

Comparison Of Doppler Indices of Superior Thyroid Artery Between Normal and Pathological Thyroid

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Abstract

Background: Thyroid ultrasonography is the initial imaging modality for thyroid anatomy assessment whereas the hormonal profile helps with the functional status of the gland. Doppler parameters along with conventional B-mode ultrasonography will help identify and distinguish various thyroid pathologies. There are more evidences on doppler parameters of inferior thyroid artery and very rare on superior thyroid artery. **Aims and objectives:** To study the normal ranges of Doppler indices (PSV, PI, RI) of superior thyroid artery in normal population and to compare the Doppler indices (PSV, PI, RI) of superior thyroid artery in normal population and those with pathological thyroid (either abnormal TFT or abnormal thyroid ultrasonography or both). **Methodology:** This prospective observational comparative study was conducted by including the patients of all ages and either gender. Those with abnormal thyroid profile or sonography been considered as pathological group and without any observed changes as control group. They were subjected for superior thyroid artery doppler. All the obtained parameters were compared between these two groups. **Results:** 31 patients in each group were included. There was no significant difference in age of the participants in both group but cases group had female predominance. Of all the thyroid pathology, 32.3% (10/31) with thyroiditis was the commonest followed by Graves' disease among 25.8%. We observed significant higher TSH in cases group. PSV and RI were significantly increased doppler parameter among pathological thyroid group than controls. Whereas between the Graves' disease and thyroiditis, mean PSV on either lobe as well as overall was significantly higher in Graves' disease than for the thyroiditis cases. **Conclusion:** We interpret that PSV cannot be alone used to differentiate between normal and pathological thyroid status. However, it can be vital in differentiation Graves' disease from thyroiditis.

Keywords: Thyroid ultrasonography, superior thyroid artery Doppler, Graves' disease, thyroiditis.

INTRODUCTION

Thyroid is an endocrine gland situated in the front of the neck just over the trachea, weighing approximately 15 to 20 grams in an adult. Two potent hormones, thyroxine (T4) and triiodothyronine (T3), which influence basal metabolic processes and/or enhance oxygen consumption in nearly all body tissues are produced and secreted from thyroid gland. These hormones play a major role in growth, brain function including intelligence and memory, neural development, dentition, and bone development. Thyroid gland is also responsible for calcitonin release which has short term effect on calcium and phosphate metabolism.^[1,2]

According to a projection from various studies on thyroid disease, it has been established that about 42 million people in India suffer from thyroid diseases. Spectrum of disorders includes hyperthyroidism, hypothyroidism including their subclinical status due to various etiologies, thyroid nodules, and goiter.^[3,4] Most thyroid disorders are initially evaluated with thyroid hormonal assay as they are more specific to functional status of the gland. Common imaging modalities include ultrasonography and nuclear scintigraphy, both of which needs to be correlated with hormonal assay for appropriate diagnosis.^[5]

Ultrasonography evaluated glandular architecture, vascularity of the gland, morphology and vascularity of thyroid lesions and adjacent anatomical relations prior initiating medical or surgical treatment. Early diagnosis and treatment of thyroid disorders is essential due to their systemic complications and morbidity.^[6] Ultrasonography is a non-invasive, widely available, less expensive and does not use any ionizing radiation. All of these factors make this modality an initial imaging investigation of choice for thyroid disorders. Real time imaging and lack of ionizing radiation makes it a feasible option for long term follow-up and guiding biopsies.^[7]

Thyroid glandular parenchyma is usually sonographically normal in the early stages of thyroid disease and Doppler evaluation of arteries supplying thyroid is not routinely done in most centers.^[8] As mentioned in 2011 ATA (American thyroid association), the Color Doppler Flow Sonography (CDFs) of thyroid has a role in evaluation of thyrotoxicosis. From the perspective of blood vessel detection, it is rather difficult to accurately position while measuring the velocity of inferior thyroid artery.^[9]

