# "ROLE OF HIGH RESOLUTION ULTRASONOGRAPHY IN EVALUATION OF THYROID NODULES AND PATHOLOGICAL CORRELATION"


**By**

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**Under the Guidance of**

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| CT | Computed tomography |
| CN | Colloid nodule |
| FA | Follicular adenoma |
| FTC | Follicular thyroid carcinoma |
| HRS | High resolution sonography |
| MRI | Magnetic Resonance Imaging |
| MNT | Multinodular thyroid |
| NH | Nodular hyperplasia |
| PC | Papillary carcinoma |
| STN | Solitary thyroid nodule |

# ABSTRACT

**TITLE**

Role of high resolution ultrasonography in evaluation of thyroid nodules and pathological correlation.

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**Purpose of the study**:

1) To identify morphologic patterns on high resolution sonography (HRS) those are predictive of benign thyroid nodules and malignant thyroid nodules.

2) To evaluate the efficacy of HRS in differentiating benign and malignant thyroid nodules in comparison with histopathology.

**Materials and Methods:** HRS of thyroid was performed in 50 patients with clinically palpable STN, referred to Department of Radiodiagnosis, R.L.Jalappa Hospital and Research Centre, Tamaka, Kolar, Karnataka over a period of 18months, using SIEMENS ACCUSON X 300 and SIEMENS G 50 with 5-10 MHz transducers Thyroid sonographic findings relevant to benign or malignant thyroid nodules were recorded and these findings were compared with histopathology reports of the post-operative specimen.

**Results:** Out of 50 cases of solitary thyroid nodules evaluated at HRS, 33 were diagnosed to be benign thyroid nodules. 17 were malignant thyroid nodules. After histopathological evaluation, 35 cases were found to be benign thyroid nodules and 15 were malignant thyroid nodules. Among benign thyroid nodules, follicular adenoma 51.4% (18 cases) was most common followed by nodular hyperplasia 28.6.5 (10 cases) and colloid nodule 20% (7 cases). Among malignant nodules, papillary carcinoma 86.7% (13 cases) was most common followed by follicular carcinoma 13.3% (2 cases).

**Conclusion:** Thyroid nodules were common in the females of age group 31 – 45 years. HRS is a safe, fairly accurate investigation to differentiate benign from malignant thyroid nodules with sensitivity of 80 % and specificity of 85.7 %.

**Key words**: solitary thyroid nodule; high resolution sonography; histopathology.

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# INTRODUCTION

Thyroid nodule is a discrete lesion and a common clinical condition. Solitary thyroid nodules are commonly being present in up to 50% of the elderly population. Thyroid nodules are found in up to 20% clinically by palpation and in up to 70% on sonographic studies.[1]

The thyroid gland is unique among endocrine glands, in that it is the first endocrine gland to appear in the fetus. It is the largest of all endocrine glands (weighing about 25 gm) and is the only one which is amenable to direct physical examination because of its superficial location.[2]

One or more additional non-palpable thyroid nodules may be found by HRS in about 50% of patients with a clinically palpable solitary nodule and they are also incidentally detected by imaging studies performed for various reasons.[3]

STN is one of the commonest thyroid disorder. STN is common in females than males with a ratio of 5:1 and prevalence mainly depends on age, sex, iodine intake, diet and environmental exposure, though STN is common in women, malignancy in STN is common in men.[4]

Sonography is a choice of investigation in evaluation of thyroid nodules. The high resolution sonography has resulted in discovery of large number of thyroid nodules which are obscured clinically. Many sonographic features have been described to differentiate benign nodules from malignant nodules.[5]

For each thyroid nodule, gray scale and color Doppler ultrasound are used to evaluate the sonographic features, which include shape, echogenicity (hypoechoic or isoechoic or hyperechoic), composition (solid, purely cystic, cyst with thin septa, mixed and spongiform), margin, halo, as well as presence or absence of coarse /

microcalcification, vascularity of the nodule and presence or absence of regional lymhnodes.[6]

