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THYROID DOPPLER FINDINGS IN PATIENTS WITH ABNORMAL THYROID HORMONAL STATUS

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Abstract

The usefulness of colour Doppler sonography in hypo- or hyperthyroidism has been the subject of ongoing controversy for some time, with no clear findings coming from any of the current investigations. Goals: We want to learn more about thyroid Doppler sonographic findings in individuals who have an aberrant thyroid hormone status. Method: Coronal cross-sectional analysis. The study's methodology involved recruiting 38 people with aberrant thyroid hormone states, including 21 hypothyroid and 17 hyperthyroid individuals. Not to mention the 15 healthy individuals who served as a control group. Every patient and volunteer underwent a thyroid Doppler examination, during which the researchers measured the thyroid hormone status by correlating the diffuse parenchymal vascularity patterns (DPVP) with the thyroid Doppler indices [peak systolic velocity (PSV), resistive index (RI), and pulsatility index (PI)]. End result: Both hyper- and hypo-thyroid hormone statuses were associated with an enhanced blood flow, as shown below: in the hypothyroid group, seven out of twenty-one patients (or 33.3% of the total) exhibited a diffuse hypervascular pattern (grades III and IV), while in the hyperthyroid group, sixteen out of twenty-one patients (or 76.1% of the total) had a high peak systolic velocity (>25 cm/s). A total of 14 patients (82.3%) exhibited significant PSV, while 5 patients (29.4%) exhibited DPVP (grade III & IV). Doppler findings that are out of the ordinary for the thyroid, such as high DPVP and/or PSV, are an extremely sensitive and specific predictor of an aberrant thyroid hormonal status (84.2%). In cases of hyper- or hypothyroid hormonal status, the sensitivity and specificity are almost identical. There was no statistically significant association between the individual thyroid hormones and high PSV; however, there was a correlation between high PSV and aberrant thyroid hormonal status (hypo- or hyperthyroid). While high DPVP was able to detect an abnormal thyroid hormone status with a 100% specificity rate, it had a low sensitivity rate of 29% and no statistically significant link with the abnormality. Neither the resistive index (RI) nor the pulsatility index (PI) was associated with hypo- or hyperthyroidism or abnormal thyroid hormone levels. In conclusion, elevated DPVP and PSV on thyroid Doppler are indicative of an aberrant thyroid hormone level but do not differentiate between hypo- and hyperthyroidism; furthermore, there was no statistically significant link between RI and PI and an abnormal thyroid hormonal status.

Keywords Thyroid hormone, colour Doppler sonography, hyper- or hypothyroid, resistive index

Introduction

Background About 5% of the population experiences thyroid gland disease, which is frequent and mainly affects females. Thyroid dysfunction can show in many ways since the thyroid axis regulates metabolism and cellular development in almost all nucleated cells. Even in those whose thyroid functions normally, structural thyroid disorders like goitre can develop. Thyroxine (T4) and triiodothyronine (T3) are two related hormones produced by the thyroid gland. They work through nuclear receptors and are essential for cell differentiation during development. As an adult, these hormones also contribute to maintaining thermogenic and metabolic equilibrium. When the thyroid gland is attacked by the immune system, it can lead to either an excess of thyroid hormones (hyperthyroidism) or a lack of hormones (hypothyroidism). It is also possible to detect benign nodules and some types of thyroid cancer just by looking at the patient's neck. (2) For patients diagnosed with thyroid illness, ultrasonography has emerged as a crucial imaging tool in the past ten years. The use of thyroid sonography with the patient's history, physical exam, and other thyroid diagnostics (particularly needle biopsy) has greatly enhanced the quality of care patients receive. (3) The current gold standard for diagnostic yield and accuracy is likely to be ultrasound-guided fine-needle aspiration biopsies. Past reports have shown a strong correlation between TBF and levels of free triiodothyronine (5) and iodine uptake (6), but other research has failed to reach definitive conclusions. (4) Hypo- and hyperfunctioning thyroid diseases can alter TBF. Because they are intrusive, the techniques for directly measuring thyroid blood flow, like intraarterial thermodilution and electromagnetic flowmetry (8), are not commonly used. To directly evaluate TBF, one can utilise colour Doppler sonography, a noninvasive method that shows intra-parenchymal vessels (9) on a picture. 6. The rapid advancements in ultrasonic imaging can be attributed to both the ever-increasing diagnostic capabilities and the ever-better equipment and technology. There has been

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tremendous improvement in sonographic diagnosis thanks to colour Doppler sonography, ultrasound contrast agents, and developments in standardising diagnostic criteria and establishing recommendations. (10). High-resolution real-time greyscale and colour Doppler sonography can show normal thyroid anatomy and pathological disorders with extraordinary clarity because of the thyroid gland's superficial position. Consequently, this method is now crucial for assessing thyroid disease in diagnostics. The thyroid gland can be evaluated using a variety of diagnostic tools, sonography being just one of them. Physiologic evaluation of thyrotoxicosis and diagnosis of nonpalpable thyroid tumours that may evade identification on physical examination and nuclear imaging investigations are both aided by ultrasonography, a safe, noninvasive, portable, and cost-effective imaging technology. (12) Doppler sonography aids in the diagnosis and monitoring of Graves' illness because of the distinct thyroid hypervascularity that occurs in this condition. (13) Nearly all structural thyroid abnormalities of clinical relevance can be detected using today's high-resolution ultrasound imaging. Ultrasound features cannot accurately diagnose benign thyroid lesions, but they can suggest "suspicious" for malignancy in cases when signs like core vascularity, microcalcifications, and uneven borders are present in thyroid nodules. Although Doppler flow analysis has the potential to increase the predictive value for thyroid lesion cancer risk assessment, no existing ultrasound method can reliably identify benign lesions. (4) It is still not known if Doppler sonography is useful as a diagnostic tool for distinguishing between benign and malignant thyroid nodules. (13)

DOPPLER SONOGRAPHY

1.5.3. A: General

Doppler physics as it relates to diagnostic sonography concerns the behavior of high frequency sound as they referred from moving fluid usually blood.[25]

1.5.3. B: The Doppler Effect

When high frequency sound beam meets a moving structure, such as blood flow in a vessel, the reflected sound returns at different frequency. The speed (velocity) of moving structure can be calculated from this frequency shift.

The returning frequency will be increased if the flow is towards the sound source (transducer) and will be decreased if flow is away from the sound source. The frequency of the returning wave can be converted to an audible signal.

