

UTILITY OF DOPPLER INDICES OF BILATERAL SUPERIOR THYROID ARTERIES IN NORMAL AND IN PATHOLOGICAL THYROID

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Abstract :

Background: thyroid gland diseases are common around the world. Diagnosis is usually by thyroid profile estimation levels. The accuracy of Doppler ultrasonography is accurate and sensitive in evaluating the gland in detail (size, margins and nodule's). The indices like peak systolic volume, pulsatility index and resistive index is useful for diagnosing pathological thyroid. The aim of the study was to assess the findings of Doppler indices [PSV, PI, RI] of bilateral superior thyroid arteries [STAs] in normal and pathological thyroid conditions and use them as reference to evaluate the thyroid status and correlate the USG findings with thyroid function tests.

Methods: This observational study was conducted between January 2020 and June 2021 at Vydehi institute of medical sciences. The study consisted of 140 patients divided into two groups 70 each i.e normal thyroid and pathological thyroid respectively.

Results: The mean age of the pathological group was 44.11 ± 10.54 years and mean age of normal group was 42.54 ± 10.27 years. The study consisted of 27 males and 113 females. Totally 119 were hypothyroid and 21 were hyperthyroidism. In the pathological group 6 had low T3 and t4 levels and 17 had increased TSH levels whereas in the normal group 7 had increased TSH levels. Pathological group the mean PSV was 21.87 ± 1.20 , mean PI was 1.02 ± 0.23 and mean RI was 0.74 ± 0.06 . The normal group the mean PSV was 16.4 ± 1.29 , mean PI was 0.91 ± 0.46 and mean RI was 0.54 ± 0.04 . The results suggested patients with increased TSH levels had increased PSV, PI and RI which was significant.

Key word: Thyroid gland, peak systolic velocity, resistive index and pulsatility index.

Introduction :

The thyroid gland is one of the most superficial endocrine glands of human body. It is located in the anterior neck and extends from C5 – T1 vertebrae. It consists of two lobes which are connected by central isthmus. The functional unit of thyroid gland is the thyroid follicle which produces two thyroid hormones – triiodothyronine (T3) and thyroxine (T4) and Calcitonin. Thyroid hormones are essential for the metabolism, growth and protein synthesis. Another important hormone called calcitonin is responsible for calcium homeostasis[1].

Diseases of thyroid gland are very common worldwide. There is a significant burden of thyroid diseases reported from India as well. Various studies report that around 42 million

people in India suffer from thyroid diseases. Thyroid diseases range from various congenital anomalies, inflammatory diseases, autoimmune diseases and tumors. Pathological disorders of thyroid include simple goiter, Hyperthyroidism, Hypothyroidism, Thyroid nodules, Thyroiditis and Thyroid cancers[2].

Diagnosis of thyroid diseases is most commonly done by estimating thyroid hormone levels in the blood. Ultrasonography of thyroid gland also is very practical approach in diagnosing thyroid diseases. The superficial location of thyroid gland makes the evaluation of anatomy, normal anatomical variants and pathological conditions by Doppler ultrasonography feasible[3].

Ultrasonography is non – invasive, less expensive and easily available. It is a method which does not use any ionizing radiation. Ultrasonography of thyroid nodules is a very accurate and highly sensitive method as it helps in evaluating size, margin, number of nodules, echo texture of the nodules, calcification within the nodules and vascularity of the nodules. Many of the diffuse pathologies of thyroid are associated with altered vascularity in very early stages of the disease and there is limited data whether ultrasonography can identify these parameters at an early stage[4].

Although ultrasonography can be used to detect various thyroid abnormalities, there is a need to establish the Doppler indices like Peak Systolic Velocity (PSV), Pulsatility Index (PI) and Resistance Index (RI) in normal thyroid and pathological thyroid. Few studies have depicted that there are significant differences in the Doppler parameters of the superior thyroid artery in normal and hyperthyroid patients. Few studies have shown that the PSV of superior and inferior thyroid arteries are useful in differentiating various causes of hyperthyroidism[5].

There is a need for accurate assessment of Doppler indices of Superior Thyroid Arteries by radiologists such that it serves as a potent diagnostic tool in evaluation of normal thyroid and various thyroid disorders at an early stage of disease. There is a lacuna in this area of research in our country; hence, the present study is taken up to determine the Doppler indices of superior thyroid artery among euthyroid and diseased thyroid patients. Hence the present study was planned to assess the findings of Doppler indices [PSV, PI, RI] of bilateral superior thyroid arteries [STAs] in normal and pathological thyroid conditions and use them as reference to evaluate the thyroid status and to correlate the USG findings with thyroid function tests[6].

