



Role of Color Assisted Duplex Sonography in Evaluation of Thyroid Diseases

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Abstract

Objectives: *The study evaluated the pattern including vascular pattern in clinically significant thyroid diseases using color assisted duplex sonography*

Methods: *In this prospective study of 40 patients, with clinical thyroid diseases, color assisted duplex sonography was performed, later they underwent ultrasound guided fine needle biopsy of the lesions detected. The thyroid volume was calculated, evaluation of the sonographic pattern and Doppler examination of the thyroid gland was done. Evaluation of thyroid nodules and classification into benign and malignant nodules on the basis of sonographic patterns were also done. Pre- designed proforma were used to collect patient data, clinical findings, laboratory reports and Doppler reports. Findings of the thyroid ultrasound scan were correlated with the clinical and laboratory findings*

Results: *Acceptable ultrasonographic images and Doppler waveforms were obtained in all patients. All were subjected ultrasound guided fine needle biopsy. Ultrasound was able to pick up lesions in all with a sensitivity and specificity of 100%. Ultrasound had a 100% sensitivity and specificity in detection of chronic thyroiditis. Color assisted duplex sonography was able to identify benign lesions with a sensitivity of 88% and specificity of 100%. and malignant lesions with sensitivity of 75% and specificity of 97%*

Conclusion: *Thyroid ultrasound is very efficient in differentiating solid from cystic lesions, solitary nodules from multinodular, diffuse enlargement from extra thyroidal lesions. It is helpful in differentiating between the malignant and benign nodules when used with certain ultrasound patterns. Color flow doppler sonography can differentiate untreated Grave's disease from Hashimoto's thyroiditis which has similar gray scale findings.*

Keywords: *Color Assisted Duplex, Evaluation Of Thyroid Diseases.*

Introduction

The thyroid gland maintains the normal growth and activity of humans. It is one of the major secreting organs, the secretion being generated by its own auto-regulatory mechanism. Any factor causing a discrepancy in the auto regulatory function results in a spectrum of thyroid function

disorders. Knowledge of the prevalence of thyroid disorders in the general population is based on clinical epidemiological studies and autopsy series. Iodine deficiency is one of the important causes for thyroid disorders. India is in the transition phase from iodine deficiency to iodine sufficiency, and this is expected to change the

thyroid status of the population. The thyroid status and the auto-immune status of adult Indian population is largely unknown⁽¹⁾. The clinical spectrum of thyroid diseases vary from a simple benign goitre to a profound malignancy. So it is essential to have proper imaging tools for the evaluation of thyroid gland. Before the advent of high resolution ultrasound capability, radionuclide scintigraphy was the chief means to evaluate the thyroid gland both functionally and morphologically. Along with being much safer and nonionising, ultrasound is also a much cheaper alternative. C.T and M.R.I are used in the evaluation of thyroid masses, but are not as sensitive as ultrasound in the detection of intrathyroidal lesions but are used for the evaluation of mediastinal extension of thyroid masses⁽²⁾. Thyroid ultrasound differentiates solid from cystic lesions, solitary nodules from multinodular and diffuse enlargement, and extrathyroidal lesions. Nearly 50% of patients with a clinically solitary thyroid nodule have avoided surgery by thyroid scanning⁽²⁾. The newly developed high resolution ultrasonography with color doppler flow mapping can reveal fine details of the thyroid gland and the haemodynamic features of thyroid neoplasms⁽³⁾. Thus the combination of conventional sonography and color flow doppler provides benefits in increasing the screening sensitivity and accuracy in distinguishing malignant thyroid nodules⁽⁴⁾ and hence the need for the study.

Objectives

- To evaluate the pattern of duplex sonography of clinically significant thyroid diseases.
- To study the waveform and vascular pattern of thyroid diseases using duplex sonography.

Materials and Methods

Present study included a total number of 40 patients meeting the inclusion criteria.

Inclusion Criteria

Clinically suspected cases of thyroid diseases.