The Doppler Effect is responsible for variation in the pitch of the sound wave from an ambulance siren as it moves towards or away from person. The siren pitch becomes higher as the ambulance approaches and lowers as the vehicle departs. [25]

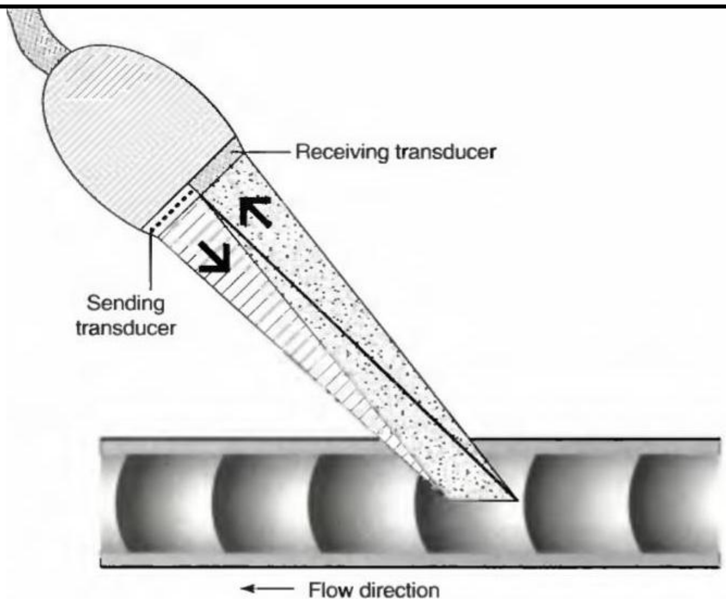

Fig.(4): A pulsed Doppler transducer demonstrating the direction of transmitting sound beam towards the flow of the blood and the receiving sound beam back to the transducer.[25]

The Doppler spectrum is defined as a quantitative graphic display of the velocities and directions of moving red blood cells present in the Doppler sample volume. The Doppler spectral display represents the range of frequency shifts, or velocities, on the Y axis and of time on the X axis. The amplitude of each velocity component is presented as a shade of gray. The greater the amplitude, the brighter the velocity component appears on the display. [26]

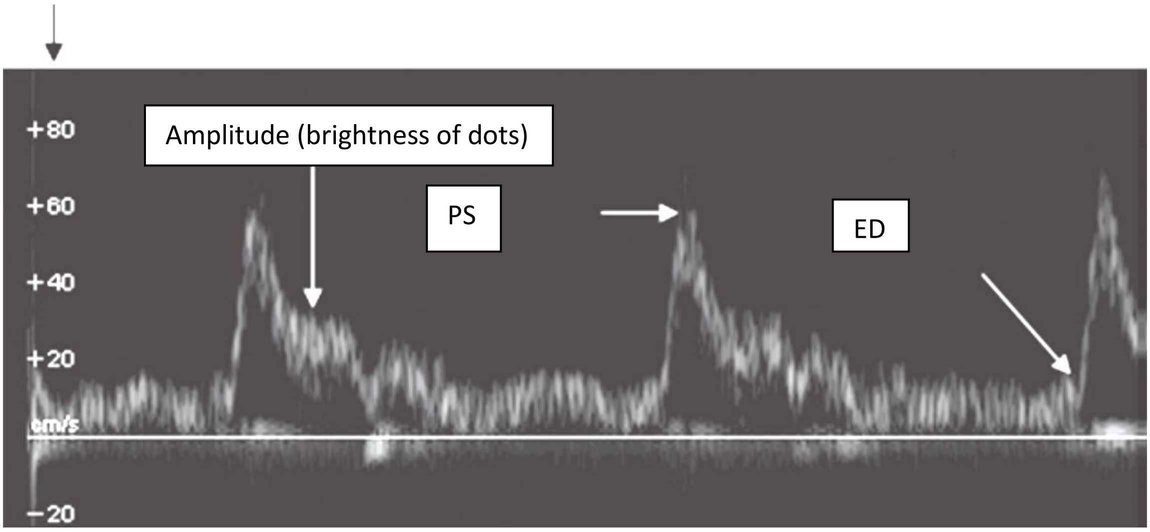

Fig. (5): Spectral waveform. The spectral display provides the following information: time, velocity, frequency shift, flow direction, and amplitude. (PS = Peak systolic, ED = End diastolic. [27]

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1.5.3. C: Clinical correlation

The Doppler Effect is helpful in localizing blood vessels and determining optimal site for velocity measurements. Vein typically have a low-pitched hum, where as arteries have an alternating pattern with high pitched systolic component. [25]

1.5.3. D: Doppler indices

- Resistive index (RI)
- Pulsatility index (PI)
- Peak systolic velocity (PSV)

1.5.3. D.1: Resistive index (RI)

The arterial resistivity index (also called as Resistance index, abbreviated as RI), used to quantitate the resistiveness of distal bed. Example of the use of RI is for the analysis of the kidneys in cases of hydronephrosis. [27]

Formula for resistive index

Formula **RI = A – B / A**

Where A: peak systolic B: End diastolic [27]

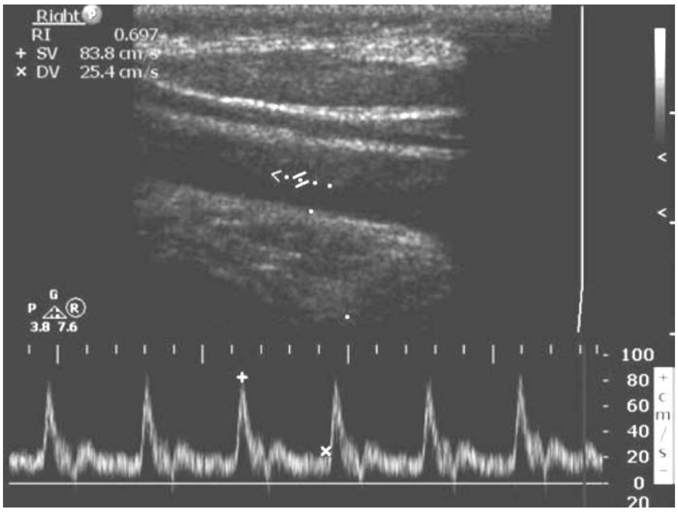

Fig. (6): Resistive index. This image demonstrates the measurement obtained for the resistive index. [27]

1.5.3. D.2: Pulsatility index (PI)

Used to determine how a pulsatile vessel is over time. The PI is often used in obstetrics in evaluation of fetal brain and umbilical cord. Both of these measurements (RI & PI) attempt to estimate the relative difference between systole and diastole. [27]

Formula **PI = A – B / Mean**

Where PI: Pulsatility index A: Peak systolic B: End diastolic

Mean = average velocity between peak systolic & end diastolic

1.5.3. D.3: Peak systolic velocity (PSV)

This is the maximum velocity recorded within the spectrum at the point in time that represents peak systolic flow. This velocity represents the fastest moving blood in the vessel. The maximum velocity can similarly be measured at end diastole. [28]

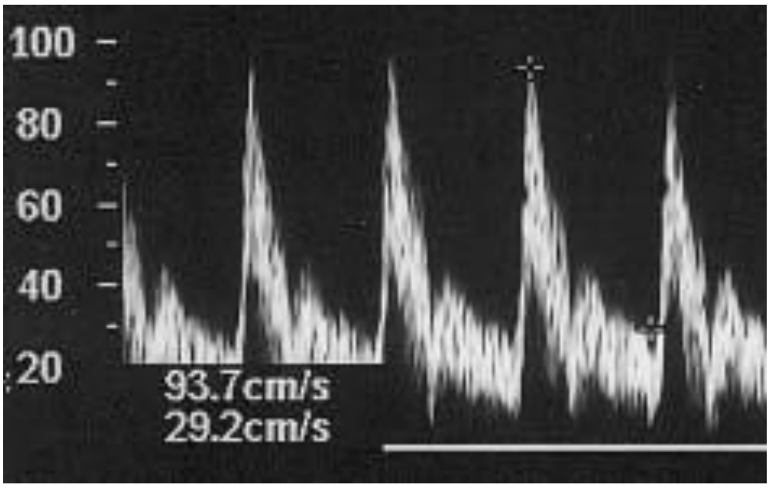

Fig (7): Doppler spectrum showing the measurement of maximum peak systolic velocity, *S*, and maximum end diastolic velocity, *D*. B: The mean velocity can be calculated from the Doppler spectrum, displayed by the black line.[28]