MATERIAL AND METHODS:

Study Details

The study was conducted among patients attending department of Radio diagnosis of Vydehi Institute of Medical Sciences and Research Centre (VIMS & RC) as an observational study. Institutional ethical committee approval was obtained prior to the initiation of the study. All patients referred for ultrasound of neck to the department of radio diagnosis (in and out patient) of Vydehi Institute of Medical Sciences and Research Centre (VIMS & RC). During the study 140 patients were included and divided into two group's i.e 70 pathological and 70 normal patients [7].

Inclusion and exclusion criteria

All patients who attend OPD and IPD for ultrasonography of neck and who have Thyroid Function Tests reports, all patients with normal and diffuse thyroid diseases, all patients with focal or nodular lesions of thyroid and patient of >18 years of age were included in this study. Patients below 18 years, patients in whom partial and total thyroidectomy is performed and non-consent subjects were excluded from the study[8].

Data collection methodology

All the ultrasounds was performed using Phillips HD15 Ultrasound machine using a linear probe of frequency 7–12 MHz, along with a coupling agent (ultrasound gel). At first was using, B-mode scan and will look for echogenicity of the gland and for any lesions. STA artery is the first branch of external carotid artery that arises anteriorly at the level of hyoid bone. In most of the cases, the vessel can be traced up to the upper pole of thyroid gland, and then the color Doppler mode is used. Spectral waveform is taken with a sample gate size of 1 mm and Doppler angles of 30–60. Peak systolic velocity (PSV), Plasticity index (PI), and resistivity index (RI) of bilateral STAs was calculated[9].

Data analysis

The collected data was collected, coded, entered into Microsoft excel work sheet and exported to SPSS. Data was analyzed using SPSS version 21. Data is presented as percentage in categories and then presented as tables and diagrams. Independent t test, and paired t-test were used for test of significance[10].

RESULTS:

The age distribution among both the groups, in the pathological group 10 were between 21 and 30 years, 18 between 31- 40 years, 28 between 41- 50 years and 14 were between 51- 60 years. The normal thyroid group age distribution was 9 between 21 and 30 years, 30 between 31- 40 years, 27 between 41- 50 years, 16 were between 51- 60 years and 3 were above 60 years. The mean age of the pathological group was 44.11 ± 10.54 years and mean age of normal group was 42.54 ± 10.27 years. The sex distribution were the pathological group consisted of 17 males and 53 females and the normal group had 10 males and 60 females. The sex ratio was 0.32:1 and 0.16:1 respectively.

In the pathological group 58 had hypothyroidism and 12 were hyper. The normal group consisted of 61 hypothyroid patients and 9 hyperthyroid patients. In the pathological group 6 had low T3 and t4 levels and 17 had increased TSH levels whereas in the normal group 7 had increased TSH levels and t3 and t4 remained normal. Doppler indices findings, the pathological group the mean peak systolic velocity was 21.87 ± 1.20 , mean pulsatility index was 1.02 ± 0.23 and mean resistive index was 0.74 ± 0.06 . The normal group the mean peak systolic velocity was 16.4 ± 1.29 , mean pulsatility index was 0.91 ± 0.46 and mean resistive index was 0.54 ± 0.04 . In the study it was observed the pathological group has increased values than the normal group.

Doppler indices findings, the pathological group the mean peak systolic velocity was 21.87 ± 1.20 , mean pulsatility index was 1.02 ± 0.23 and mean resistive index was 0.74 ± 0.06 . The normal group the mean peak systolic velocity was 16.4 ± 1.29 , mean pulsatility index was 0.91 ± 0.46 and mean resistive index was 0.54 ± 0.04 . In the study it was observed the pathological group has increased values than the normal group. The correlation between ultrasound findings and T3, T4 levels. The results suggested patients with low T3 and T4 levels had increased PSV, PI and RI which was proved statistically ($p < 0.001$) in both the groups. The correlation between ultrasound findings and TSH levels. The results suggested patients with increased TSH levels had increased PSV, PI and RI which was proved statistically ($p < 0.001$) in both the groups.