As a pre requisite before surgery in patients of thyroid diseases.

The exclusion criteria were:

Pregnant patients

Patients not willing to undergo ultrasonography and fine needle aspiration cytology.

Color assisted duplex sonography was performed following a detailed history and physical examination. Ultrasound guided FNAC was done as soon as informed consent was taken. Later the patient was subjected to thyroidal hormonal assay depending on the clinical and sonological picture

Ultrasound scanning

Technique

In our study, we use 7.5- 12 MHz short focus transducer without water bath. All cases were examined with contact scanning method.

Positioning of the patient

The patient is examined in the supine position with the neck hyperextended. 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 end 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 gland was evaluated using the well-established criteria of solid, mixed and cystic pattern.

Solid nodules were divided into (A) homogeneous and (B) heterogenous pattern.

The homogeneous being subdivided into

- i) hyperechoic, ii) isoechoic and
- iii) hypochoicetexture.

The mixed group was divided into

- i) predominantly solid, ii) predominantly cystic and iii) complex group where no delimit-component was predominant, the predominantly solid group was again divided into a) hyperechoic, b)isoechoic and c) hypoechoic depending upon the echo pattern of the solid elements

The margins of the nodule were evaluated for regularity, surrounding and calcification. In addition, surrounding structures were studied in any pathology especially lymphadenopathy. Lymph node with any abnormal features in terms of size or echotexture also underwent FNAC.

Technical factors are important to produce adequate images.

Major Consideration Includes

- Power- Adequate power to penetrate thyroid tissue. It is best to keep the power at the minimum level required to penetrate the thyroid gland.
- Gain- The variable gain needed is provided by time gain compensator.
- Transducer - High resolution linear array transducers ranging from 7.5 to 10 MHz can be used.
- Use of power Doppler to detect minimal intranodal vascularity.

Diagnosis & Follow up:

After the history, physical examination, ultrasound examination, thyroidal hormonal array and FNAC, a diagnosis is made. Some cases were subjected to histopathological examination when necessary. Color Doppler was applied in order to study the vascularity of the thyroid gland. The inferior thyroid artery was identified by duplex sonography and spectral waveforms were

obtained. Power Doppler was applied to detect intranodal vascularity.

Statistical Analysis

Statistical analysis was done by using proportions. The sensitivity, and specificity and positive predictive value were determined for all cases using the following formulae.

Sensitivity = $A / (A+C)$

Specificity = $D / (D+B)$

Positive predictive value = $A / (A+B)$

Negative predictive value = $D / (D+C)$

A = True positive, B = False positive, C = False negative, D = True negative

Results

40 patients with clinically suspected thyroid diseases were evaluated with color assisted duplex sonography. Acceptable images were obtained in all cases.

Table -2: Sex Distribution

Sex	No. of patients	Percentage
Female	35	87.5
Male	5	12.5
Total	40	100

Table -3: Age and Sex Distribution

Age in years	Male	Female	Total	Percentage
0-10	0	0	0	0
11-20	1	2	3	7.5
21-30	2	14	16	40
31-40	1	9	10	25
41-50	1	4	5	12.5
51-60	0	6	6	15

The age of the patient ranged from 15 years to 56 years. It is evident from the table that the third decade showed the highest incidence. The incidence among females was also highest in this decade. The youngest case in this study was a 15 years old boy and the oldest cases were two women aged 60 years.

Clinical Manifestations

Table 4 : Symptoms

Symptoms	No. of patients	Percentage
Swelling in front of the neck	40	100
Difficulty in swallowing	4	10
Difficulty in breathing	2	5
Hoarseness of voice	3	7.5
Pain in the swelling	3	7.5
Evidence of hyperthyroidism	3	7.5
Evidence of hypothyroidism	0	0

Duration of Swelling

The duration of swelling ranged from 6 months to 10 years. Table 5 showing duration of swelling.

