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ORIGINAL ARTICLE

HIGH RESOLUTION ULTRASONOGRAPHIC AND COLOUR DOPPLER EVALUATION OF THYROID LESION

Amit Jain[1], J. S. Sikarwar[2], Atul Saraogi[3]

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ABSTRACT: OBJECTIVE: The objective was to assess the utility of gray-scale USG and colour doppler to identify patterns of thyroid lesions and to correlate the characteristics of benign and malignant nodules with pathological diagnosis. **MATERIALS AND METHODS:** From September 2013 to September 2014, a total of 100 patients (17 males and 83 females) were included in this study. The gray scale and Doppler characteristics of various lesions were determined. The results were then compared with fine needle aspiration (FNA)/histopathological diagnosis. **RESULTS:** Of the 100 patients examined, 9 (9%) were found to be malignant on cytopathology. The malignant nodules demonstrated presence of microcalcification (Sensitivity 44.5%, specificity 98.5%); irregular or poorly defined margins (Sensitivity 77.7%, specificity 90%); absent or thick incomplete halo (Sensitivity 88.8%, specificity 87.3%); RI >0.7(sensitivity 88.8%, specificity 95.7%) and type iii and iv flow(sensitivity 77.7%, specificity 59%). **CONCLUSION:** Gray-scale USG and colour Doppler features of thyroid nodules are useful to distinguish patients with clinically significant thyroid nodules from those with innocuous nodules despite the overlap of findings. From our study, it is apparent that the USG findings of poorly defined margins, absent halo and RI> 0.7 have a high diagnostic accuracy and microcalcifications have high NPV for identifying malignant thyroid nodules.

KEYWORDS: Sonography, thyroid, lesions.

INTRODUCTION: Thyroid lesions are a common finding in the general population, esp. in iodine deficiency areas such as in our country thyroid disorders like thyroid neoplasm still pose a major problem in both developing and developed countries. Nodular abnormality of thyroid represent a significant problem all over the world, the incidence of nodular thyroid disease is on the rise owing to the association of childhood irradiation with increased incidence of both thyroid nodularity and carcinoma. In western countries approx. 5% and in iodine deficient countries approx. 25% of the general population have thyroid nodules. Although most of them are benign, 5-10% of thyroid nodules are malignant.

Among the several imaging techniques that provide clinically useful anatomic information and pathologic condition about thyroid gland, sonography has become the method that is most commonly employed.[1],[2],[3],[4] It's use has resulted in early and accurate detection of various thyroid disorders. This is of immense help in timely management and prevention of complications.

Colour Doppler sonography is used in thyroid vascular study. Dynamic information such as velocity and direction of blood flow as well as degree of vascularity of organ can be revealed by colour doppler studies. Ultrasound vascular study is a noninvasive and low cost method.

The purpose of the study was made to evaluate and establish certain gray scale and colour doppler criteria for distinguishing between benign and malignant thyroid lesions.

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MATERIALS AND METHODS: From September 2013 to September 2014, a total of 100 patients with clinically swelling in neck referred from the outpatient department (OPD) of our institute were included in this study. Of these, 17 were males and 83 were females. In all, 100 patients were evaluated sonographically, and all patients then proceeded for an FNA exam. The patients were in the age range of 13-75 years. A thorough clinical history was obtained. Investigations to be performed were explained to each patient and written informed consent was taken. The study was approved by the ethics committee of the institute.

USG EXAMINATION:

TECHNICAL CONSIDERATION:

- Colour Doppler ultrasound unit – Aloka Prosound alpha-6.
- High frequency linear array ultrasound transducer.
- Ultrasound jelly.

Linear array transducer were preferred to sector transducer because of wider near field of view and the capability to combine high frequency gray scale and Colour Doppler images.

Doppler settings were standardized to compare the vascularity of thyroid pathologies among different patients and to ensure intra individual consistency.

Observations were recorded in the proforma.

TECHNIQUE OF SCANNING: Patients were scanned in supine position. Visualization was enhanced by performing the examination with the neck hyper extended and by asking the patient to swallow so as to elevate the subclavicular portion of the gland. A small pad was placed under the shoulders to provide better exposure of the neck, particularly in patients with short stocky habitus.

Scans were obtained in standard transverse & longitudinal as well as multiple oblique positions. Alteration in echogenecity and echotexture were noted and focal nodules were localized, measured and characterized.