1.5. E: Doppler sonography of the thyroid gland

The vascularity of thyroid gland can be assessed with color flow & pulsed Doppler imaging. Depending on the clinical problem (diffuse or focal thyroid disease), the goal of the examination may quantify thyroid vascularity or demonstrated its vascular architecture. Pulsed Doppler is used to measure peak systolic velocity & volume flow in the thyroid arteries. The ITA makes a bend posterior to CCA. The apex of the bend consistently appears as vascular cross section in longitudinal scan over CCA. The STA located just medial to CCA at upper pole of thyroid gland, is imaged with slight modified longitudinal scan. Its opposite flow direction relative to the adjacent CCA is easily to be identified. [30]

The thyroid vessels normally have peak systolic velocity of 25 cm/sec & volume flow of 6ml/min per vessel. [31]The diffuse vascularity in florid Graves' disease is so pronounced that it may be pathognomic for the disease. [32]

In Graves' disease, the peak systolic velocities average more than 100cm/s, the volume flow more than 150ml/min. Even when a euthyroid state has been established by medical treatment, the increased blood flow in the thyroid gland initially persist and will persist and will decline only with passage of time. [30]

Due to the unique thyroid hypervascularity in Graves' disease, Doppler sonography is helpful in the diagnosis and follow-up. [13]

In Hashimoto's thyroiditis, color flow at the sensitive setting shows a definite increase in TBF, but less than in florid Graves' disease. In De Quervain's thyroiditis, the inflammation usually does not involve the entire thyroid gland but infiltrate the gland in a nonhomogenous pattern. The sonographic correlate is a disordered pattern of hypoechoic and hypervascular areas. [30]

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Some studies utilized color Doppler ultrasonography (CDU) to evaluate the thyroid blood flow area (TBFA) quantitatively, which's used to differentiate Graves' disease and destruction-induced thyrotoxicosis in patients with thyrotoxicosis. TBFA is obtained by dividing TBF on thyroid area multiplied by 100%.

It showed high sensitivity (84%) and specificity (90%) in distinguishing Graves' disease from destructive thyroiditis. [33]

Color flow Doppler is a useful addition to B-mode scanning for distinguishing benign and malignant neoplasms in the follow-up of thyroid cancer. Power-mode Doppler sonography significantly improves imaging of perinodular and intranodular blood flow when compared with conventional color flow Doppler. The presence of an echo complex pattern or irregular hyperechoic small intranodular structures and the presence of an irregular diffuse intranodular blood flow are the best indicators of malignancy, whereas an SI (The Solbiati index) [SI= ratio of largest to smallest diameter] >2 is highly indicative of benign changes. [34]

Most thyroid carcinomas are hypoechoic with peripheral and central vascularity. To justify a suspicion of malignancy, the sonographic criteria for malignancy must be interpreted in relation to radionuclide findings (cold spot) and clinical parameters. [30]

The role of color Doppler in differentiation between benign and malignant thyroid tumor is a an issue of controversy, Fukunari N *et al*. suggest that ultrasound with the color-Doppler function can play a more important role in the differential diagnosis of thyroid tumors,[35] While Bianek-Bodzak A *et al*. propose that diagnostic value of Doppler sonography in the differentiation of benign from malignant thyroid nodules is not established yet.[13]

1.5.4: Nuclear medicine study

Isotope scanning provides functional rather than anatomical detail. Both lobes and the isthmus can be identified. It is useful for identifying ectopic thyroid tissue, which is most likely to be in the base of the tongue, reflecting its site of development. 99mTc- or iodine-labeled agents are used [Tc99 m] pertechnetate, which is trapped by the thyroid in the same way as iodine. [14]

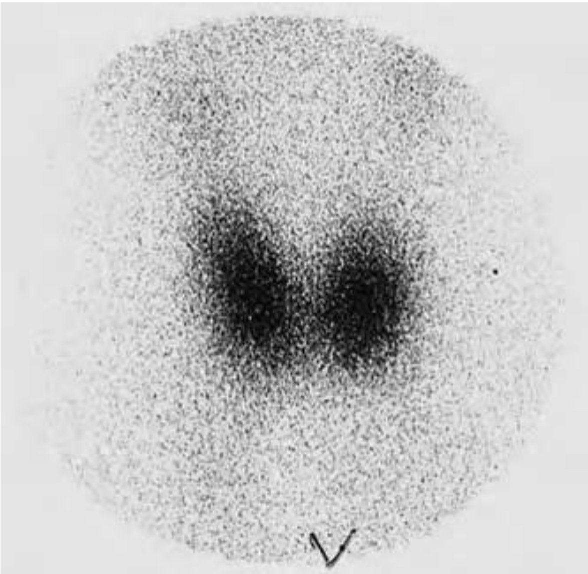

Fig. (8): Normal thyroid scintigraphy. [29]

1.5.5: CT scan

CT may be used to assess the gland in the axial plane. It shows as soft-tissue areas of high attenuation because of the iodine content. The surrounding structures of the neck may also be imaged. Imaging with short scan times during dynamic infusion of contrast gives the best images and definition of the gland and surrounding structures. [14]

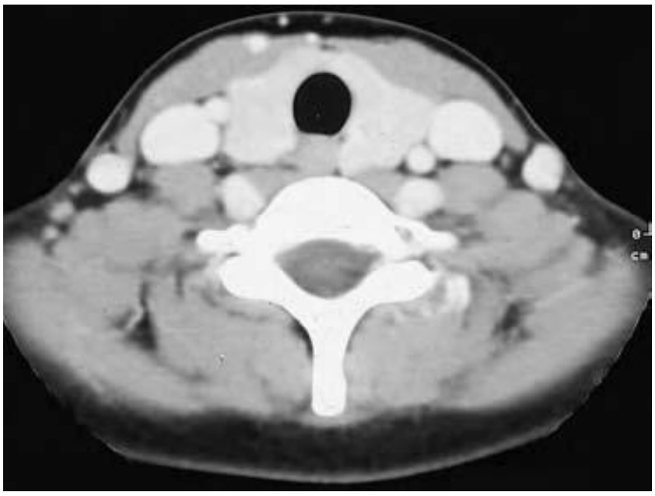

Fig. (8): Contrast-enhanced CT of the neck at the level of the C7 vertebra. The thyroid gland shows intense enhancement. Posterolaterally lie the carotid sheaths. The vertebral vessels have not yet entered the foramen transversarium. [29]

1.5.6: MRI

MRI can image the gland in any plane along with the surrounding structures. The thyroid gland is of higher signal intensity than surrounding muscles on T2-weighted images. The use of surface coils improves detail. [14]

Current imaging techniques show a relatively homogeneous texture of thyroid gland. It is highly vascular however, and demonstrates intense contrast enhancement on CT and MRI. Its superficial location makes the thyroid gland an ideal organ for ultrasound examination. [29]

Patients and Methods

This 10-month cross-sectional study (March 20jun uary 2014) took place at the endocrine and diabetes centre in Al-Sader Medical City, located in the Al-Najaf health directorate.

This study included fifteen healthy volunteers with a euthyroid hormonal status and no clinical symptoms of thyroid illness, as well as patients with aberrant laboratory results (hypo- or hyper-thyroid hormonal status).

Every patient and healthy volunteer gave their verbal agreement before a single radiologist, working under the supervision of a consultant radiologist, performed a Doppler sonographic examination on them.

The procedure of the study received approval from the university ethics committee at Kufa University's Faculty of Medicine.