Table -5: Duration of Swelling

Duration	No. of patients	Percentage
0-30 days	0	0
1-6 months	3	7.5
7-12 months	6	15
1-6 years	25	62.5
7-12years	6	15
13-20 years and above	0	0
Total	40	

The longest history was that of a woman aged 60 years with a duration of swelling of 10 years. The shortest duration was that of 6 months in 3 patients.

Clinical Diagnosis

It was arrived from the symptoms and signs by clinical examination. Thyroid function test was also done simultaneously.

Table -6: Clinical Diagnosis

Clinical diagnosis	No. of patients	Percentage
Solitary thyroid nodule	16	40
Multinodular goiter	12	30
Thyroiditis	4	10
Carcinoma of thyroid	1	2.5
Thyrotoxicosis	5	12.5
Thyroid cyst	2	5

Clinical Involvement of Thyroid Gland Clinical Assessment was carried out depending on the extent of lobar involvement and Cervical Lymphadenopathy.

Table -7: Clinical Involvement of the Thyroid Gland

Clinical assessment	No. of patients	Percentage
Right lobe with or without isthmus	6	15
Left lobe with or without isthmus	10	25
Isthmus	0	0
Both lobes	12	30
Diffuse enlargement	12	30
Cervical lymphadenopathy	1	2.5

Ultrasound Evaluation

The size of the nodule varied in our study from 4mm to 6cm. Out of the 40 patients, 16 patients were thought to have solitary nodule by palpation. Ultrasonography was confirmatory in 10 cases. Multiple nodules were detected in 6 cases.

Table- 8: Clinical Diagnosis Confirmed by Ultrasonography

Clinical diagnosis	No. of patients	Percentage
Solitary	16	40
Sonographic findings	10	25
Solitary nodules		
Multiple nodule	6	15

Out of the 40 patients, 12 cases were clinically diagnosed as having multiple nodules. 12 cases were diagnosed as having multiple nodules by ultrasound. Both did not have the same group of patients.

Comparison of Clinical and Ultrasound Assessment of Intrathyroidal Position of Lesion

Table -9: Intrathyroid Location

Intrathyroid location	Clinical assesment	Ultrasonic assesment
Right lobe with or without isthmus	6	7
Left lobe with or without isthmus	10	8
Isthmus	-	-
Both lobes	12	16
Diffuse enlargement	12	9

It seems to be evident that most of the intrathyroidal lesions are seen in both lobes.

Lesion Appearance on Ultrasound and Diagnosis

Table 10: Ultrasound Characteristics Of The Lesion

		No. of patients	Percentage
1	Internal consistency		
	Solid	30	80
	Cystic	4	10
	Mixed	4	10
2	Echogenicity relative to adjacent thyroid parenchyma		
	Hyperechoic	23	57.5
	Hypoechoic	12	30
	Isoechoic	1	2.5
3	Halo		
	Thin complete halo	2	0.5
	Thick incomplete halo	1	2.5
4	Margins		
	Well defined	36	90
	Ill defined	4	10
5	Calcifications		
	Egg shell calcification	1	2.5
	Coarse calcification	1	2.5
	Microcalcification	2	5
6	Doppler		
	Peripheral flow pattern	18	45
	Internal flow pattern	2	5
	Both peripheral and internal flow pattern	12	30
	No significant vascularity	8	20
	Thyroid inferno (PSV>70cm/s)	2	5
7	Others		
	Vascular enhancement	-	
	Cervical lymphadenopathy	1	2.5

Table -11: Ultrasonographic diagnosis of the Cases

	Ultrasound diagnosis	No. of patients	Percentage
1	Solitary nodule-total	10	25
	Adenomatous solitary nodule	6	15
	Follicular neoplasm	4	10
2	Multinodular goiter	12	30
	Cystic lesions	4	10
3	Chronic thyroiditis	7	17.5
4	Graves disease	2	5
5	Carcinoma thyroid	5	12.5

F.N.A.C. Diagnosis

Out of the 40 patients all 40 underwent FNAC, 1 underwent FNAC of cervical lymphadenopathy along with FNAC of thyroid nodule.