Examination was laterally extended to include the region of carotid artery and jugular vein to identify enlarged jugular chain of lymph nodes, superiorly to visualize submandibular adenopathy and inferiorly to define any pathological supraclavicular lymph nodes

OBSERVATIONS: The findings in the study on 100 patients referred to the department of radiodiagnosis are given below.

There were 83 females and 17 males of the total 100 cases. The male to female ratio in our study 1:4.88.

The age group studied included patients ranging from 75 yrs with youngest being female of 13 years and oldest male of 65 years. The major age group affected is between 20-40 years with 56 percentage cases.

Thyroid disorders can either be diffuse or nodular. Thyroid disorders are predominantly nodular with ratio of diffuse to nodular being 1:4

Heterogeneous involvement of thyroid parenchyma was a feature of 15 (75%) patients. Fine 1-6 mm micro nodules were present in only 3 (27%) patients.

Out of total 80 thyroid nodules 18.75% were cystic, 51.25% were solid and 30% were mixed in Echotexture.

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Various B-Mode Criteria used in characterization of thyroid nodules are echogenecity, margins, halo and calcification. They are tabulated in Table No.1.

B-Mode Findings	No. of Cases N-49	Percentage
ECHOGENECITY		
Hypoechoic/Echofree	44	55%
Isoechoic	21	26.25%
Hyperechoic	15	18.75%
A) HALO		
Thin & Complete	64	80%
Thick & Incomplete	16	20%
B) MARGINS		
Regular	67	83.75%
Irregular	13	16.25%
C) Calcification		
Microcalcification	5	6.25%
Coarse Or Egg Shell	14	17.5%

TABLE 1: INCIDENCE OF DIFFERENT B-MODE FINDINGS IN THYROID NODULES

Out of the total 80 nodules 21 were Isoechoic, 15 Hyperchoic and 44 Hypoechoic. 64 patients has thin and complete halo around the nodule whereas 16 patients has thick, incomplete or absent halo. Margins of the nodule were regular in 67 cases whereas it was Irregular in 13 cases.

All the patients didn't show calcification. Only 5 patients have Microcalcification whereas 14 patients have evidence of coarse of eggshell calcification.

Nodular Vascularity was determined by colour Doppler and classified into 4 types which are shown in Table No.2.

Colour Doppler Pattern	No. of Cases	Percentage
Type I	18	22.5%
Type II	26	32.50%
Type III	34	42.50%
Type IV	2	2.5%
Total	**80**	**100%**

TABLE 2: COLOUR DOPPLER PATTERN IN THYROID NODULES

The table shows that most of the patients have type III pattern & II. Type I pattern in which there is only peripheral flow is seen in 18 (22.5%) nodules. Type II pattern having peripheral and central component of flow with peripheral component predominating is seen in 26 (32.5%) patients. Type III pattern with central component predominating over the peripheral is seen in 34 (42.5%) patients. Only 2 patients had type IV pattern, which has only central flow.

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Colour Doppler indices, which were taken into account in our study, were resistive index and peak systolic velocity. They are depicted in Table No.3.

Colour Doppler Indices	No. of Cases N-49	Percentage
Resistive Index (RI)		
<0.70	71	88.75%
>0.70	9	11.25%

TABLE 3: COLOUR DOPPLER INDICES IN THYROID NODULES

Most of the thyroid nodules (88.75%) have resistive index less than 0.7 with only 11.25% having RI over 0.7.

On the basis of different B-Mode criteria diagnosis was assigned to the patient, which was then compared with FNAC. Sensitivity and specificity of each diagnosis was calculated which is shown in Table No. 4.

Thyroid Pathologies	B-Mode	FNAC	False Positive	False Negative	Sensitivity	Specificity
Simple Goitre	11	12	-	1	92.3%	100%
Solitary Thyroid Nodule	15	14	3	2	85.7%	95.6%
Multinodular Goitre	43	40	3	-	100%	93%
Adenoma	15	14	4	5	73.6%	94.2%
Carcinoma	8	9	1	1	90%	98.6%
Hashimoto's Thyroiditis	4	5	-	1	80%	100%
Graves disease	4	6	-	2	75%	100%
Total	**80**	**80**	**11**	**12**	**86.95%**	**-**

TABLE 4: COMPARISON OF B-MODE DIAGNOSIS WITH FNAC

Sensitivity of B-Mode to diagnose malignancy is good 90%. Among diffuse thyroid diseases B-Mode was able to diagnose correctly all but one case of Simple Goitre and sensitivity for Hashimoto's Thyroiditis was 80% B-Mode under diagnosed 2 cases of Grave's disease. Overall sensitivity of B-Mode in diagnosing thyroid pathologies is 86.95%.