Sonographic features which may be highly predictive of benign nodule on the basis of certain characteristics which includes wider than tall in shape, hyperechoic or isoechoic, solid nodule or purely cystic / cystic with thin septa / mixed / spongiform, well-defined margins, complete peripheral halo, coarse or egg shell peripheral calcification and perinodular vascularity.[7]

Sonographic features which may be highly predictive of malignant nodule are taller than wide shape, predominantly hypoechoic or hypoechoic, solid nodule, ill-defined margins, incomplete peripheral halo, microcalcification, intranodular vascularity, regional lymphadenopathy and local invasion of adjacent structures.[8]

Prediction of malignancy using HRS still remains difficult. Since there is overlap of sonographic features between benign and malignant thyroid nodules, because it is not possible to distinguish a benign follicular adenoma from a follicular carcinoma by HRS, FNAC, core biopsy and frozen sections, as vascular and capsular invasion can only be evaluated on histological specimen, so sonographic features are usually corroborated with histopathology results in differentiating various thyroid nodules.[9]

The goal in evaluating a thyroid nodule is to determine whether it is benign nodule or malignant nodule so that patients can undergo treatment at an earlier stage to reduce possible morbidity and mortality due to the disease, while avoiding unnecessary tests and surgery in patients with benign nodules.[11]

# OBJECTIVES

1. To identify morphologic patterns on high resolution sonography (HRS) those are predictive of benign and malignant thyroid nodules.

2. To evaluate the efficacy of HRS in differentiating benign from malignant thyroid nodules in comparison with histopathology.

# REVIEW OF LITERATURE

In 1656 Thomas Wharton named the gland which is situated in the anterior part of neck as thyroid, which means shield shaped gland derived from Greek description.[11]

Thyroid nodules are common in clinical practice, while most thyroid nodules are benign nodules and about 5% of all palpable nodules are malignant nodules.[12]

High resolution sonography is commonly used to evaluate the thyroid gland and some sonographic features may help distinguish benign or malignant nodules.[5]

A study done on STN by Fenn AS.et al revealed male: female incidence of 1:5, the maximum being in age group of 30-40 years.[13]

In a study undertaken on STN by Nagori and Algotar, benign follicular adenomas were most common accounts 44% followed by nodular hyperplasia 33% and among malignant nodules, papillary carcinoma accounts to 11% being the commonest malignant nodule.[14]

Lin D et al studied thyroid follicular adenomas diagnosed by HRS. A retrospective review of 6499 patients who underwent thyroid HRS, 209 was diagnosed as follicular adenomas by histopathological report. They concluded that most of the benign follicular adenomas revealed by HRS having wider than tall, isoechoic solid nodule, well defined margins, complete peripheral halo with perinodular vascularity.[15]

HRS reveals taller than wide, hypoechoic solid nodule, poorly defined margins, absent peripheral halo, intranodular coarse calcifications and intranodular vascularity were majority of medullary carcinoma. Since this sonographic pattern only rarely occurs in benign thyroid nodules, the results indicate that thyroid HRS can contribute to the diagnosis of medullary carcinoma.[16]

Shimamoto K et al: studied the usefulness of ultrasonography for pre-operating staging of thyroid papillary carcinoma in 77 patients who later underwent total thyroidectomy. In the study, the sensitivity in the detection of the regional lymphnode metastasis was 36.7%.They concluded that HRS was useful for pre-operative investigation of thyroid papillary carcinoma.[17]

# ANATOMY OF THYROID GLAND

## EMBRYOLOGY

The thyroid gland begins as an endodermal pouch (bud) from the floor of the pharynx between the first and second branchial pouches. Elongation of this bud forms a tubular outgrowth known as the thyroglossal duct continues inferiorly or caudally into the neck until the duct lies in a plane anterior to the developing tracheobronchial bud. As the development progresses, a bilobed organ connected by, a midline isthmus is eventually formed. Certain abnormalities connected with thyroid development include arrested growth, accessory tissues and cystic development of the thyroglossal duct.[18]