Also, the variation of vessel lumen sizes and artery coursing directions may interfere with the blood flow velocity detection. The inferior thyroid artery is commonly used in clinical practice. However, since it is deeply located, the accurate positioning is difficult. On the contrary, superior thyroid artery (STA) is superficial and could be easily positioned from its intersecting point with thyroid lobes. In addition, the anatomic variation of STA rarely occurs. Hence, peak systolic velocity (PSV) of STA as the ideal marker of

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thyroid blood flow status. Official recommendation has not been made due to limited number of studies.^[10,11]

There are a few studies in Indian context which have highlighted the use of Doppler assessment for inferior thyroid artery, less so for STA. This study intends to find Doppler indices namely Peak Systolic velocity (PSV), Pulsatility Index (PI) and Resistivity Index (RI) of STA in normal population and to compare the same in patients with pathological thyroid, as defined. Doppler studies on thyrotoxicosis have found high systolic velocities. This study may add up to evaluation of thyrotoxicosis without the need for FNAC or radioactive iodine scan reducing the radiation exposure, availability and cost. The present study conducted to study the normal ranges of Doppler indices (PSV, PI, RI) of superior thyroid artery in normal population and to compare the Doppler indices (PSV, PI, RI) of superior thyroid artery in normal population and those with pathological thyroid (either abnormal TFT or abnormal thyroid ultrasonography or both).

METHODS

This study was conducted in the Department of Radio-Diagnosis, Vydehi institute of medical science and research institute. Whitefield. Bangalore, India, to compare the Doppler indices of superior thyroid artery between normal and pathological thyroid.

Data Acquisition: After obtaining informed consent regarding the radiological procedure, a detailed clinical history and examination were recorded. The patients were asked to rest for 10 minutes on the examination couch before the sonographic scan. Ultrasonography was done using Samsung UGEO H60 ultrasound machine with a 7-12 MHz linear probe and a coupling agent. Patient was put in dorsal decubitus position with a cushion under the shoulders and the neck hyperextended. In order not to underestimate the vascularization intensity, the probe was positioned lightly on the skin without any compression. B-mode sonography and Doppler of STA was done with appropriate Doppler angle at the upper pole of thyroid gland and Doppler indices (PSV, PI, RI) were recorded bilaterally. Data was analyzed using SPSS software and Excel. Categorical variables were given in the form of frequency table. Continuous variables were given in Mean \pm SD/ Median (Min, Max) form. Ordinal data was analyzed by independent t-test and Mann Whitney U test. Normality was analyzed by Shapiro wilk test... P-value less than or equal to 0.05 indicates statistical significance

RESULTS

Data contains information of 31 subjects each in two group, Control and Case. Control with Normal thyroid and Case with pathological thyroid. The following tables give the summary of data.

Table 1: Distribution of subjects according to demographic details over groups

Variable	Sub Category	Groups		p-value
		Control	Case	
Age (Years)	Mean \pm SD	35.51 \pm 10.72	39.35 \pm 13.25	0.214 ^t

	Median (Min, Max)	34 (20, 58)	40 (11, 72)	
Gender#	Female	14 (45.2%)	22 (73.3%)	
	Male	17 (54.8%)	8 (26.7%)	
USG thyroid	Normal	31 (100%)	0	
	Graves'	NA	8 (25.8%)	
	Hyperthyroid	NA	3 (9.7%)	
	Hypothyroid	NA	5 (16.1%)	
	Nodule	NA	5 (16.1%)	
	Thyroiditis	NA	10 (32.3%)	

Abbreviation: #-data is missing of gender in Case group, t-independent t test, C- Chi square test, *- indicates statistical significance

From independent t test, it can be observed that, there is no significant difference in mean of age over groups. The average age of the control and cases was 35.51 \pm 10.72 years and 39.35

\pm 13.25 years respectively with no significant difference. Even the distribution of gender, though we could observe 73.3% females in cases and 45.2% in controls, the association observed was not significant. Thyroiditis among 10 (32.3%) of 31 cases was the commonest pathology followed by 8 (25.8%) with Graves'. Rest of the pathologies were distributed as described in the above table.