The incidence of different B-Mode and Colour Doppler findings in benign and malignant thyroid nodules were studied retrospectively, after the diagnosis was confirmed on FNAC. These different findings are depicted in Table No. 5.

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Ultrasound Findings	Benign		Malignant	
	N	%	N	%
ECHOGENECITY				
Hypoechoic	38	47.5%	6	7.5%
Isoechoic	19	23.75%	2	2.5%
Hyperchoic	14	17.5%	1	1.25%
HALO				
Thin & Complete	62	77.5%	1	1.25%
Thick & Incomplete	9	11.25%	8	10%
MARGINS				
Regular	64	80%	2	2.5%
Irregular	7	8.75%	7	8.75%
CALCIFICATION				
Microcalcification	1	1.25%	4	5%
Coarse or Egg Shell	13	16.25%	1	1.25%
COLOUR DOPPLER PATTERN				
Type I & II	42	52.5%	2	2.5%
Type III & IV	29	36.25%	7	8.75%
RESISTIVE INDEX (RI)				
<0.75	68	85%	1	1.25%
>0.75	3	3.75%	8	10%

TABLE 5: B-MODE & COLOUR DOPPLER FEATURES IN BENIGN & MALIGNANT THYROID NODULES

In our study most of the malignant lesions are Hypoechoic with thick incomplete halo, irregular margins, microcalcification,resistive index >0.70 Colour Doppler pattern type III & IV is 77.8% sensitive and 59% specific for malignancy

Most of the benign lesions are Isoechoic or Hyperechoic with thin complete peripheral halo, regular margins, coarse or eggshell calcification, resistive index <0.70.Colour Doppler pattern type I & II is 59% sensitive and 18.4%specific for benign nodules.

The Positive predictive value (PPV), Negative predictive value(NPV) and diagnostic accuracy of various gray scale and Doppler findings in differentiating malignant from benign lesions are shown in table 6

	PPV	NPV	DIAGNOSTIC ACCURACY
Absent Halo	47 %	98 %	87.5%
Irregular Margin	50 %	96.9%	88.75%
Microcalcification	80%	92.8%	21.25%
RI > 0.7	72.7%	98.5%	95%
Colour Doppler Type III and IV	19.4%	95.4%	61.25%

TABLE 6

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Thus we can see that highest Positive predictive value is with Micro calcification, the highest Negative predictive value and diagnostic accuracy is with RI>0.70.

The sensitivity and specificity of various gray scale and Doppler findings in differentiating malignant from benign lesions is depicted in table below

	Carcinoma	Benign Nodules	Sensitivity	Specificity
Absent halo	8/9	9/71	88.8%	87.3%
Irregular Margin	7/9	7/71	77.7%	90%
Micro calcification	4/9	1/71	44.5%	98.5%
RI >0.7	8/9	3/71	88.8%	95.7%
Type III &IV Flow	7/9	29/71	77.7%	59%

TABLE 7

Thus Micro calcification and RI >0.7 has high specificity in prediction of malignant thyroid nodules.

The specificity of type III and IV flow in detection of malignancy is low.

The effect on sensitivity when type of flow is combined with gray scale features is shown in table no.8

	Carcinoma	Benign Nodules	Sensitivity	Specificity
Absent Halo +Type III &IV flow	6/9	6/71	66.7%	91.5%
Irregular Margin +Type III & IV Flow	5/9	4/71	55.5%	94.36%

TABLE 8

Thus we see that on combination of colour Doppler and gray scale parameters the specificity is increased.

DISCUSSION: The introduction of high-resolution ultrasonography had made it possible to detect many non-palpable nodules in the thyroid. The incidence of such lesions in the general population appears to be high approximately 10-40%.[5,6,7]

The present study was concluded in the department of radiodiagnosis in J.A. Group of Hospitals Gwalior from Oct. 2013-Sept 2014. The study population consisted of 100 patients who were diagnosed to have thyroid abnormality on ultrasonography.