In case of arrested development of the thyroid, the gland may not migrate beyond the point of origin in the floor of the pharynx. In this case it may present as a lingual thyroid. Lingual thyroid may coexist with other thyroid tissues, varying from minimal tissue nodules to a hemi thyroid or normal thyroid. Even when there is normal development of the thyroid glands, there may be accessory thyroid tissue in the region of the neck at any point along the original track of the thyroid gland or beyond it in the mediastinal space or on rare occasion in the tracheal wall.[19]

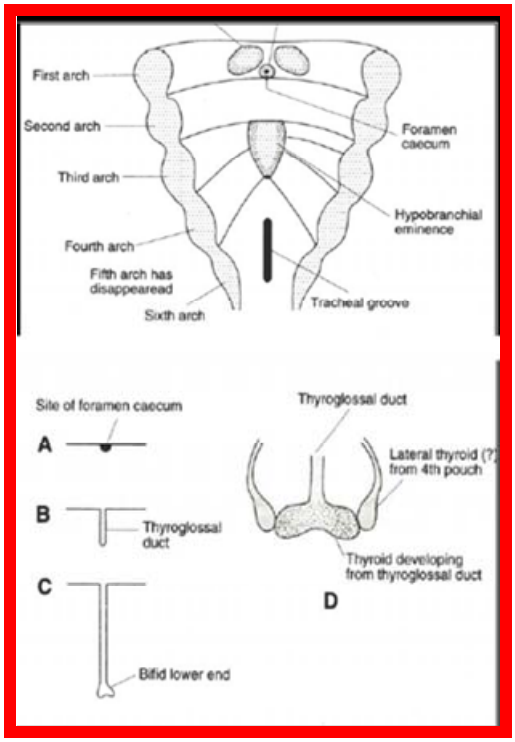



**FIG 1: Development of the thyroid**

# ANATOMY

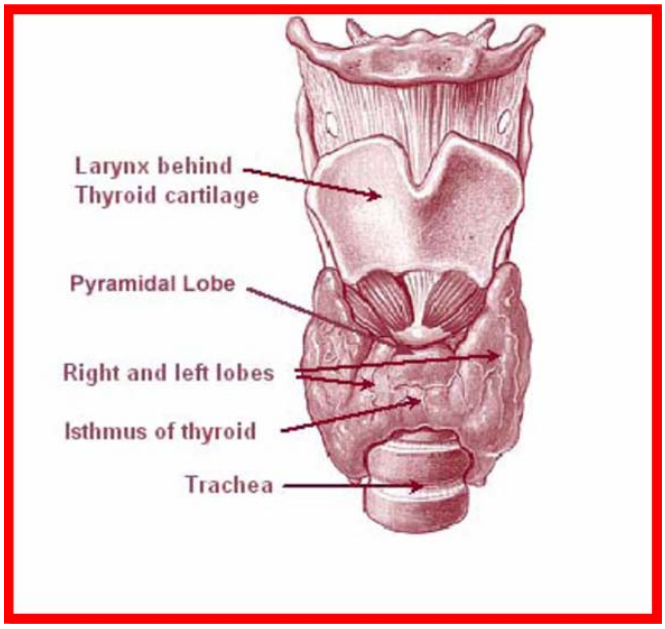



**FIG 2: Anatomy of normal thyroid gland**

The thyroid in Greek means Shield. As the name implies the thyroid gland is shield shaped although its form varies considerably, sometimes being more H or more U shaped. Each of the elongated lateral lobes consists of inferior and superior pole.

The gland is highly vascular and lies approximately at the level of the fifth cervical to the first thoracic vertebral body. It is located in the antero-inferior part of the neck (infrahyoid compartment) in a space bounded by muscle, trachea, esophagus, carotid arteries, and jugular veins.[20]

The thyroid gland is made up of two lobes located along either side of the trachea and connected across the midline by the isthmus, a thin structure draping over the anterior tracheal wall at the level of the junction of the middle and lower thirds of the thyroid gland, and to the anterior surface of the trachea, at the level of the 2nd and 3rd tracheal rings.[21]

From 10% to 40% of normal patients have a small thyroid (pyramidal) lobe arising superiorly from the isthmus and laying in front of the thyroid cartilage.