Table 2: Distribution of subjects according to different in Case group

Variable	Sub Category	Number of subjects (%)
USG Echotexture	Normal	13 (41.9%)
	Altered	18 (58.1%)
USG Nodules	Present	6 (19.4%)
	Absent	25 (80.6%)
USG Vascularity	Normal	16 (51.6%)
	Increased	15 (48.4%)

Out of 31 (100%) subjects in case groups, 13 (41.9%) have normal USG echotexture and 18 (58.1%) have altered echotexture, 6 (19.4%) had nodules and 15 (48.4%) had increased vascularity.

Table 4: Distribution of subjects according to Doppler indices over groups

Variable	Sub Category	Groups		p-value
		Control	Case	
Right PSV	Mean \pm SD	17.19 \pm 2.7	32.02 \pm 21.21	0.0139* ^{MW}
	Median (Min, Max)	17.4 (11.4, 22.6)	22.4 (10.4, 72.4)	
Left PSV	Mean \pm SD	17.57 \pm 2.08	31.26 \pm 20.17	0.0107* ^{MW}
	Median (Min, Max)	17.4 (13.9, 22.4)	23.4 (12.3, 77.6)	
Mean PSV	Mean \pm SD	22.26 \pm 6.76	29.76 \pm 13.25	0.0483 ^{MW}
	Median (Min, Max)	19.76 (13.98, 35.38)	20 (13.26, 54.88)	
Right PI	Mean \pm SD	0.74 \pm 0.17	0.79 \pm 0.22	0.290 ^t
	Median (Min, Max)	0.7 (0.4, 1.10)	0.8 (0.4, 1.37)	
Left PI	Mean \pm SD	0.73 \pm 0.22	0.85 \pm 0.25	0.061 ^{MW}
	Median (Min, Max)	0.72 (0.5, 0.99)	0.8 (0.4, 1.4)	
Mean PI	Mean \pm SD	0.75 \pm 0.11	0.80 \pm 0.15	0.337 ^{MW}
	Median (Min, Max)	0.73 (0.54, 1.09)	0.79 (0.61, 1.24)	

Right RI	Mean \pm SD Median (Min, Max)	0.54 \pm 0.85 0.5 (0.4, 0.7)	0.56 \pm 0.12 0.6 (0.4, 0.8)	0.384 ^{MW}
Left RI	Mean \pm SD Median (Min, Max)	0.50 \pm 0.12 0.5 (0.14, 0.7)	0.57 \pm 0.11 0.6 (0.3, 0.8)	0.037* ^{MW}
Mean RI	Mean \pm SD Median (Min, Max)	0.54 \pm 0.05 0.53 (0.42, 0.65)	0.61 \pm 0.06 0.55 (0.41, 0.7)	0.0291^t
Sr. T3	Mean \pm SD Median (Min, Max)	1.14 \pm 0.38 0.98 (0.58, 1.8)	1.37 \pm 0.99 1.10 (0.2, 4.2)	0.968 ^{MW}
Sr. T4	Mean \pm SD Median (Min, Max)	8.68 \pm 1.35 8.7 (6.4, 10.8)	8.19 \pm 4.43 8.8 (2.4, 16.5)	0.936 ^{MW}
Sr. TSH	Mean \pm SD Median (Min, Max)	2.26 \pm 1.23 2.4 (0.5, 4.4)	11.29 \pm 10.88 11.3 (0.0010, 55.5)	<0.001* ^{MW}

Abbreviation: MW- Mann Whitney U test, t- independent t test, *- indicates statistical significance

From Mann Whitney U test, it can be observed that, there is significant difference in means of Right PSV, Left PSV, Left RI, Sr. TSH over groups. However, there is significant difference in mean of Mean PSV and mean RI but no significant difference in PI. Sr. T3, Sr. T4 over groups. From independent t test, it can be observed that, there is no significant difference in means of Right PI, Mean RI over groups.

