignant. Out of 5 cases showing punctate echogenic foci, all 5 cases were malignant nodules and all of them were papillary carcinoma. 4 cases of thyroid nodules showing macrocalcification were benign nodules. 1 case of peripheral rim calcification was benign nodule. 2 cases showing comet tail artifacts were benign nodules. 38 nodules showed the absence of calcification, out of which 30(78.9%) were benign and

8 (21.1%) were malignant (Table-9 and 10). Thus benign nodules showed macrocalcification, peripheral rim calcification ad comet tail artifacts. The specificity, positive predictive value, negative predictive value and accuracy of punctate echogenic foci for malignancy were 100%, 100%, 82.22% and 84 % respectively. Popli MB, Rastogi A, Bhalla P, Solanki Y.[15] conducted a study on 240 nodules and found that thyroid lesions showing punctate echogenic foci like microcalcifications were found to be malignant in 87.8% patients. They found specificity as 97.9%. They showed that microcalcifications were the highly specific indicator of malignancy with a high positive predictive value of 87.8%. Our study is in accordance with Popli MB, Rastogi A, Bhalla P, and Solanki Y [15].

Out of 50 cases, 5 cases (10%) were showing the presence of extra-capsular spread. All of the 5 cases showing the extra capsular spread were malignant. Out of 45 cases which were not showing the extra capsular spread, 37 cases were benign and 8 cases were malignant. Associated regional lymph nodal metastases were seen in 3 cases (23%) out of 13 malignant cases. These were shown by one papillary carcinoma, one poorly differentiated follicular carcinoma and patient with a known case of carcinoma of the breast.

TIRADS

TIRADS score of <4 were obtained in 27 lesions (54%). TIRADS score of 4 was obtained in 14 lesions (28%). While TIRADS score of 5 was observed in 9 lesions (18%).TIRADS score of 1-3 were observed in 27 thyroid nodules of which 26 (96.3%) were benign and 1 (3.7%) was malignant. TIRADS 4-5 were observed in 23 thyroid nodules of which 11 (47.8%) were benign and 12 (52.2%) were malignant. Thus TIRADS score 1-3 were commonly observed in benign nodules. TIRADS score 1 was observed in 1 thyroid nodule which was benign nodule. Score 2 was observed in 4 nodules which were also benign nodules. Score 3 was observed in 22 nodules, out of which 21 were benign (95.5%) and 1 was malignant (4.5%). TIRADS score 4 was observed in 14 thyroid nodules, out of which 11 were benign (78.6%) and 3 were malignant (21.4%). TIRADS score 5 was observed in 9 nodules, out of which all of them were malignant nodules. Thus TIRADS score 1-2 suggestive of benign nodules. TIRADS score 3 and 4 was observed in both benign and malignant thyroid nodules, more in benign nodules. TIRADS score 5 suggestive of malignant nodules (Table-15and 16). The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of TIRADS criteria in our study were 92.3%, 70.3%, 52.2%, 96.3%,and 76%, respectively. Hoang JK *et al.* [16] conducted a retrospective study using American College of Radiology (ACR) Thyroid Imaging Reporting and Data System (TI-RADS)[6] criteria to evaluate 100 thyroid nodules by ultrasound features which were cytologically or pathologically proven. They found that after applying ACR TI-RADS criteria, overall sensitivity, specificity, and accuracy were 92%, 44%, and 52%, respectively. Our study correlates well with Hoang JK *et al*.[16].