It can be regularly visualized in younger patients, but it undergoes progressive atrophy in adulthood and becomes invisible.[22]

The size and shape of the thyroid lobes vary widely in normal patients and approximately its weight is usually about 25 grams but varies slightly, heavier in females and enlarging during menstruation and pregnancy.[12]

**BLOOD SUPPLY OF THE THYROID GLAND**

The thyroid gland receives a dual blood supply from the superior and inferior thyroid arteries, which have abundant collateral anastomosis with each other, both ipsilaterally and contralaterally.

**SUPERIOR THYROID ARTERY:**

This is the first branch of the external carotid artery. In a small percentage of cases, it may arise from the common carotid artery just before its bifurcation into the internal and external branches. Near the upper pole of the lateral lobe, the superior thyroid artery sends a small branch, the cricothyroid artery across the cricothyroid muscle towards the midline. This vessel anastomosis with its opposite member in the midline on the surface of the median cricothyroid ligament.[23]

**INFERIOR THYROID ARTERY:**

This artery arises from the thyrocervical trunk, a branch of the first part of the subclavian artery at the level of the first rib. It ascends vertically for a short distance before turning medially, forming an arching loop and entering the trachea-esophageal groove. Most of its small branches penetrate the posterior aspect of the lateral lobe but there is a longitudinal branch that anastomosis with the superior thyroid artery near the superior pole.[24]

**VENOUS DRAINAGE OF THE THYROID GLAND:**

Three pairs of veins provide the venous drainage. The veins drains into internal jugular, brachiocephalic and anterior jugular veins.[24]

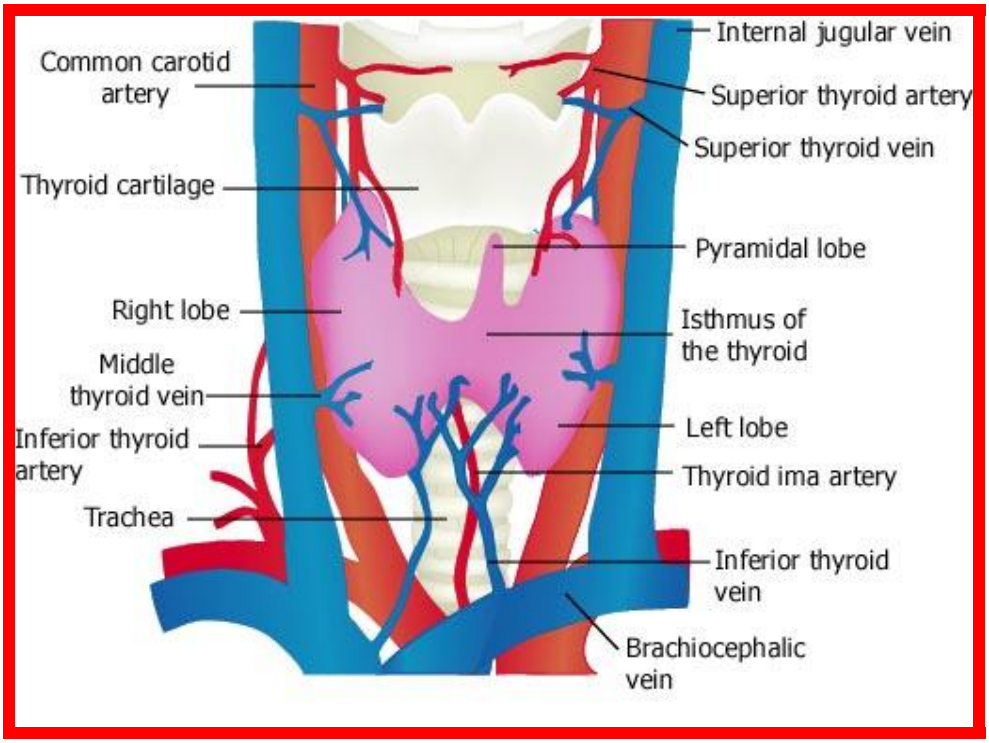



**FIG 3: Blood supply to the thyroid gland**

**LYMPHATIC DRAINAGE OF THE THYROID GLAND:**

Within the gland lymphatic channels occur immediately beneath the capsule and communicate between lobes through the isthmus.