In the present series out of 100 patients 83 were females and 17 were males. There is predominant involvement of thyroid gland in females with F: M ratio of 4.88:1.

In our series most of the patients were found to be in the age group of 20-40 years with mean age 28 years. Youngest patients was a female of 13 years and oldest was a male of 75 years

Early age incidence in our study may be due to increased number of patients with endemic goitre as India is an endemic zone for goitre with 54 million people affected. (Park & Park et al)[8]

The first goal of thyroid ultrasound is to define whether the patient has diffuse or nodular abnormality.

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In our study out of 100 patient 80 patients has nodular thyroid disease and 20 have diffused thyroid disease. Nodular involvement of thyroid is more common than diffuse involvement, which was also observed in another study by Brander A et al.[9]

Out of the total 20 cases of diffuse involvement, heterogeneity was seen in 15 pts, micronodulations was present in only 3 cases. On the basis of these B/mode findings out of 20, 4 patients of each of Grave's, 4 patients of Hashimoto's Thyroiditis and 11 patient of simple goitre were diagnosed.

When the same patients were subjected to Colour Doppler imagin,very high flow was observed in patients of graves' disease. Amount of flow in patients of Grave's disease is very high & this criterion can be used to differentiate between Hashimoto and Grave's disease.

In our study micronodules as a feature of Hashimoto's Thyroiditis is highly predictive. These are small hypoechoic 1-6 mm nodules with an echogenic rim. Our finding correlates with that of Yeh et al[10] who among 67 patients of proven HT found micronodules in 94.7% cases.

Sonography is been used to differentiate between soilid, cystic and mixed thyroid nodules since its inception. Our accuracy was 100% in this respect. In our study out of 80 thyroid nodules we categorized 41 nodules as solid, 15 as cystic and 24 mixed which was later proved correct on FNAC. The incidence of solid lesion was higher in our study.

In our study 36 (45%) thyroid nodules were either Isoechoic or Hyperechoic and 44 (55%) nodules were Hypoechoic. 6/9 malignant nodules were Hypoechoic, the remaining three were one Hyperechoic and two Isoechoic. Hypoechogenecity as a criterion for malignancy has a reasonable specificity but low sensitivity

Presence of Hypoechoic halo is one of the important features to differentiate between benign and malignant thyroid nodules. In our study out of 80 nodules thin & regular halo was seen in 62 benign nodules and 1 malignant nodules. Whereas thick & incomplete or absence of halo was observed in 9 benign and 8 malignant nodules.

From our observation we can say that thick and incomplete halo is more commonly associated with malignant nodules.

Another important criteria taken into account to differentiate between benign and malignant nodule is margin. In our study 66 patients had regular margins out of which 64 were benign and 2 malignant. Irregular margin was found in 7 benign and 7 malignant nodules. This clearly shows that irregular margin is more specifically associated with malignant nodules.

In our study all the patients did not have the evidence of calcification. Out of the total 80 nodules only 19 patients had calcification. Micro calcification was present in 5 patients out of which 4 were malignant and only 1 benign. Whereas 14 patients had either coarse or egg shell calcification out which 13 were benign and only one malignant. Our series indicate that presence of micro calcification or coarse & eggshell calcification is highly specific for malignant and benign thyroid nodules respectively.

In our study colour Doppler pattern was classified into 4 subtypes. Type II & I pattern was seen in 42 benign and 2 malignant nodules This series showed type III & IV pattern in 29 benign and 7 malignant nodules. Thus we can see that type of flow alone has low sensitivity and specificity in differentiating benign from malignant nodules.

Micro calcification as a single characteristic has the highest specificity and PPV of 98.5% and 80% respectively. RI >0.7 has the highest diagnostic accuracy of 95%.When absent halo was

combined with type III and IV flow the specificity increased from 87.3% to 91.5%.Similarly when irregular margin was combined with type III and IV flow specificity increased from 90% to 94.36 %. In our study the results shows that when B-Mode and CD were used simultaneously the overall specificity improved.

In our study FNAC compatible diagnosis was reached in 69 out of 80 patients. Sensitivity of B-Mode to detect nodular lesion in our study was 86.9% as compared to that of 75% by Garetti & Gallo et al.[11] When both modalities are combine together sensitivity decreased marginally but there was significant improvement of specificity.

CONCLUSION: High resolution ultrasonography is highly sensitive in diagnosing thyroid disorders. Colour Doppler acts as an important adjunct to B-mode in increasing the accuracy.