Elastography

Elasticity score 4 was seen in 12 lesions (24%), score 3 was observed in 11 lesions (22%). Score 2 was observed in 22 lesion (44%) and score 1 was observed in 5 lesions (10%). 38 of thyroid nodules showed elasticity score of 1-3 out of which 37(97.4 %) were benign and 1 case(2.6%) was malignant. 12 thyroid nodules showed an elasticity score of 4, all of which were malignant. Thus elasticity score 4 was seen in malignant thyroid nodules. Elasticity score 1 was seen in 5 thyroid nodules, all of them were benign (100%). Elasticity score 2 was seen in 22 thyroid nodules (100%), all of them were benign. Elasticity score 3 was seen in 11 thyroid nodules, out of them 10(90.9%) were benign and 1 was malignant (9.1%). Thus elasticity 1 and 2 were seen in benign thyroid nodules (Table-17 and 18). The sensitivity, specificity, positive predictive value, negative predictive value and accuracy of elasticity score for malignancy were 92.3%, 100%, 100%, 97.4% and 98 % respectively. Wang *et al*.[17] conducted a study using traditional ultrasonography and real-time elastography on 131 thyroid solid nodules. They found that the sensitivity and specificity of the elastography for thyroid diagnosis of malignancy were 78% and 80%, respectively. Asteria *et al*. [5] conducted a prospective study on 67 consecutive patients with 86 thyroid nodules to evaluate the diagnostic accuracy of real-time ultrasound elastography in the differential diagnosis of thyroid malignancy. They reported that sensitivity; specificity, positive predictive value, negative predictive value and accuracy of elasticity score for malignancy were 94.1%, 81%, 55.2%, 98.2% and 83.7%. Rago *et al*.[18] conducted a study on 92 patients using 5 point elasticity score. They found that the elasticity scores 4 and 5 were highly predictive of malignancy (P < 0.0001). In their study, they found sensitivity; specificity, positive predictive value and negative predictive value were 97%, 100%, 100% and 98%. Therefore they concluded that high elasticity score, being the finding with the highest sensitivity and specificity, was in statistically significant relation with malignancy. Colakoglu *et al*. [19] conducted a study on patients with 293 thyroid nodules. They found that patterns 3 and 4 were malignant, and patterns 1 and 2 were benign. The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of elastography were 100%, 80.2%, 61.7%, 100%, and 85%, respectively. Our study is in accordance with Wang *et al*. [17], Asteria *et al*. [5], Rago *et al.* [18] and Colakoglu *et al*.[19].

In our study, we used strain ratio elastography for improving the diagnostic accuracy of sonographic examination of the thyroid gland. We prospectively evaluated the elastographic appearance of 50 thyroid lesions and we found that strain ratio greater than 4 was the greater predictor of malignancy ($P < 0.001$). Strain ratio ≥ 4 was seen in 10 lesions (20%) and < 4 was seen in 40 lesions (80%). Strain ratio of ≥ 4 was seen in 10 thyroid nodules, all of which were malignant. Strain ratio of < 4 was observed in 40 thyroid nodules. Out of which 37 (92.5 %) were benign and 3(97.5%) were malignant (Table-19 and 20). Mean strain ratio in 13 malignant nodules was 4.9±1.5. Mean strain ratio in 37 benign nodules was 1.5±0.9. Mean strain ratio in adenomatous nodule was 1.6±0.8, follicular adenoma was 1.7±1.5 and for multinodular goiter was 0.8±1. For follicular carcinoma mean strain ratio was 4.5±1.4, for papillary carcinoma 5.3±1.7 and metastatic carcinoma from carcinoma of the breast was 4.5. Thus both the elastography score and strain ratio were lower for benign nodules and higher for malignant nodules. The values of strain ratios were higher than 4 was in statistically significant relation with malignancy. Receiver operating characteristic curve analyses was done using the specificity and sensitivity of elastography scores, strain ratio and TIRADS scores to differentiate benign from malignant thyroid nodules. The AUC was 0.996 for strain ratio cut off value as 4. The AUCs of strain ratio was greater than elastography scores and TIRADS scores. Receiver operating characteristic (ROC) analysis (Figure-6) demonstrated that the optimum strain ratio cut-off value for discriminating between benign and malignant lesions was 4.05(at 100% specificity). Diagnostic accuracy of both elastography scoring and strain ratio was higher than TIRADS scoring. After applying strain ratio criteria as 4, we found overall sensitivity, specificity, positive predictive value, negative predictive value and accuracy were 76.9%, 100%, 100%,92.5% and 94% respectively. Wang *et al*. [20] conducted a prospective study to compare the strain ratio in malignant and benign thyroid nodules. They found that as compared elastography scoring system strain ratio findings were more specific for differentiating between benign and malignant nodules. They found that mean strain ratio malignant nodules (5.34 ± 2.55) were higher than for benign nodules (2.06 ±1.29). The AUC of strain ratio was higher than that of the elastography score system. Our study correlates well with Wang *et al*. [21] Lyshchik *et al*. [21] found that a strain index greater than 4 was the strongest independent factor in predicting malignancy of nodules, with 82% sensitivity and 96% specificity. Ning *et al*.[22] reported that both the elastography score system and strain ratio were lower for benign nodules and higher for malignant nodules. Our study is in accordance with Wang *et al*. [20], Lyshchik *et al*. [21] and Ning *et al*. [22].