Table 1 – Distribution of Information

	Pathological group	Normal group
Age		
21- 30 years	10	9
31- 40 years	18	30
41- 50 years	28	27
51- 60 years	14	16
>60 years	--	03
Sex		
Males	17	10
Female	53	60
Total	70	70
Type		
Hypothyroid	58	61
Hyperthyroid	12	09
Thyroid function test		
T3		
Normal	64	70
Low	06	--
T4		
Normal	64	70
Low	06	--
TSH		
Normal	53	63
Increased	17	07
Doppler indices findings		
Mean PSV	21.87 ± 1.20	16.4 ± 1.29
Mean PI	1.02 ± 0.23	0.91 ± 0.46
RI	0.74 ± 0.06	0.54 ± 0.04

Table 2- Association of the indices among the pathological and normal group

	Mean	SD	95% CI		p-value
			Lower	Upper	
PSV (Pathological group)	21.87	1.20	5.054	5.893	<0.001*
PSV (Normal group)	16.4	1.29			
PI (Pathological group)	1.02	0.23	0.522	0.164	<0.001*
PI (Normal group)	0.91	0.46			
RI (Pathological group)	0.74	0.06	0.184	0.2173	<0.001*
RI (Normal group)	0.54	0.04			
*Level of significance: 0.05					

Table 3- Correlation between ultrasound findings and T3 and T4 levels

	T3 & T4	Mean	SD	95 % CI		p-value
				Lower	Upper	
PSV	Normal	16.79	1.827	5.665	4.600	<0.001*
	Low	21.92	1.243	5.648	4.616	<0.001*
PI	Normal	0.922	0.046	0.167	0.053	<0.001*
	Low	1.033	0.244	0.172	0.048	<0.001*
RI	Normal	0.556	0.051	0.216	0.179	<0.001*
	Low	0.754	0.052	0.219	0.180	<0.001*
*Level of significance: 0.05						

Table 4- Correlation between ultrasound findings and TSH levels

	TSH	Mean	SD	95 % CI		p-value
				Lower	Upper	
PSV	Normal	19.59	2.793	1.510	4.072	<0.001*
	Low	16.80	3.076	1.378	4.204	<0.001*
PI	Normal	0.983	0.190	0.194	0.139	<0.001*
	Low	0.923	0.047	0.199	0.099	<0.001*
RI	Normal	0.664	0.111	0.056	0.152	<0.001*
	Low	0.560	0.766	0.066	0.142	<0.001*
*Level of significance: 0.05						

Discussion :

In the present study, in the pathological group 14.2% were between 21 and 30 years, 25.7% between 31- 40 years, 40% between 41- 50 years and 20% were between 51- 60 years. In the normal thyroid group, age distribution was 12.8% between 21 and 30 years, 42.8% between 31- 40 years, 38.5% between 41- 50 years, 22.8% were between 51- 60 years and 4.2% were above 60 years. The mean age of patients in a study by Upendra K J et al was 37.7 years. 22

The present study findings were similar to a study by Upendra K J et al in which 71.1% were females and 28.9% were males. The present study findings were similar to a study by C Dhruwa et al in which 66.4% were females and 33.6% were males. The present study findings were similar to a study by Sunil K A et al in which around 76% of study population were females and 24% were males[11].

In this study, in the pathological group 82.8% had hypothyroidism and 17.2% had hyperthyroid state. The normal group consisted of 87.1% hypothyroid patients and 12.9% hyperthyroid patients. The present study findings were different to a study by Sunil KA et al in which 54% were hyperthyroid; 16% were hypothyroid; 30% were euthyroid.

The present study findings were almost similar to a study by S C Chiou et al in which among the 63 patients, 47.6% were euthyroid patients, 42.8% were hyperthyroid patients and 4.7% were hypothyroid patients. The present study showed that in the pathological group 8.5% had low T3 and t4 levels and 24.2% had increased TSH levels whereas in the normal group 10% had increased TSH levels and t3 and t4 remained normal[12].