Table -12: FNAC Diagnosis of the Present Study

	FNAC Diagnosis	No. of patients	Percentage
1	Colloid goiter		
	Solitary	7	17.5
	Multinodular	16	40
	Total	23	57.5
2	Follicular neoplasm	7	17.5
3	Benign cyst	-	-
4	Chronic thyroiditis		
	Hashimoto's thyroiditis	6	15
	Nonspecific thyroiditis	1	2.5
	Total	7	17.5
5	Papillary carcinoma	3	7.5

Table-13: Comparison between Ultrasonographic and Pathological Diagnosis

	Disease	USG detected	Clinically detected	Pathologically detected
1	MNG	12	12	16
2	Solitary nodule	10	16	14
3	Colloid nodule	6	7	7
4	Follicular neoplasm	4	-	7
5	Thyroid cyst	4	2	-
6	Chronic Thyroiditis	7	4	7
7	Graves disease (toxic goiter)	2	5	-
8	Carcinoma	5	1	3

Table -14: Evaluation of Thyroid Disease by Colour Doppler Duplex Sonography

		Sensitivity	specificity	PPV
1	Detection of thyroid lesions by USG as compared to clinical examination	100%	100%	100%
2	Detection of benign lesions by USG as compared to cytology	88%	100%	100%
3	Detection of malignant lesions by USG as compared to cytology	75%	97%	75%
4	Detection of chronic thyroiditis by USG as compared to cytology	100%	100%	100%

Discussion

With the development of real time small part sonography, it has become practical to evaluate routinely the superficial structures of the neck. A basic and practical use of sonography is the establishment of the precise anatomic location of the palpable cervical mass. The determination of such a mass adjacent to the thyroid gland cannot be always made out on the basis of physical examination alone. Radionuclide studies provide important functional but limited anatomical information. Ultrasound is a useful modality in the work up of thyroid abnormalities. It can easily differentiate between thyroid nodules and other cervical masses. Alternatively sonography may help to confirm the presence of a thyroid nodule when the findings of physical examinations are equivocal. This has added a new dimension to the management of solitary nodule of the thyroid. Rodney J Butch et al in 1985 stated that that the major use of thyroid scanning has been to identify additional thyroid nodules when one of them is palpable. Asymptomatic thyroid nodules are common in the general population especially in the middle aged. Virtually any thyroid disease can manifest itself as one or more nodules. Because of the real problem of morbidity and at times mortality, surgical excision of a solitary nodule should be preserved for all those thyroid neoplasms whose ultrasonographic picture are suspicious of malignancy and cytology reveals malignant cells. Conventional ultrasound is highly sensitive in finding nodules and texture differences in the thyroid gland. In 1978 Brown M C et al stated that ultrasound offers more accurate assessment of thyroid volume than either palpation or radionuclide scanning⁽¹¹⁾. Nirad Mehta et al in 1994 stated that ultrasound of the thyroid is a reliable method for evaluation of solitary thyroid nodules when combined with FNAC⁽⁸⁾. The present series of study consisted of 40 cases who presented with thyroid diseases.

Sonographic Patterns of Thyroid Lesions found:

Colloid Goitre: The most frequent solid lesion is the echogenic nodule, which is also called

adenomatous nodule. More often, the whole gland may consist of adenomatous nodules of nearly equal size. Most of the nodules are hyperechoic, echogenic or mixed echogenic. Few of them are hypoechoic. In our study, we found colloid goitres the commonest lesion with 23 cases out of 40 cases (57.5%). Almost 18 of these lesions were hyperechoic, 1 of the case` was isoechoic. 4 cases were cystic in nature. Nirad Mehta et al in 1993 found colloid goiter in 119 patients. The sonographic patterns of 119 patients were as follows: 13 (10.9%) were hyperechoic 25 (21%) isoechoic, 30(25.2%) was hypoechoic, 5 (4.2%) were heterogenous in echotexture.19 (15.9%) were mixed echogenicity, 20(16.8%) were predominantly cystic and 7 (5.8%) were completely cystic. William Scheible et al found 13 (52%) out of the 25 cases were colloid goiters (98). William Scheible has seen peripheral "halo" rim in 4 of 13 cases and incomplete "halo" in another 4 cases⁽⁵⁾. In our study we saw 2 cases with complete peripheral halo and 1 case with incomplete thick halo. James and Charbeneau mentioned that peripheral or egg shell calcification is the most reliable sign of benign nature of the thyroid nodule. Our study revealed 1 case showing such peripheral or egg shell calcification⁽⁷⁾