Table 5: Mean comparison between Graves' and thyroiditis over different variables

Variable	Sub Category	Groups		p-value
		Graves' (n=8)	Thyroiditis (n=10)	
Right PSV	Mean \pm SD Median (Min, Max)	64.4 \pm 7.7 65.2 (48.6, 72.4)	25.4 \pm 11.1 21.4 (12.1, 45.3)	<0.001* ^{MW}
Left PSV	Mean \pm SD Median (Min, Max)	63.1 \pm 8.9 60.5 (52, 77.6)	23.2 \pm 7.4 24.7 (12.3, 32.8)	<0.001* ^t
Mean PSV	Mean \pm SD Median (Min, Max)	63.1 \pm 8.9 60.5 (52, 77.6)	23.2 \pm 7.4 24.7 (12.3, 32.8)	<0.001* ^t
Right PI	Mean \pm SD Median (Min, Max)	0.73 \pm 0.07 0.7 (0.6, 0.81)	0.88 \pm 0.31 0.85 (0.5, 1.37)	0.190 ^t
Left PI	Mean \pm SD Median (Min, Max)	0.7 \pm 0.14 0.66 (0.6, 1)	0.96 \pm 0.37 1 (0.4, 1.4)	0.141 ^{MW}
Mean PI	Mean \pm SD Median (Min, Max)	0.71 \pm 0.09 0.7 (0.6, 0.9)	0.92 \pm 0.32 0.97 (0.45, 1.3)	0.099 ^t
Right RI	Mean \pm SD Median (Min, Max)	0.59 \pm 0.11 0.6 (0.4, 0.7)	0.58 \pm 0.13 0.6 (0.4, 0.8)	0.842 ^t
Left RI	Mean \pm SD Median (Min, Max)	0.55 \pm 0.1 0.55 (0.4, 0.7)	0.6 \pm 0.16 0.65 (0.3, 0.8)	0.432 ^t
Mean RI	Mean \pm SD Median (Min, Max)	0.53 \pm 0.05 0.53 (0.46, 0.61)	0.57 \pm 0.08 0.59 (0.41, 0.7)	0.277 ^t

Abbreviation: MW- Mann Whitney U test, t- independent t test, *- indicates statistical significance

From Mann Whitney U test, it can be observed that, there is significant difference in means of Right PSV over groups (Graves' and thyroiditis). However, there is no significant difference in mean of Left PI over groups (Graves' and thyroiditis).

From independent t test, it can be observed that, there is significant difference in means of Left PSV, Mean PSV over groups (Graves' and thyroiditis). However, there is no significant difference in mean of Right PI, Mean PI, Right RI, Left RI Mean RI over groups (Graves' and thyroiditis).

DISCUSSION

Diagnosis of thyroid diseases is usually based on the hormone assay. Ultrasonography, a non-invasive modality is indeed a practical method for evaluating thyroid anatomy. Superficial location of the thyroid gland makes it easily accessible in evaluation of the anatomical variations and pathological conditions with high accuracy. It can get quite challenging, due to the possibility of painless thyroiditis and early-stage atypical Graves' disease. By Doppler studies, the PSV would describe the etiological differentiation of thyrotoxicosis encountered in clinical practice. PSV is a quantitative entity which reflects a part of thyroid vascularity. There are various evidences suggesting STA Doppler in differentiating Graves' disease from thyroiditis but comparative studies with control group are rare. Hence, the present study was conducted to compare the Doppler indices (PSV, PI, RI) of STA in normal population and those with pathological thyroid (either abnormal TFT or abnormal thyroid ultrasonography or both).