The present study findings were similar to a study by P Trimboli et al in which 85.4% showed normal TSH levels and 14.6% had elevated TSH levels. All patients in this study had normal T3 and T4 levels. The present study findings were also similar to a study by P Vejberg et al in which the mean TSH levels were found to be 1.65 mU/l. 6

In the present study, the Doppler indices findings, in the pathological group showed the mean peak systolic velocity was 21.87 ± 1.20 , mean pulsatility index was 1.02 ± 0.23 and mean resistive index was 0.74 ± 0.06 . In the normal group the mean peak systolic velocity was 16.4 ± 1.29 , mean pulsatility index was 0.91 ± 0.46 and mean resistive index was 0.54 ± 0.04 . In the study it was observed the pathological group has increased values than the normal group[13].

The present study findings were comparable with a study C Dhruwa et al in which among euthyroid patients the mean peak systolic velocity was 16.84 ± 5.1 cm/sec. Mean Pulsatility index was 0.97 ± 0.35 and Mean Resistivity index was 0.58 ± 0.17 . The present study findings were similar to a study by Macedo T A et al in which In this mean systolic peak velocity (SPV), resistive index (RI) and pulsatility index (PI) in the superior thyroid artery of healthy non – iodine deficient population were and 25.85 cm/sec, 0.62, and 1.04, respectively.21

The present study findings concurred with a study by Joish U K et al, in which mean PSV obtained in clinically euthyroid individuals was 16.94 ± 5.3 cm/s. Mean PI and RI were 0.93 ± 0.31 and 0.5 ± 0.13 , respectively. The present study findings were similar to a study by F Bogazzi et al in which pathological thyroid state like Graves' disease and Thyroid adenomas showed higher PSV values.

Hiraiwa S et al observed that the mean peak systolic velocity of superior thyroid artery was 58.9 cm/s among patients with Graves' disease and 25.6 cm/s among patients with painless thyroiditis and 24.1 cm/s among normal controls. Arntzeniu AB et al in his study found that the Mean flow velocity among euthyroid patients in superior thyroid artery was 13.9 ± 4.1 cm/s[14].

In this study, the associations of indices were assessed between both the groups were found to be statistically significant for all the three indices that is peak systolic velocity, pulsatility index and resistive index. This signifies that in the pathological group the Doppler indices are increased in comparison with normal thyroid patients. The present study findings were comparable to a study by Sunil K A et al in which average PSV of bilateral STAs was statistically higher in patients with hyperthyroidism than in those with euthyroidism.

The present study findings were concurrent with a study by Sundarram KST et al it which mean PSV in superior thyroid artery among patients with Graves' disease was significantly higher when compared among patients with Thyroiditis ($p < 0.001$). In a comparative study of Doppler indices of bilateral superior thyroid arteries in euthyroid and hyperthyroid patients it was observed that the Doppler indices of STA in hyperthyroid patients were significantly higher than euthyroid subjects with p value < 0.05 [15].

Similar findings were observed in a study by Eldes et al in which PSV, EDV and RI values of superior thyroid arteries were significantly higher in patients with hyperthyroidism compared to the control group ($p < 0.001$). In the present study, the correlation between ultrasound findings and T3, T4 levels was done. The results suggested patients with low T3 and T4 levels had increased PSV, PI and RI which was proved to be statistically significant ($p < 0.001$) in both the groups. In this study, the correlation between ultrasound findings and TSH levels was done. The results suggested patients with increased TSH levels had increased PSV, PI and RI which was proved to be statistically significant ($p < 0.001$) in both the groups

The present study findings were similar to a study by F Bogazzi et al in which patients with low T3 and T4 levels had higher peak systolic velocity. In a study by Kumar KV et al. it was found that the Thyroid blood flow, as assessed by PSV of ITA, was significantly higher in untreated Graves' disease than in Graves' disease on treatment but hyperthyroid and euthyroid Graves respectively. The present study findings were similar to a study by Erdogan MF et al it which the vascular patterns were significantly more prominent, and the mean PSV values were significantly higher in the Graves' disease patients compared to the Hashimoto Thyroiditis patients ($p < 0.001$) and controls ($p < 0.001$)[16].

CONCLUSION:

The present study was undertaken an aim to assess the Doppler indices findings of bilateral superior thyroid arteries. The objectives of the study was to determine the association of Doppler indices between pathological and normal group. The results suggested patients with low T3 and T4 levels had increased PSV, PI and RI which was proved statistically ($p < 0.001$) in both the groups. The correlation between ultrasound findings and TSH levels. The results suggested patients with increased TSH levels had increased PSV, PI and RI which was proved statistically ($p < 0.001$) in both the groups. There was no significant difference between diffuse and focal thyroid conditions in relation to the severity of the disease and to the Doppler indices values.