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Requirements for Inclusion

This study comprised a total of 38 patients. Nine patients were newly diagnosed with thyroid hormone status and had no treatment prior to diagnosis; the other twenty-nine were known cases of hypo- or hyper-thyroid status and were all taking medication. Hypothyroidism was defined as having high TSH with low or lower normal T3 and T4, and hyperthyroidism as having low TSH with high or upper normal T3 and T4.

Criteria for exclusion:

1-Before and during pregnancy

One pregnant woman who did not have a normal thyroid function was not included in this study because her pregnancy would have caused her T3 and T4 levels to rise and her TSH to fall below the normal range. one (1)

Two, severe obesity

The examination was challenging for one female patient with hypothyroidism because of her extremely short neck, dyspnoea, and severe obesity, so she was not included in this study.

The control group consisted of fifteen healthy volunteers who did not exhibit any indications of thyroid illness and whose thyroid function tests came back normal.

Using the Siemens SONOLINE Versa Pro ultrasound machine, as indicated in figure 10, all patients and volunteers underwent a Doppler sonographic examination (section 2.4).

To better examine the neck, especially in cases where it is short, the patient was asked to lie down with their head slightly propped up on a tiny pillow that was placed beneath their shoulders.

An ultrasonic probe with a high frequency of 7.5 MHz was employed. Following a standard thyroid ultrasound, the researchers used colour Doppler imaging to look for signs of diffuse thyroid vascularity (DPVP), which are represented by red and blue spots, respectively, that indicate the direction of flow relative to the transducer. Using a system similar to Ralls and Bogazzi's, the researchers graded the DPVP into four categories (9, 36).

I. Minimal or nonexistent intraparenchymal vascularity

II: Unequal and patchy patterns of parenchymal blood flow

III: A little enhancement in colour flow Patchy distribution in the Doppler signal

IV: Significantly enhanced colour conveying the 'Thyroid Inferno' pattern, a Doppler signal with homogeneous distribution and diffused appearance.

Grades I and II indicated normal or low vascularity, whereas Grades III and IV indicated greater vascularity for the gland. (37) The ITA on both sides was located, and its short axis is typically easily visualised behind the CCA, which is visible in the long axis. (38) After that, we highlight the ITA, look at the Doppler spectral waveform, and average the right and left ITA's Doppler indices (PSV, RI, and PI).

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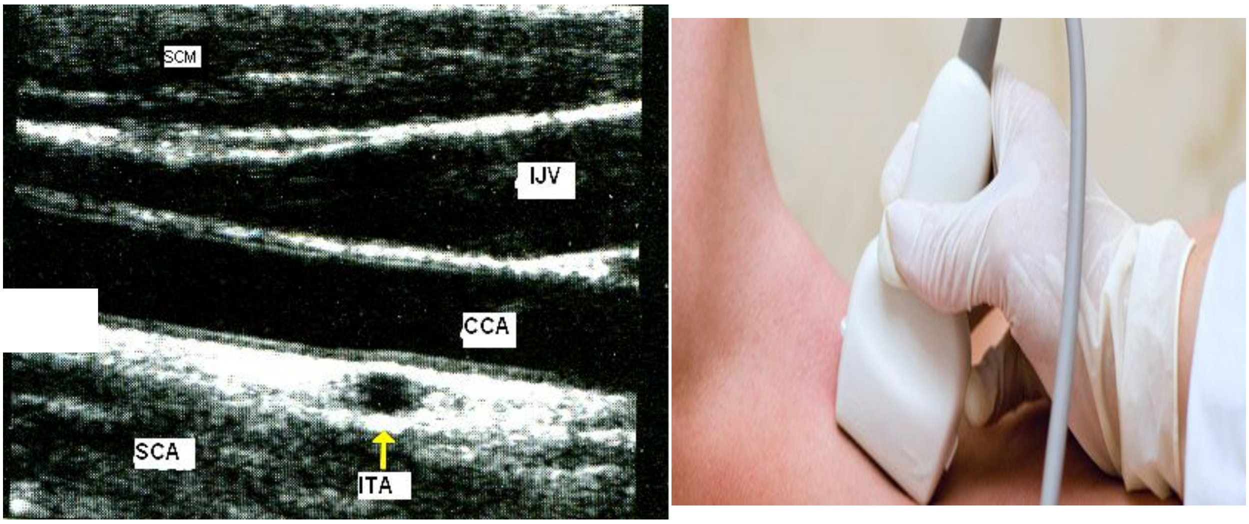

Fig (11) A & B :longitudinal scan below level of thyroid gland , demonstrate location of ITA & it's relation to neck vessels & muscles. (SCM-Sternocleidomastoid muscle. IJV-Internal jugular vein, SCA-Scalenus anterior muscle.). [38, 10]

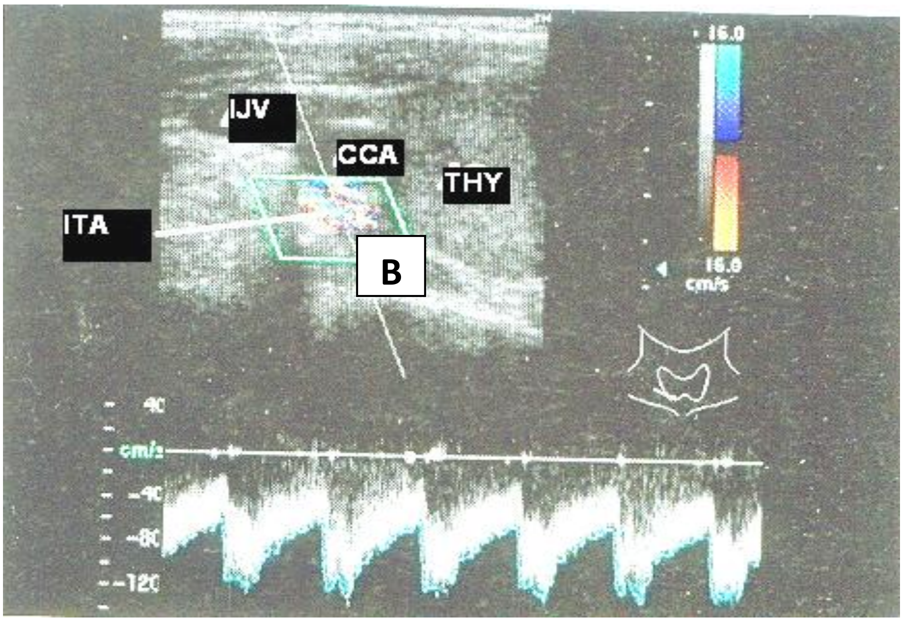

Fig (12): Showing Doppler waveform of inferior thyroid artery. IJV = internal jugular vein, THY = thyroid gland. [38]

2.5: Data Collection and questionnaire forum

Name:

Age: **Gender:**

LAB results:	**T3**	(N = **0.5 – 1.6 ug / dl**)
	T4	(N= **4 – 11 ug / dl**)
	TSH	(N=**0.5 – 5 uU / ml**)

Doppler Finding:

Parenchymal vascularity Low vascularity (grade I & II)

High vascularity (grade III & IV)

Doppler indices of inferior thyroid artery (mean values):

PSV = (N=25 cm/ sec)

RI = (N=0.6-0.7)

PI= (N=1)

2.6: Laboratory equipments

The participants were examined by one of 2 machines, depending on availability of corresponding kit.