On histopathology 30 lesions (60%) were adenomatous nodule or hyperplastic or colloid nodules, 5 lesions (10%) were follicular adenoma, 2 lesions (4%) multinodular goiter, 8 lesions were papillary carcinoma(16%), 4 lesions (8%) were follicular carcinoma and 1 lesion turnout to be metastasis from carcinoma breast(2%). There were in all 13 malignant cases out of which (n=5) % were taller that wider in shape with the aspect ratio >1. (n=5) 38.4% cases showed the presence of extracapsular spread. (n=9)69.2 % nodules showed irregular margins. All the cases of nodules were solid in composition, (n=10) 77% cases appeared hypoechoic and (n=2) 15.3% cases appeared isoechoic and only one case was hyperechoic (7.7%). (n=5) 38.4% cases showed the presence of microcalcification like punctate echogenic foci within the nodules and they all were found to be papillary carcinoma on FNAC. In our study groups, papillary carcinoma was the most common malignant tumor to occur. Out of 8 cases of papillary carcinoma found in our study, 5(62.5%) cases were showing microcalcifications like punctate echogenic foci. Also (n=3) 37.5% cases there was an absence of any type of calcification. All of them were solid in composition, Out of 8 cases, 7 were showing irregular margins and one was showing smooth margins.4 cases were showing taller than wide shape and 4 were showing wider than tall shape.7 lesions were hypoechoic and one was isoechoic .4 lesions were showing mixed peripheral and chaotic central vascularity, 2 lesions were showing central vascularity, one lesion was showing only peripheral vascularity and one lesion was avascular. 4 lesions were showing presence of extracapsular invasion. One lesion was showing associated regional cervical lymph nodal metastasis. There was no presence of peripheral halo was in any of the cases. All were showing elasticity score of 4. Mean strain ratio for papillary carcinoma was 5.3±1.7. Out of 8 cases of papillary carcinoma, 7 (87.5%) were showing TIRADS score of 5 and one was showing TIRADS score of 4(12.5%). Total 4 cases of follicular carcinoma were seen. All of them were solid in composition. One case was showing irregular margins and 3cases were showing smooth margins.3 cases were wider than tall and one case was taller than wide.2 cases were showing hypoechogenicity, one was isoechoic and one was hyperechoic. One case was showing incomplete peripheral halo and rest cases were not showing the presence of peripheral halo.3 lesions were showing both central and peripheral vascularity and one lesion was showing only peripheral vascularity . 2 lesions were given TIRADS a score 4, one lesion was given a score 3and one lesion was given TIRADS score 5. On elastography, 3 lesions were showing score of 4 and one lesion was showing score of 3. For follicular carcinoma mean strain ratio was 4.5±1.4. One lesion was showing extracapsular spread and one lesion was associated with regional cervical lymph nodal metastasis. Few limitations were observed while conducting this study. Among the malignant lesions, numbers of patients with papillary carcinoma were high and patients with medullary or anaplastic carcinoma were not found during the study period. Thus imaging features of anaplastic and medullary carcinoma require further study. Therefore, future studies with large samples are required for finding more diverse patient groups. The elastography score system had inter-observer variations as it depends upon the observer. The deeper lesions were receiving less pressure and resulting into less tissue distortion. Thus elastography scoring is affected by the depth of the lesion.

Conclusion

Grey scale ultrasonography, color Doppler, power Doppler and real-time elastography were extremely useful in studying characteristics of thyroid nodules. Ultrasound can predict if the lesion is benign or malignant. When it is combined with TIRADS scoring, elastography scoring and strain ratio, it can give an accurate diagnosis. TIRADS scoring helps to decrease unnecessary FNACs of benign thyroid lesions. Diagnostic accuracy of both elastography scoring and strain ratio was higher than TIRADS scoring.

Ethical consideration

Institute Ethics Committee Clearance was obtained before the start of the study. Informed consent was obtained from all patients for being included in the study.

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