Lymph from the upper part of the gland reaches the deep cervical lymph nodes either directly or through the prelaryngeal nodes. Lymph from the lower part of the gland drains to thyroid lower deep cervical nodes directly, and also through the pretracheal and Para tracheal nodes.[24]

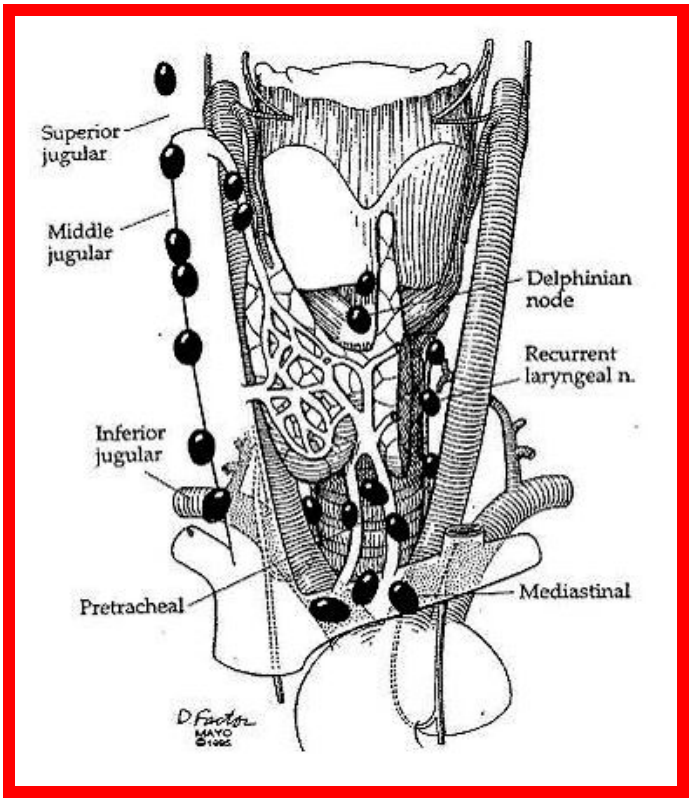



**FIG 4: Lymphatic drainage**

Papillary carcinoma is commonly associated with adjacent nodal metastasis and medullary carcinoma has a strong predilection for metastatic lymphatic involvement, usually within central compartment.[24]

**HISTOLOGY OF THYROID GLAND:**

The functional unit of thyroid is the follicle, which is separated from the interstitium by a complete basement membrane.

Group of 20 to 30 follicles are organized into lobules, which are separated by thin layers of fibrous connective tissue. The central region of the follicle contains colloid in which thyroglobulin is stored.

The follicular cells vary in size and shape depending on their functional status. In general follicular cells with a columnar shape are considered to be functionally active, where as those with a flattened shape are relatively inactive.[27]