Follicular Neoplasm: Follicular adenoma can be clearly distinguished from the adenomatous nodules which are the results of hypertrophy of the glandular tissue. The follicular adenoma is a functional autonomous nodule or a precursor of follicular thyroid neoplasm. The echogenicity of thyroid adenomas vary considerably but the majority are more echogenic than normal thyroid parenchyma and are solitary whereas adenomatous nodules are usually multilocular. In our study, 4 out of the 40 cases (10%) were found to be thyroid neoplasm. On ultrasound all these cases were hyperechoic. Simeone et al found follicular adenoma in 79(68%) out of 116 cases. This was very high when compared to our study.⁽⁶⁾

Thyroid Cyst: Cysts in the thyroid gland can be easily diagnosed by sonography. These cysts are

rarely true epithelial cysts. Most of the reported cystic lesions represents degenerative changes in adenomatous nodular goiter or adenoma. These cysts may contain colloid fluid, yellow fluid (old blood), fresh blood or infective material (suppurative thyroiditis). In the series of Simeone et al and associates, 16% of follicular adenomas had greater than half of the lesion containing fluid⁽⁶⁾. In our study, we found 4 cases which were predominantly cystic in nature. We did not find any lesion completely cystic. On ultrasonic imaging we found the cystic lesion were very similar to other cysts in the body. They were anechoic lesions with well-defined walls showing posterior acoustic enhancement. No calcification was detected within any lesion. Solid component within the cysts were echogenic in 3 cases. Ultrasound guided fine needle aspiration biopsy was done in all 4 cases and showed that they were benign colloid goiters.

Thyroiditis: The most common is chronic autoimmune lymphocytic thyroiditis (Hashimoto's thyroiditis). It is an autoimmune disease where the patient develops anti-bodies to their own thyroglobulin. The typical sonographic appearance of Hashimoto's thyroiditis is diffuse coarsened parenchymal 100 echotexture generally more hypoechoic than the normal thyroid. Micronodulation is a highly sensitive sign of chronic thyroiditis with a positive predictive value of 94.7 %.(10).ErdoganMF,Anil C, Cesur M et al had found 24 cases (43.6%)of Hashimoto's thyroiditis while evaluating 55 patients with hyperthyroidism. Lin JD, Huang B Y et al had found 11 cases of chronic thyroiditis. Ultrasonic patterns of 11 cases were diffusely enlarged gland with diffuse hypoechoicity. Micronodulation was seen in all cases⁽⁹⁾. In our study, we found 7 cases (10%) of chronic thyroiditis with 6 of them being Hashimoto's thyroiditis and one being non-specific. All of them showed diffuse enlarged gland with diffuse hypoechoicity. Small micro-nodules were seen in 6 cases.

Graves Disease: Autoimmune disorder with late acting thyroid stimulating antibodies (LATS) producing hyperplasia with hypertrophy of thyroid gland. On ultrasound imaging, enlarged gland is hypoechoic and with heterogeneous spotty echo pattern with increase in parenchymal vascularity. Color Doppler sonography often demonstrates a hyper vascular pattern referred to as the 'thyroid inferno'. Spectral Doppler will 101 often demonstrate peak systolic velocities exceeding 70 cm/s which is the highest velocity found in thyroid disease. Erdogan MF, Anil C et al had studied 55 patients with hyperthyroidism.29 patients (52.7%) were diagnosed as Graves disease⁽⁹⁾. Gray scale pattern of both Graves disease and Hashimoto's thyroiditis are similar and difficult to differentiate. vascular patterns were significantly more prominent, and the mean PSV values were significantly higher in the Graves' disease rather than Hashimoto's thyroiditis⁽⁹⁾. Our present study revealed 2 cases (5%) of Graves' disease. Thyroid inferno type of vascular pattern was detected in them.