1 - Mini VIDAS

Is a multi-parametric immunoassay product offered at Block Scientific. [39]

Fig. (14): Demonstrates Photograph for (Mini VIDAS) immunoassay machine.

2 – Gamma counter, 2005 Perkin Elmer Wallac Wizard 1470-020

Are designed for superior counting performance with all types of samples and for every gamma counting application.[40]

Fig. (15): Shows photograph for – Gamma counter, 2005 Perkin Elmer Wallac Wizard 1470.

Statistical Analyses

Statistical analysis was done by using SPSS (statistical package for social sciences) version 20 in which we use Chi square test for categorical data and independent sample T-test for measurement data also we use pearson correlation coefficient to find correlation between two continuous variables.

We set P value <0.05 as significant.

RESULTS

3.1: Age & gender distribution:

This study includes 38 patients with abnormal thyroid function test. Thirty four were females (89.4%) & four were males (10.5%) as shown in figure (16) shown below.

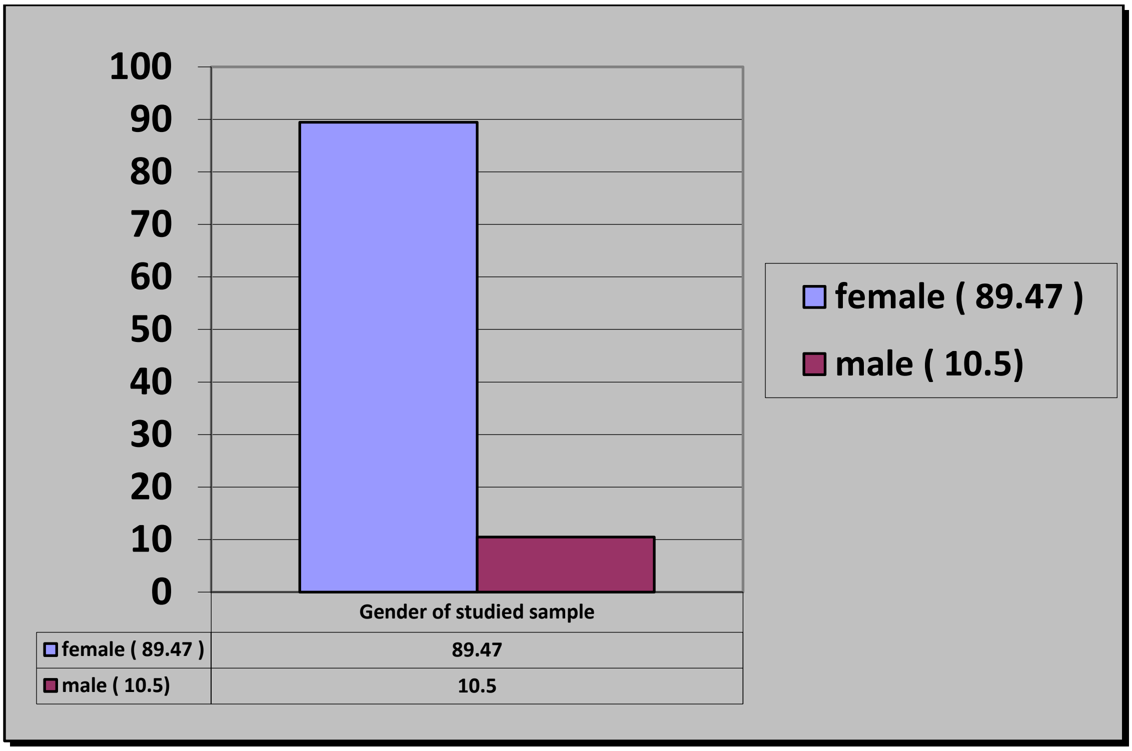

Figure (16): Gender distribution of the studied patients with thyroid dysfunction.

- Age range for hypothyroidism patients was (19 -52 years) with mean age was (37.66±8.25).
- Age range for hyperthyroidism was (23 -51) with mean age (35±7.89).
- All hypothyroid patients were females(100%) whereas (76.4%) of hyperthyroid patients were females.

3.2: The diffuse parenchymal vascularity pattern (DPVP):

Twelve out of 38 patients with abnormal thyroid hormone(31.5%) having high DPVP(grade III & IV) & the remaining 26 patients (68.5 %) with low DPVP(grade I & II).

Seven out of 21 hypothyroid patients (33%) showed high DPVP(grade III & IV) and seven out of 12 patients with high DPVP (58.3%) were hypothyroid.

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Five out of 17 hyperthyroid patients (29.4%) showed high DPVP (grade III or IV) and five of 12 patients (41.6%) with high DPVP were hyperthyroid. All the 15 control patients were having low DPVP (grade I or II).

There is no statistically significant correlation between DPVP and abnormal thyroid hormone status (p value= 0.045).

Theses information are summarized in the following table:

Table (4): Correlation between the thyroid hormonal status and DPVP in all patients**.**

		DPVP		P value
		Low	**High**	
Total No of patients (38)		**26 (68.5%)**	**12 (31.4%)**	
	Hypothyroidism (21)	**14**	**7**	**0.053**
		66.6%	**33.3%**	
	Hyperthyroidism (17)	**12**	**5**	
		70.5%	**29.3%**	
	Control (15) Euthyroid	**15**	**0**	
		100%	**0**	

3.3: The hypothyroid patients; correlation between Doppler indices & their hormone status in comparison with control:

Only the PSV showed significant correlation with the hypothyroid hormonal status when compared to control (P value of 0.006).

The study failed to find a statistically significant correlation between RI & PI with hypothyroidism status.

The following results are summarized in the table shown below:

Table (5): Correlation between Doppler indices & hormone status in comparison with control in hypothyroid patients;

	Group	Mean	Std. Deviation	P value
PSV	**Control**	**24.4667**	**2.53170**	**0.006**
	Hypothyroidism	**28.2381**	**4.44865**	
RI	**Control**	**0.6780**	**0.03509**	**0.050**
	Hypothyroidism	**0.6571**	**0.02648**	
PI	**Control**	**0.9767**	**0.04776**	**0.062**
	Hypothyroidism	**0.9429**	**0.05460**	
	Hypothyroidism	**37.6667**	**8.25429**	

3.4: The hyperthyroid patients; correlation between Doppler indices & their hormone status in comparison with control:

Only the PSV showed significant correlation with the hyperthyroid hormonal status when compared to control (P value of 0.001).

The study failed to find a statistically significant correlation between RI & PI with hyperthyroidism status.

The following results are summarized in the table shown below:

Table (6): Correlation between Doppler indices & hormone status in comparison with control in hyperthyroid patients:

	Group	Mean	Std. Deviation	P value
PSV	Control	24.4667	2.53170	0.001
	Hyperthyroidism	30.1176	5.52135	
RI	Control	0.6780	0.03509	0.125
	Hyperthyroidism	0.6524	0.05356	
PI	Control	0.9767	0.04776	0.219
	Hyperthyroidism	0.9441	0.08959	

3.5: The correlation between Doppler indices in hypo- & hyperthyroid hormonal status:

This study failed to find significant statistical correlation in Doppler indices between hypo- & hyperthyroid hormonal status; with P value (0.253, 0.721, and 0.958) for PSV, RI & PI respectively.

The following results are summarized in the table shown below:

Table (7): Relation between Doppler indices hypothyroid and hyperthyroid groups.