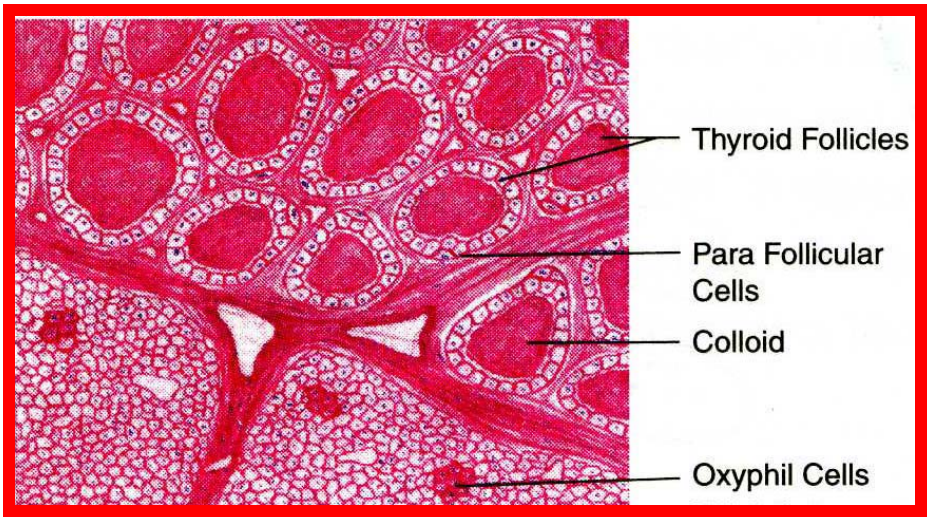



**FIG 5: Ultra structure of the thyroid gland**

## ANATOMY OF PARATHYROID

There are four parathyroid glands, two superior and two inferior, each measuring about 5 × 3 × 1 mm and weighing on average 35 to 40 mg (range, 10-78 mg).Supernumerary glands (>4) may be present and result from the separation of parathyroid anlage when the glands pull away from the pouch structures during the embryologic branchial complex phase merary glands are often associated with the thymus in the anterior mediastinum, suggesting a relationship in their development with the inferior parathyroid glands.[28]

Supernumerary parathyroid glands have been reported in 13% of the population; however, many of these are small, rudimentary or split glands. “Proper” supernumerary glands (>5 mg and located well away from the other four glands) are found in 5% of cases.[29]

Normal parathyroid glands vary from a yellow to red-brown color, depending on the degree of vascularity and the relative content of yellow parenchymal fat and chief cells. The chief cells are the primary source for the production of parathyroid hormone. The glands are generally oval or bean shaped but may be spherical, lobular, elongated, or flattened.[30]

Normal parathyroid glands are occasionally seen with high-frequency ultrasound, typically they are not visualized, likely because of their small size, deep location and poor conspicuity related to increased glandular fat. Ectopic parathyroid glands typically derive their major blood supply from branches of the inferior thyroid artery, with a lesser and variable contribution to the superior glands from the superior thyroid artery.[31]

**ULTRASOUND PHYSICS:**

A thorough understanding of the physics, technology and safety of usage of ultrasound is an essential pre-requisite before operating the machine and to make use of the potential of the equipment.

Physical basis of diagnostic ultrasound

**Definition:**

Ultrasound waves (latin: ultra = beyond or excess and sonic = sound) are the sounds of frequencies beyond human audible range (20Hz – 20000 Hz).Unlike conventional X ray and CT which make use of transmitted energy for imaging, Ultrasound makes use of makes use of reflecting energy for imaging.

**Mechanism of production of ultrasound:**

Usually ultrasonic waves are both generated and detected by a piezoelectric crystal. These crystals deform under the influence of an electric field and, vice versa, induce an electric field over the crystal upon deformation. As a consequence, when an alternating voltage is applied over the crystal, a compression wave with the same frequency is generated. A device converting one form of energy into another form (in this case electric to mechanical energy) is called a transducer.[32]

**HRS:**

Higher ultrasound frequencies have shorter wavelengths and higher spatial resolution but limited penetration due to increased absorption. Ideally, a high-frequency transducer (7–12 MHz) should be used for scanning the thyroid to obtain the benefit of better spatial resolution, since penetration is not a major issue due to the superficial location of the thyroid. However, in cases such as large masses, deep seated tumors, lesions with retrosternal or retroclavicular extension, obese patients

with short necks, and patients who cannot extend their neck adequately, a low frequency transducer should be used.[33]


**FIG 6: HRS Transducer**

**Conduction of ultrasound waves in tissue:**

Most clinical application of ultrasound use brief bursts or pulses of energy. The sound propagation in tissue and fluids is along the direction of particle movement (longitudinal waves). Propagation velocity is largely determined by the resistance of the medium to compression. In the body, propagation velocity of sound is assumed to be 1540 m/s.