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Supplementary data

Case 1: 46 year old male patient came to hospital with c/o swelling of neck since 6 months with normal thyroid levels and was subjected for USG neck.

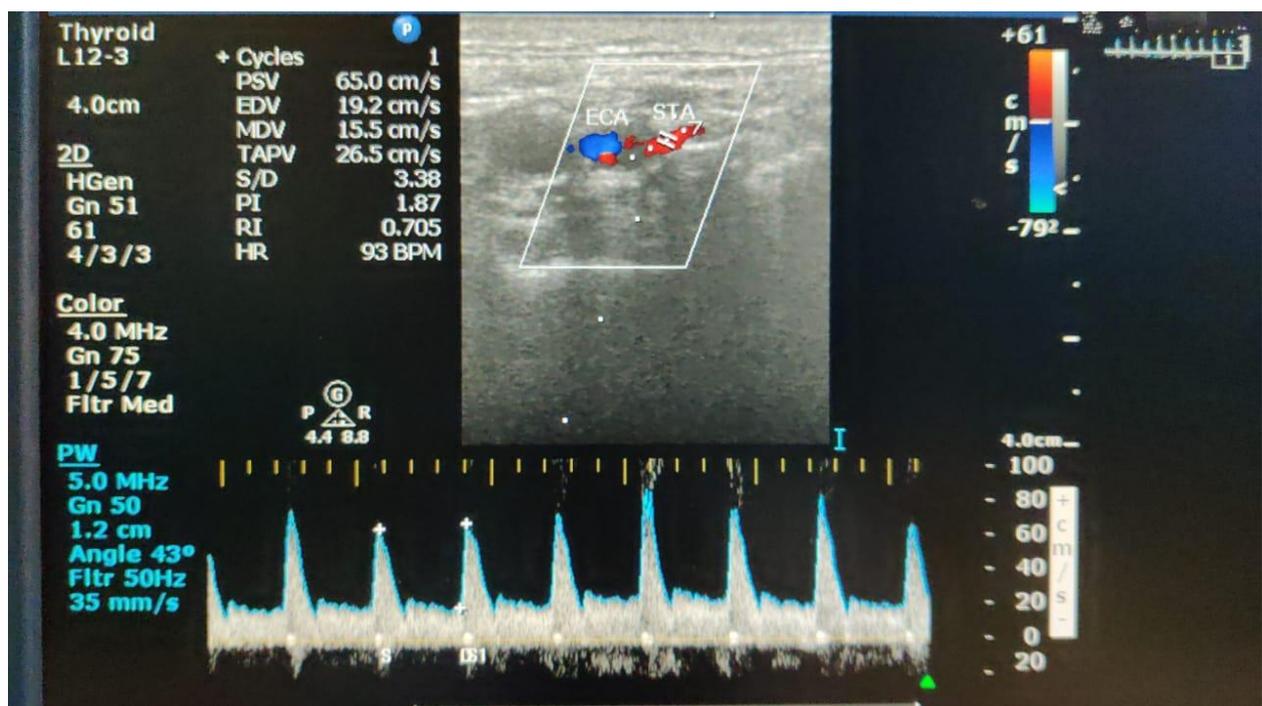


Figure 1: On USG there was a large fairly well-defined, taller than wider heteroechoic lesion with peripheral wall calcification noted involving the right lobe of thyroid. On Doppler interrogation there is increased vascularity and raised Doppler indices[PSV-65 cm/sec, PI-1.87, RI-0.7]-TIRADS-4

Case 2: 39 year old male patient came to hospital with complaints of swelling of neck and difficulty in swallowing since 1.5years with normal thyroid levels and was subjected for USG neck.