	Group	Mean	Std. Deviation	P value
PSV	Hypothyroidism	28.2381	4.44865	0.253
	Hyperthyroidism	30.1176	5.52135	
RI	Hypothyroidism	0.6571	0.02648	0.721
	Hyperthyroidism	0.6524	0.05356	
PI	Hypothyroidism	0.9429	0.05460	0.958
	Hyperthyroidism	0.9441	0.08959	

3.6: The correlation between PSV & T3 level:

There was no significant statistical correlation between PSV & T3 level with P value = 0.164.

The following results are summarized in the figure shown below:

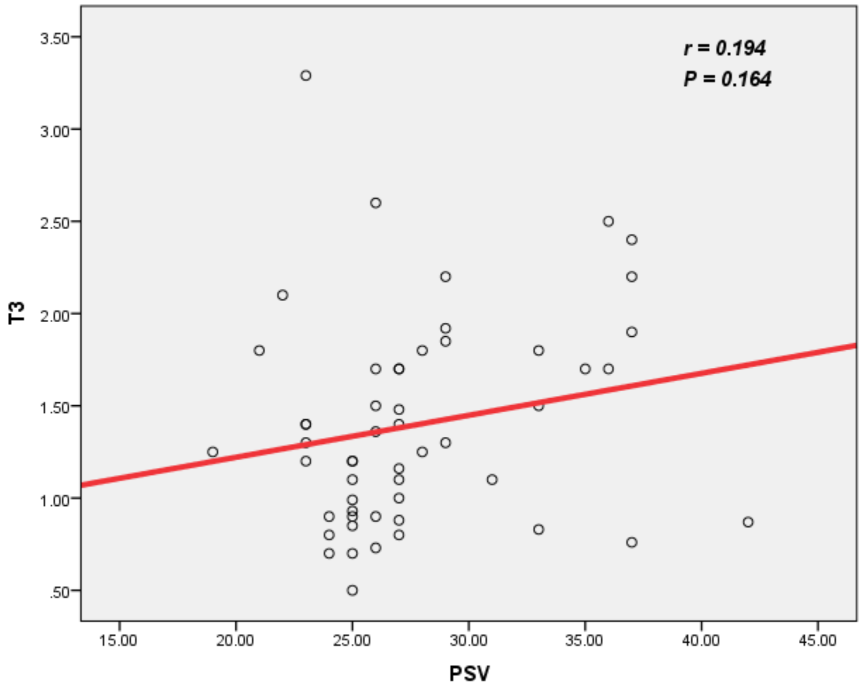

Fig. (17): showing the correlation between PSV & T3 level.

3.7: The correlation between PSV & T4 level:

There was no significant statistical correlation between PSV & T4 level with P value = 0.2. The following results are summarized in the figure shown below:

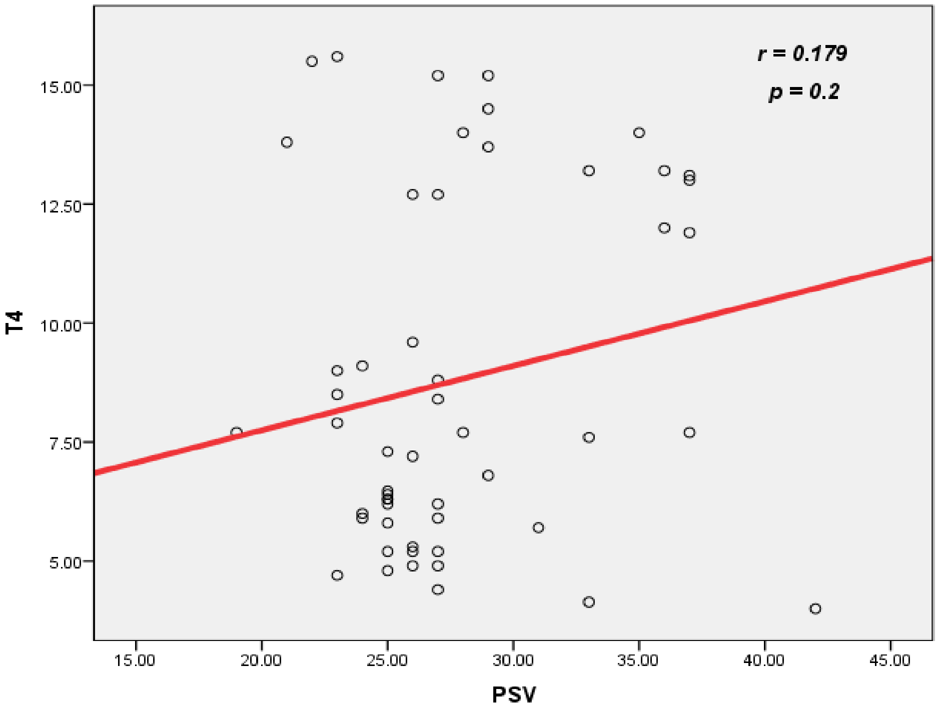

Fig. (18): showing the correlation between PSV & T4 level.

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3.8: The correlation between PSV & TSH level:

There was no significant statistical correlation between PSV & TSH level with P value = 0.699. The following results are summarized in the figure shown below:

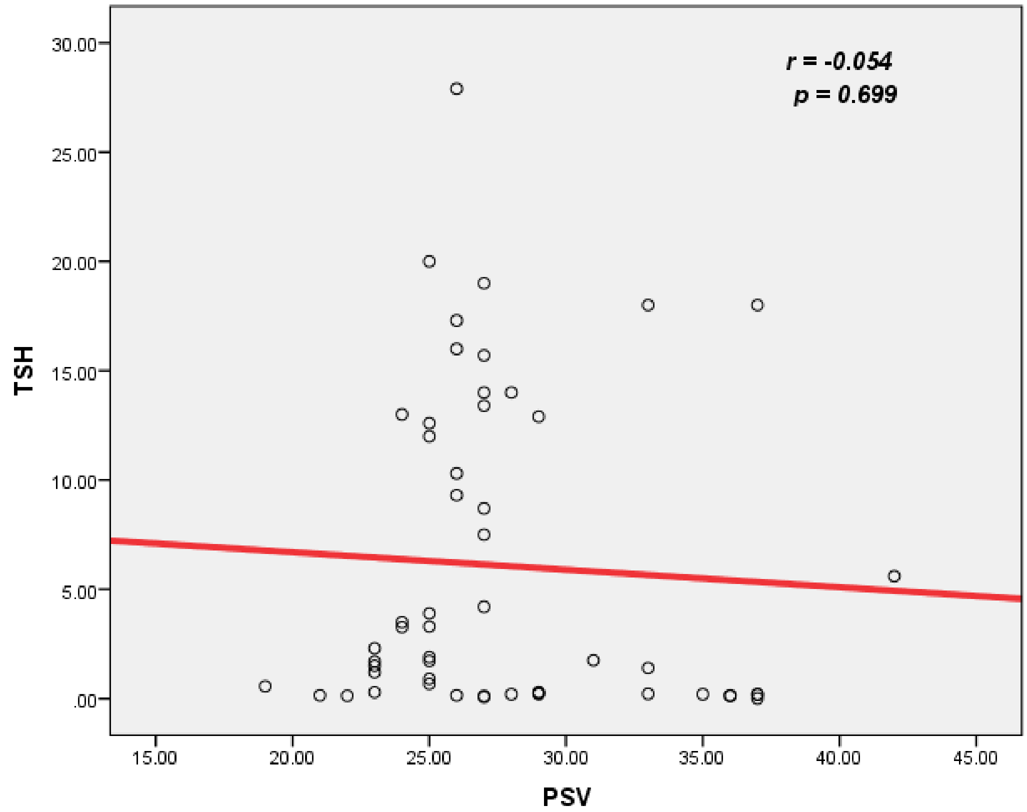

Fig. (19): showing the correlation between PSV & TSH level.