Demographic data: In this study, we had recruited a total of 62 subjects, 31 subjects in each group, categorized into control, who had observed to be with normal thyroid functions and the case group with deranged thyroid function indicating pathological thyroid status. Demographic data showed that the average age of our case group samples was 39.35 \pm 13.25 years and for control group it was 35.51 \pm 10.72 years with no much statistical difference. Among controls 45.2% were females whereas in cases group, the incidence of female patients was as high as 73.3%. Rest controls and cases were males. Even in Naveen S et al,^[12] sex distribution in cases group had 17 males and 53 females and the normal group had 10 males and 60 females, explaining that thyroid disorders being common among females. Palaniappan MK et al,^[13] had compared the Doppler indices among benign and malignant tumors, even the age distribution their study population was almost like ours. 41.5 \pm 9.65 in benign and 49.3 \pm 10.4 years for malignant nodules cases but with no gender predominance. Donkol RH et al,^[14] compared the Doppler indices between thyroiditis and Graves' disease. They their study population were aged between 31 to 33 years.

Underlying condition: On tabulating the thyroid pathology in cases group, we found that majority of them, accounting for about 32.3% had diagnosed with thyroiditis followed by 8 (25.8%) of them with Grave's. 5 (16.1%) each had hypothyroidism and thyroid nodules. Rest 3 (9.7%) cases were found to be diagnosed with hyperthyroid status. Irrespective to this, 58 had hypothyroidism and 12 were hyper

among cases group and normal group consisted of 61 hypothyroid and 9 hyperthyroid individuals in Naveen S et al.^[15]

USG echotexture and vascularity: The appearance on USG showed that all control groups were presented with normal echotexture, no nodules and normal vascularity. Whereas among 31 cases, 18 (58.1%) of them had altered echotexture. Six of 31 (19.4%) subjects had nodules and 48.4% exhibited increased vascularity. Palaniappan MK et al,^[13] had observed significantly increased vascularity among their cases. Unlike the present study, as 100% of their cases were either benign or malignant thyroid tumor, it was expected.

Thyroid profile: In the present study, the thyroid function test parameters T3 and T4 did not have much difference between the groups but TSH indicated a significant difference with the control group having a mean TSH of 2.26 ± 1.23 and the case group with 11.29 ± 10.88 ($p < 0.001$). Implying TSH would be the reliable marker than T3 and T4. This was almost same as the outcome observed by Naveen S et al.^[12] In Zhao X et al,^[15] the mean free t3 was significantly high among their study population diagnosed with Graves' disease but the TSH and T4 were almost similar in both groups.

Doppler indices: The Doppler indices revealed that right PSV, for the control group was 17.19 ± 2.7 and 32.02 ± 21.21 for cases with the significant increase, indicated by p value of 0.0139. The left PSV in control and cases was 17.57 ± 2.08 and 31.26 ± 20.17 , respectively with the statistically significant increase ($p = 0.0107$). The overall mean PSV was $22.26 \pm$

6.76 in controls and 29.76 ± 13.25 among cases with significant difference.

The right PI for controls and cases was 0.74 ± 0.17 and 0.79 ± 0.22 respectively, with no significant difference. Whereas the left PI was moderately higher in cases than controls with the observed value of 0.73 ± 0.22 and 0.85 ± 0.25 in controls and cases correspondingly ($p = 0.061$).

The right RI in controls was 0.54 ± 0.85 , which was comparable among cases with average value of 0.56 ± 0.12 , with neither radiological nor statistical difference. Whereas, the left RI in controls and cases was 0.50 ± 0.12 and 0.57 ± 0.11 , with significantly higher difference of p value 0.037. Overall mean values of RI in controls and cases were 0.54 ± 0.05 and 0.61 ± 0.06 respectively with significant difference.