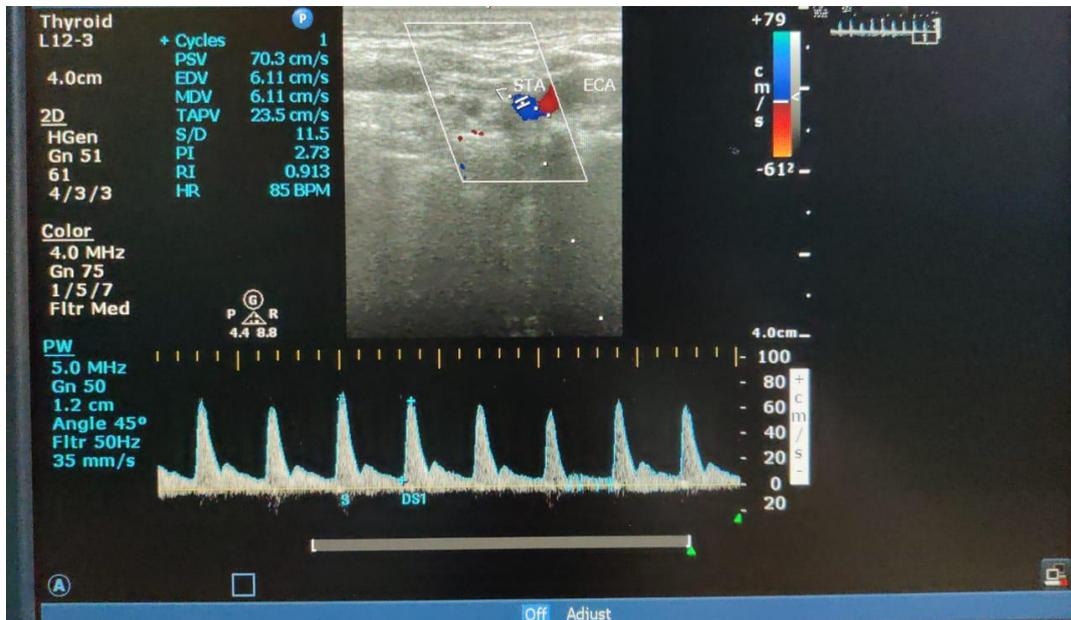


Figure 2: On USG there was a large ill-defined, taller than wider, solid cystic lesion with few areas of calcification within noted in the left lobe of thyroid. On Doppler interrogation there is increased vascularity and raised Doppler indices[PSV-70 cm/sec, PI-2.7, RI-0.9]-TIRADS-5

Case 3: 37 year old female patient came to hospital with complaints of swelling of neck since 1 year and was subjected for USG neck.