3.9: Sensitivity & specificity of abnormal Doppler study (DPVP and/or PSV) in the detection of an abnormal thyroid hormone status:

The sensitivity and specificity of abnormal Doppler results (i.e. high DPVP and /or high PSV) is equal to 84.2 % and 86.7% respectively, in the detection of abnormal thyroid hormone status.

The Positive predictive value = 94.1%

The Negative predictive value = 68.4%

The following results obtained from the table shown below

Tale (8): Correlation between abnormal Doppler indices (high PSV & grade III & IV DPVP) in abnormal hormonal status comparing with control.

	Abnormal thyroid function test results	**Control**	**Total**
Positive (Abnormal Doppler results)	32 (94.1%)	2 (5.8%)	34
Negative (Normal Doppler result)	6 (31%)	13 (68.4%)	19
Total	38 (71.6)	15 (28.3%)	53

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3.10: Sensitivity & specificity of abnormal Doppler study (DPVP & PSV) among patients with hypothyroid hormonal status:

The sensitivity and specificity of abnormal Doppler results (i.e. high DPVP and /or high PSV) is equal to 85.7%and 86.7% respectively, in the detection of hypothyroid hormone status.

Positive predictive value = 90%

Negative predictive value = 81.3%

The following results obtained from the table shown below

Table (9): showing the correlation between abnormal Doppler study (DPVP & PSV) in hypothyroid hormonal status comparing with control.

	Hypothyroid hormonal status	Control	Total
Positive (Abnormal Doppler results)	18 (90%)	2 (10%)	20
Negative (Normal Doppler result)	3 (18%)	13 (81%)	16
Total	21 (58.3%)	15 (41%)	36

3.11: Sensitivity &specificity of high PSV among patients with hypothyroid hormonal status:

The sensitivity and specificity of high PSV is equal to 80.9%and 86.6% respectively, in the detection of hypothyroid hormone status.

Positive predictive value = 89.4%

Negative predictive value = 76.4%

The following results obtained from the tabıe snown below

Table (10): showing the correlation between high PSV in hypothyroid hormonal status comparing with control.

	Hypothyroid hormonal status	**Control**	**Total**
Positive (PSV > 25 cm/ sec)	17 (89%)	2 (10.2%)	19
Negative (PSV< 25 cm / sec)	4 (23%)	13 (76.4%)	17
Total	21 (85.3%)	15 (41%)	36

3.12: Sensitivity & specificity of abnormal DPVP (grade III&IV) among patients with hypothyroid hormonal status:

The sensitivity and specificity of high DPVP is equal to 33.3% and 100% respectively, in the detection of hypothyroid hormone status.

Positive predictive value = 100%

Negative predictive value = 51.7%

The following results obtained from the table shown below

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Table (11): showing the correlation between high DPVP in hypothyroid hormonal status comparing with control.

	Hypothyroid hormonal status	Control	Total
Positive (grade III & IV DPVP)	7 (100%)	0	7
Negative (grade I & II DPVP)	14 (48.2%)	15 (51.7%)	29
Total	21 (85.3%)	15 (41%)	36

3.13: Sensitivity & specificity of abnormal Doppler study (DPVP & PSV) among patients with hyperthyroid hormonal status:

The sensitivity and specificity of abnormal Doppler results (i.e. high DPVP and /or high PSV) is equal to 82.4 % and 87.5% respectively, in the detection of hyperthyroid hormone status.

Positive predictive value = 87.5%

Negative predictive value = 81.3%

The following results obtained from the table shown below

Table (11): showing the correlation between abnormal Doppler indices (high PSV& grade III & IV DPVP) in hyperthyroid hormonal status comparing with control.

	Hyperthyroid hormonal status	Control	Total
Positive (Abnormal Doppler results)	14 (87.5%)	2 (12.5%)	16
Negative (Normal Doppler result)	3 (18.7%)	13 (81.2%)	16
Total	17 (53%)	15 (46.8%)	32

3.14: Sensitivity & specificity of high PSV among patients with hyperthyroid hormonal status:

The sensitivity and specificity of high PSV is equal to 82.3 % and 86.6% respectively, in the detection of hyperthyroid hormone status.

Positive predictive value =87.5%

Negative predictive value = 81.2%

The following results obtained from the table shown below

Table (12): showing the correlation between high PSV in hyperthyroid hormonal status comparing with control.

	Hyperthyroid hormonal status	Control	Total
Positive (PSV > 25 cm/ sec)	14 (87.5%)	2 (12.5%)	16
Negative (PSV < 25 cm / sec)	3 (18.7%)	13 (81.2)	16
Total	17 (53%)	15 (46.8%)	32

3.15: Sensitivity & specificity of abnormal DPVP (grade III & IV) among patients with hyperthyroid hormonal status:

The sensitivity and specificity of high DPVP is equal to 29.4 % and 100% respectively, in the detection of hyperthyroid hormone status.

Positive predictive value =100%

Negative predictive value = 55.5%

The following results obtained from the table shown below

Table (13): showing the correlation between abnormal diffuse vascularity (grade III & IV DPVP) in hyperthyroid hormonal status comparing with control.

	Hyperthyroid hormonal status	Control	Total
Positive (grade III & IV DPVP)	5 (100%)	0	5
Negative (Normal DPVP)	12 (44.4%)	15 (55.5%)	27
Total	17 (53%)	15 (46.8%)	32

Discussion

Our daily practice leads us to notice that patients with hyperthyroid hormonal status often have increased thyroid vascularity on colour Doppler sonography of the thyroid gland. This finding is consistent with most studies on Doppler assessment of hyperthyroidism, which have shown a correlation between hyperthyroid status and enhanced thyroid vascularity on colour Doppler imaging (41, 42, 43, 44). Vitti P et al. even considered this finding to be a pathognomonic sign of untreated Graves' disease. (44) . Although the use of colour Doppler sonography in hypo- or hyperthyroidism has been a topic of debate for some time and multiple studies have failed to produce definitive results, this idea creates the false impression that the increased TBF and hypervascularisation are directly linked to or caused by the underlying hormone level. This is despite the fact that the colour Doppler pattern of intense hypervascularity of the thyroid gland, which was previously only seen in hyperthyroid states of Graves' disease, can also be observed in hypothyroidism. (7)

Gender and Age

All patients with aberrant thyroid hormone values in the laboratory were females (89.4%), all patients with hypothyroidism were females (100%) and most patients with hyperthyroidism were females (76.4%). Out of all patients with aberrant laboratory thyroid hormone values, only 10.5% are male. The demographic data shown in a study by Bogazzi F et al. (36) is almost identical to these findings. In that study, females made up 80.4% of the hyperthyroid patients and 76.2% of the hypothyroid patients.

According to Bogazzi et al. (36), the average age of patients with hypothyroidism was 37 years and hyperthyroidism was 35 years. In contrast, the average age of patients with hyperthyroidism was 45 years, and the average age of patients with hypothyroidism was 33 years.