Thyroid Malignancy: Most of the primary thyroid cancers are epithelial in origin and most of them are well differentiated and papillary carcinoma accounts for 75-90% of all cases. Thyroid micro calcifications are one of the most specific features of thyroid malignancy. With ultrasound, micro calcifications appear as punctate hyper echoic foci without acoustic shadowing. Coarse calcifications are the most common type of calcification are commonly associated with medullary carcinomas and also in multinodular goiters⁽¹²⁾. Ultrasound is valuable for identifying many malignant or potentially malignant thyroid nodules. Although there is some overlap between the ultrasound appearance of benign nodules and that of malignant nodules, certain ultrasound features are helpful in differentiating between the two. These features include micro-calcifications, local invasion, lymph node metastases, a nodule that is taller than it is wide and markedly reduced echogenicity. Other features, such as absence of halo, ill-defined irregular margins, solid

composition, and vascularity are less specific but may be useful ancillary signs. Distinction between follicular adenoma and well differentiated follicular carcinoma is based solely on microscopic evidence of vascular invasion which is often over difficult to determine pathologically, much less sonographically as observed by Gershengover M et al⁽¹²⁾. Walters et al in a study had found out 26% of cystic lesions are malignant. However in our study we did not find any cystic lesion with malignant changes. Most of the authors agree that absolutely specific echo graphic features of thyroid carcinoma do not exist, but literature data are very variable⁽¹³⁾. Some authors described carcinoma as exclusively hypoechoogenic but Solbiati et al found out only 68% of the malignant lesions were hypoechoogenic (74). In our study we found 4 cases (80%) of malignancy showing predominantly hypoechoogenic lesions⁽¹³⁾.

In a study conducted by Jenny K. Hoang, MBBS, FRANZCR, Wai Kit Lee et al showed that micro calcifications are one of the most specific ultrasound findings of a thyroid malignancy. Micro calcifications were found in 29-59% of all primary thyroid carcinomas⁽¹⁰⁾. In our study we detected only 2 cases (40%) of malignancy showing micro calcifications. 1 case of malignancy showed coarse calcification. Rago T, Vitti P et al showed in their study that the combination of absent halo sign plus micro calcification plus intranodal flow pattern achieved a 97.2% specificity for the diagnosis of thyroid malignancy⁽¹⁵⁾. In our study we obtained a specificity of 100% using these parameters.

Conclusion

Color Doppler sonography is a safe, fast, popular, cost effective and repeatable noninvasive procedure for investigating thyroid gland. Because of the superficial location and good vascularization of the thyroid gland, high resolution grayscale and color doppler sonography can demonstrate normal thyroid anatomy and pathological conditions with remarkable clarity.

Our experience demonstrates significantly improved sensitivity for high resolution ultrasound over other investigations for the anatomic characterization of thyroid lesions. Ultrasound is valuable for identifying many malignant or potentially malignant thyroid nodules. Although there is some overlap between the ultrasound appearance of benign nodules and that of malignant nodules, certain features are helpful in differentiating between the two. The high resolution ultrasonography with color doppler flow mapping function can reveal fine details of the thyroid gland and the haemodynamic features of thyroid neoplasms. Color flow Doppler sonography could differentiate the untreated Graves' disease from the Hashimoto's thyroiditis, which has similar gray scale findings. Thyroid ultrasound differentiates solid from cystic lesions, solitary nodules from multinodular and diffuse enlargement, and extrathyroidal lesions.

No source for grants

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