In our study we concluded that:

- Non-neoplastic nodules and adenomas usually present with regular margins whereas irregular margin is more a feature of carcinoma.
- Adenomas and non-neoplastic nodules are more commonly associated with thin and complete halo. Halo is thick, incomplete or absent in most of the carcinoma.
- Micro calcification has highest specificity for malignancy on B-Mode.
- Colour Doppler pattern is not sensitivity and specific in differentiation of malignant and benign thyroid nodules in isolation. However on combination with gray scale findings type III& IV pattern of flow increases the specificity of diagnosis of malignancy.
- Resistive index <0.70 in majority of non-neoplastic nodules. Carcinoma usually have RI >0.70
- Specificity and positive predictive value of diagnosing a lesion as malignant increases, when combination of criteria is used, instead of individual criteria.

The goal of imaging should be to avoid extensive and costly evaluation in the most patients with benign disease without missing the minority of patients with thyroid cancer. High-resolution ultrasonography has proved high sensitivity in the detection of very small nodular lesions of the thyroid. Its specificity in definition of benign from malignant nature is being greatly improved by the new vascular pattern and resistive index parameters using pulsed Doppler. In this study we found no single criteria that could distinguish benign from malignant thyroid nodules with 100% reliability. FNAC still offers the highest accuracy. Thyroid sonography is most useful in the differentiation between definitely benign nodules from suspicious which can then be subjected to further evaluation by FNAC.

REFERENCES:

1. Solbiati L, Charboneau JW, Osti V, James EM, Hay ID. The Thyroid Gland. In: Wilson SR, Charboneau JW, Rumack CM, editors. Diagnostic Ultrasound. 3 rd ed. Missouri: Mosby, Elsevier Inc.; 2005. p. 735-70.
2. Yeung MJ, Serpell JW. Management of the solitary thyroid nodule. Oncologist 2008; 13: 105-12.
3. Cooper DS, Doherty GM, Haugen BR, Kloos RT, Lee SL, Mandel SJ. Revised American Thyroid Association Management Guidelines for Patients with Thyroid Nodules and Differentiated Thyroid Cancer. Thyroid 2009; 19: 1167-214.

4. Mortenson J, Woolner L, Benneu W. Gross and microscopic findings in clinically normal thyroid glands. J. Clin EndocrinoMetab1955; 15: 1270-80.
5. Brander A, Viikinkoski P, Nickels J et al. Thyroid glad: US screening in middle-aged women with no previous thyroid disease. Radiology 1989; 737: 507-510.
6. Gorges R, Eising EG, Fotescu D et al. Diagnostic value of high resolution B-mode and power-mode sonography in the follow-up of thyroid cancer. Eur J Ultrasound, 2003 Feb; 16(3) 171-206.
7. Solbiati L, Cioffi V, Balarati E et al. Ultrasonography of the neck. Radiol Clin of North Am 1992; 30: 941-954.
8. Park & Park. Preventive and Social Medicine; 15th edition: p 306.
9. Brander A, Viikinkoski P, Nickels J et al. Thyroid gland: US screening in middle-aged women with no previous thyroid disease. Radiology 1989; 737: 507-510.
10. Spiezia S, Cerbone G, Colao A et al. usefulness of power Doppler in the diagnostic management of hypoechoic thyroid nodules. Eur J Ultrasound. 1997 Dec 1: 6(3): 165-170
11. Garretti L, Gallo N, Balma E et al. Integration of B-mode and colour Doppler ultrasonography in the preoperative diagnosis of thyroid lesions. Preliminary experience in 91 cases. Minerva Chir. 1997 Jun; 52(6): 783.

AUTHORS:

1. Amit Jain
2. J. S. Sikarwar
3. Atul Saraogi

PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Radio-diagnosis, G. R. Medical College & J. A. Hospital, Gwalior.
2. Associate Professor, Department of Radio-diagnosis, G. R. Medical College & J. A. Hospital, Gwalior.
3. 3rd Year Post Graduate Resident, Department of Radio-diagnosis, G. R. Medical College & J. A. Hospital, Gwalior.

NAME ADDRESS EMAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Atul Saraogi,
Room No. 48,
P. G. Hostel, J. A. Hospital,
Gwalior.
E-mail: aulinvincible@yahoo.co.in

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