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Thyroid Doppler Exam

Although there have been a limited number of studies that have used STA to obtain Doppler indices, such as those conducted by Karakas O et al. (48) and Zhao X et al., we evaluate the flow and Doppler indices of ITA in a manner comparable to that of Cirillo L et al. (43), Ishay A et al. (45), Schweiger U et al. (46), and Caruso G et al. (47). four digits

It is likely that the ease of anatomical tracing by ultrasonography is the main reason why ITA is selected over the superior one. We had no trouble spotting ITA compared to the superior one. Similarly to how KVS Hari Kumar et al. employed the mean value of the Doppler indices of the right and left ITAs, we do the same thing. They discovered no significant difference between the two sets of metrics. (37) We took an arithmetic mean of the two results since this was evident throughout our Doppler analysis.

Doppler research and hypothyroid hormonal state correlation

Out of 21 hypothyroid patients, we found that 33.3% had an elevated DPVP (grade III & IV) and 80.9% had an elevated PSV (>25 cm/sec). These results are higher than those of Schulz SL et al., who found varying degrees of increased vascularity in 33 hypothyroid patients out of 89 (7), or 37%. Similarly, Bogazzi F et al., who compare the value of PSV and diffuse vascularity pattern in hyperthyroid, euthyroid, and hypothyroid hormonal status, found an accentuated DPVP in 19% of hypothyroid patients. (36) It appears that the thyroid vascularity is not directly related to the thyroid hormone level, as indicated by the fact that a considerable percentage of hypothyroid patients exhibit heightened vascularity. The increased thyroid vascularity necessitates the consideration of alternative etiological factors. "There was a very close correlation between colour intensity and anti-Tg/anti-TPO antibody levels," write Schulz SL et al., who further imply that the enlarged thyroid arteries are not due to increased thyroid hormone synthesis but rather reflect the manifestation of an autoimmune process. Similarly, Bogazzi F et al. (7) concluded that hypothyroid Hashimoto's thyroiditis patients' elevated TBF is likely not due to thyroid hormone's effects, but rather to stimulation of the thyroid gland by TSH or a TSH-receptor antibody. TRAbs can either stimulate the TSH receptor, leading to Graves' thyrotoxicosis, or block it, resulting in hypothyroidism. (1) The observation that intrathyroidal vascularity and flow velocity are elevated in spontaneous hyperthyroidism, but not in hyperthyroidism caused by thyroid hormone consumption or thyroid gland destruction, lends credence to the idea that improving thyroid vascularity is associated with the autoimmune process. (36) We attempted to find a correlation between the hormonal level status and the two additional indices, RI and PI, in addition to the two main Doppler indices, DPVP and PSV, which are used in most studies regarding hypo- or hyperthyroidism, but no such correlation was found. Unfortunately, there is a lack of research that compares RI and PI with thyroid hormonal status, and the articles that do discuss RI mostly use it to try to distinguish between benign and malignant thyroid nodules. 50 and 51

Researchers Basar Sarikaya et al. also utilised the RI in their study of newly diagnosed children with Hashimoto's thyroiditis; they found no statistically significant difference in the mean RI values between patients with normal or near-normal grey-scale findings and those with marked grey-scale changes. This finding applies to both euthyroid and subclinical hypothyroid cases. Below the usual limits, both RI values were found. (52)

Doppler study results and hyperthyroid hormonal state are correlated.

In 5 out of 17 patients with hyperthyroidism (29.4%), we found an increased DPVP (grade III & IV), and in 14 out of 17 patients (82.3%), we found an increased PSV (>25 cm/sec). Indicating that an abnormal Doppler examination has an 84.2% sensitivity and an 86.7% specificity when it comes to hyperthyroid hormone status.

According to research conducted by Ota et al., TBF levels were found to be significantly higher in Graves' disease compared to painless thyroiditis, subacute thyroiditis, and normal controls. Additionally, the study found that all patients with Graves' disease had TBF values exceeding 4% of the normal range, while all patients with painless thyroiditis and subacute thyroiditis had TBF values below 4% of the normal range. The PSV of ITA was considerably higher in untreated Graves' patients than in those on treatment, who were still hyperthyroid, and even higher in euthyroid Graves' patients, according to another study by KVS Hari Kumar et al. (41), which observed that all hyperthyroid Graves' patients exhibited elevated Doppler vascular parameters with 90% sensitivity and 90% specificity in diagnosing Graves' disease. (42) Our findings in hyperthyroid patients are consistent with these studies; we observed a statistically significant correlation between elevated thyroid hormone levels and increased DVPV and PSV (p-value for correlation between PSV & hyperthyroid hormonal status=0.001). This suggests that the vascularity of the thyroid gland correlates well with the underlying hormonal functional status.

"A linear functional correlation was found between the peak flow velocities in the ITA and the fT3 or fT4 level," write Schweiger U. et al., who also confirm this. (46), Traditional grey-scale sonography and, more lately, CFDS can be helpful in diagnosing subclinical hyperthyroidism, a purely biochemical condition, by learning about thyroid function. (43) Elevated serum TSH levels (preclinical hypothyroidism) or decreased serum TSH suppression (subclinical hyperthyroidism) accompanied by normal serum fT4 and fT3 levels is characterised as subclinical thyroid dysfunction. In patients with subclinical hypothyroidism or hyperthyroidism, we found an improved TBF (45). These results are consistent with those of Ishay A. et al., who discovered that subclinical hypothyroidism was associated with elevated PSV at intrathyroidal arteries in 78% of patients and subclinical hyperthyroidism with elevated PSV at the intrathyroidal level in 53% of patients. Our findings were in line with those of Cirillo L et al., who found that "patients with subclinical hyperthyroidism showed an increased thyroid vascularisation both intranodular and peripheral and the mean PSV values were higher in case patients than in control subjects." While Sponza M et al. discovered higher values for PSV and RI compared to normal subjects in a group of 21 patients with Graves' disease before and after treatment, we were unable to find a statistically significant correlation between the other Doppler indices (RI and PI) and hyperthyroid hormonal status in our study (53). The two parameters used in this study, DPVP and PSV, are indicative of the enhanced thyroid vascularity seen during Doppler thyroid sonography. The results showed that when DPVP is elevated, PSV is nearly always elevated as well (all hyperthyroid patients with elevated DPVP have elevated PSV, and 6 out of 7 hypothyroid patients with elevated DPVP also showed elevated PSV). On the other hand, when PSV is elevated, DPVP is not necessarily elevated (only five out of fourteen, or 35.7%, of the hyperthyroid patients with elevated PSV also showed high DPVP, and six out of seventeen hypothyroid patients with elevated PSV also showed elevated DPVP).

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Conclusion

1- In detecting abnormal thyroid hormone status, an elevated DPVP is less sensitive than a high PSV, but it is a more precise sign of thyroid hormonal dysfunction than an elevated PSV.

Using either of these Doppler measurements (DPVP and PSV) independently does not reveal whether the thyroid is hyper- or hypothyroid.

3-aberrant thyroid Doppler results, such as elevated DPVP and/or PSV, are a sign of aberrant thyroid hormonal status that is 84.2% sensitive and 86.7% specific.

4-There was a statistically significant link between high PSV and aberrant thyroid hormonal status (hypo- or hyperthyroid), but no such correlation between individual thyroid hormones.

5-High DPVP did not provide a statistically significant link with the aberrant thyroid hormone status, but it did demonstrate a high specificity (100%) and low sensitivity (29%) in detecting the abnormality.

4-Neither the overall aberrant thyroid hormone status nor the hypo- or hyperthyroid status was significantly correlated with the RI and PI.

Recommendations

We suggest more research using a bigger sample size to compare thyroid Doppler results with hormone levels and autoantibody titres.

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