To substantiate this, we observed that Naveen S et al,^[12] had reported that the average PSV in their pathological group was 21.87 ± 1.20 , mean PI was 1.02 ± 0.23 and 0.74 ± 0.06 of RI was noted. Whereas among normal group the mean PSV was 16.4 ± 1.29 , mean PI of 0.91 ± 0.46 with mean RI of 0.54 ± 0.04 , indicating statistically significant increased Doppler parameters among pathological group.⁴⁷ This outcome was consistent with the observation by Macedo T A et al,^[16] in which in this mean peak systolic velocity (PSV), resistive index (RI) and pulsatility index (PI) in the STA of healthy non – iodine deficient population were and 25.85 cm/sec, 0.62, and 1.04, respectively.⁴⁶ This was consistent with the outcome of Joshi UK et al. To discuss further, Palaniappan MK et al,^[12] had provided the cut off PI and RI, whereas the PSV was not considered for differentiating benign and malignant tumors, according to them, it would be increased to

same extent in all cases.

We had compared the difference in Doppler indices for thyroiditis and Graves', which showed that the PSV mean, the right and left lobe were significantly higher in graves' than thyroiditis. The overall mean PSV in graves' cases was 63.1 ± 8.9 and among thyroiditis it was 23.2 ± 7.4 only. Donkol RH et al,^[14] as well observed PSV on either lobe as well as the overall average was significantly higher among graves' cases than thyroiditis. Contrary to our observation about mean PI and RI being similar in both groups, they observed significant increase even in these parameters among graves'. Even in Hari Kumar KV et al,^[18] they had observed significantly higher blood flow in inferior thyroid arteries in Graves' disease than in destructive thyrotoxicosis. Like the present study, Peng X et al,^[19] who had looked for peak systolic velocity of STA on USG to differentiate destructive thyroiditis from Graves' disease, been interpreted that PSV will be significantly increased in Graves' disease than destructive thyroiditis with higher sensitivity in confirming the diagnosis as well. Whereas in Zhao X et al,^[15] overall mean PSV among Graves' disease was 70.1 ± 32.6 and 38.8 ± 21.5 among thyroiditis cases, which is slightly higher than our observed parameters but the significant increase noted was same. Hiraiwa T et al,^[19] further provide the interpretation that STA PSV Doppler would differentiate Graves' disease from hyperthyroidism even in pregnant women, with >80% of diagnostic sensitivity. With this, we can interpret that modern color Doppler, especially the PSV of STA, has become dependable parameter in differentiating various thyroid disease conditions especially in differentiating Graves' disease from thyroiditis.

This study reconfirms that the thyroid pathologies are common among young age individuals with female preponderance. PSV of superior thyroid artery will be significantly increased in thyroid pathologies such as Graves' disease in contrast to normal values as recorded in thyroiditis patients. Hence, along with clinical information and hormonal evaluation, superior thyroid artery Doppler study can be considered as a reliable tool to differentiate between thyroiditis and Graves' disease which may reduce the need for further evaluation with nuclear scans and biopsy. The study also concluded that apart from various B mode parameters like size, shape, echogenicity of the thyroid gland and qualitative assessment of vascularity including PSV in the reports may add to the confidence in differentiating thyroiditis and Graves' disease.

CONCLUSION

Thyroid glandular evaluation has been routinely performed with B-mode and qualitative Doppler evaluation. However, quantifying the Doppler parameters using the already available indices like PSV, RI and PI helps radiologists guide clinicians to manage thyroid abnormalities causing less monetary and mental burden. STA courses at the superior pole of thyroid with much less variations to be wary of during the scan. Sonographic familiarity with glandular and vascular anatomy may reduce interobserver variability and may further reduce the established range of indices. Thyroid pathologies

were found to be more common in younger age group with female preponderance and also reassures the role of anatomical evaluation by sonography using B- mode and relative vascularity assessment. The Doppler indices for STA namely PSV, RI and PI were assessed and a normogram was sought. PSV happened to be an important indicator to differentiate between Graves' disease and diffuse thyroiditis; where the PSV values were much higher in Graves' disease. RI and PI values showed no significant difference and hence may not be reliable in differentiating the thyroid pathologies.

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