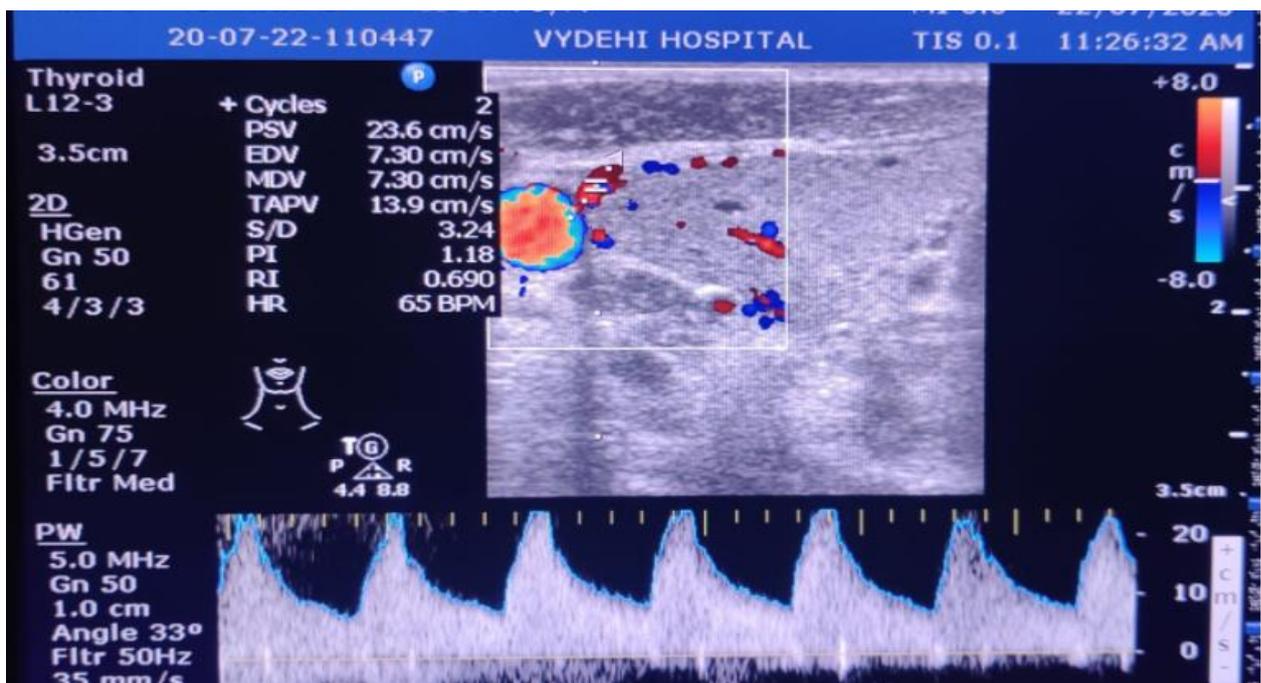


Figure 3: On USG thyroid glands appears bulky, multiple wider than taller nodules few showing spongiform appearance, few showing hypoechoic areas with cystic spaces and few showing macrocalcifications noted in both the lobes of liver. On Doppler interrogation there is increased vascularity and raised Doppler indices[PSV-23.6 cm/sec, PI-1.2, RI-0.8]-s/o Multinodular goiter- TIRADS-III.

Case 4: 29 year old male patient came to hospital with complaints of swelling of neck since 6 months with normal thyroid levels and was subjected for USG neck.

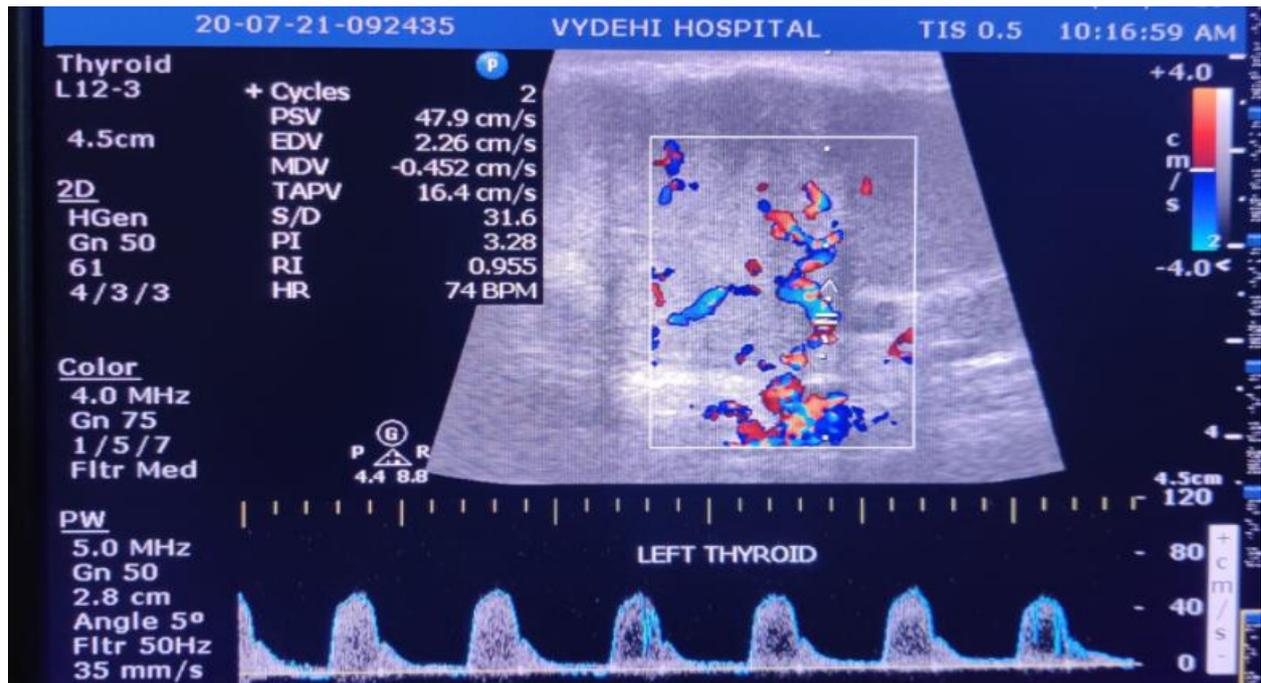


Figure 4: On USG thyroid gland appears bulky. There are well defined predominantly anechoic nodules with hyperechoic solid component within showing punctate solid echogenic foci in both thyroid lobes On Doppler interrogation there is increased vascularity and raised Doppler indices[PSV-47 cm/sec, PI-3.28, RI-0.9]- TIRADS -IV