**Acoustic impedance:**

Current diagnostic ultrasound scanners rely on detection and display of reflected sound or echoes. The amount of reflection or back scattered is determined by the difference in the acoustic impedance of material forming the interference. Acoustic impedance (Z) is determined by the product of the density (p) of the medium propagating the sound and propagating velocity (c) of sound in the medium.[34]

$$Z=pc$$

**Reflection:**

The way ultrasound is reflected when it strikes on an acoustic interference is determined by the size and surface features of the interface. Specular reflectors or interfaces, reflect the sound much as a mirror reflects light. The display of specular interface is highly depended on the angle of insonation. Diffuse reflectors are the interfaces from which echoes are scattered in all directions.[34]

**Refraction:**

The change is direction of propagation when sound passes from a tissue with one acoustic propagation velocity to a tissue with a higher or lower sound velocity.[33]

**Image display:**

Ultrasound signals may be displayed in several ways.

**A, B and M of ultrasound:**

A mode (A= Amplitude): it is simplest system in which only the depth of the echo producing interface is displaced often as a vertical deflection of an oscilloscope trace.

M mode (M=movement): in which both spatial and time dimensions are measured, useful in echocardiography for displaying value movement.

B mode (B=brightness): A 2D image can be obtained by translating the transducer between two A-mode acquisitions. This kind of imaging is called B-mode imaging, where B stands for brightness. If this measurement is repeated over time, an image sequence is obtained.[32]

**Harmonic imaging:**

It is a recently introduced sonographic modality using the effect of generation of secondary harmonics (integral multiples of the emitted frequency) in the insonated tissue. The tissue harmonic images have improved signal noise ratio, reduced side lobe artifact and reverberation artifact and improved lateral resolution.[32]

**Doppler physics:**

**The Doppler Effect:**

The Doppler principle states that when energy is reflected from a moving boundary, the frequency of the reflected energy varies in relation to the velocity of the moving boundary. This change in frequency is known as the "DOPPLER FREQUENCY SHIFT'

$\Delta F = (F_R - F_T)\ 2\ F_T.V.Cos\Phi$ or $V = \Delta F.C$

$$C \qquad 2\ F_T Cos\Phi F_T =$$

Frequency of Transmitting source in cycles/second

V = Velocity of blood flow

$Cos\Phi$ = Cosine of angle of insonation

C = Velocity of sound in tissue (1540 m/s)

$F_R$ = is the reflected frequency

$\Delta F$ = (Frequency Shift) = Difference in frequency between the emitted and returning sound.

Clinically this principle is used to determine the velocity of blood flow in the vessels. The frequency of sound reflected off moving blood cells is slightly altered from the sound emitted from the source (the transducer) in proportion to the velocity and direction of the blood cells.[33]

**INSTRUMENTATION (DOPPLER MODES):**

- Continuous wave Doppler (CW)
- Pulsed wave Doppler (PW)
- Color flow mapping (CF)
- Duplex sonography.
- Power Mode Doppler

**CONTINUOUS WAVE (CW) DOPPLER:**

A continuous sinusoidal wave is transmitted by a piezoelectric crystal, and the reflected signal is received by a second crystal. Usually, both crystals are embedded in the same transducer. CW Doppler is the only exception to the pulse–echo principle for ultrasound data acquisition. It does not yield spatial (i.e., depth) information.[32]

**PULSED WAVE (PW) DOPPLER:**

Pulsed waves are transmitted along a particular line through the tissue at a constant pulse repetition frequency (PRF). However, rather than acquiring the complete RF signal as a function of time, as in the M-mode acquisition, only one

sample of each reflected pulse is taken at a fixed time, the so-called range gate, after the transmission of the pulse. Consequently, information is obtained from one specific spatial position.[34]

**COLOR FLOW MAPPING:**

Here the conventional real time images are superimposed with blood flow information coded in colors to indicate the direction and velocity of flow. Color flow mapping displays the direction of blood flow in 3 different formats, red indicating flow towards the transducer, blue indicating flow away from the transducer, red-orange or blue - green which represents flow in several directions, suggesting turbulence.[35]

**DUPLEX SONOGRAPHY:**

Barberl in 1974, pioneered duplex sonography which displays the real time images simultaneously with pulsed wave Doppler waveforms.

It incorporates two elements:

- Grayscale Ultrasound to visualize the structure or architecture of the body part. No motion or blood flow is assessed.
- Color-Doppler Ultrasound to visualize the flow or movement of a structure, typically used to image blood within an artery.

Both displays are presented on the same screen ("duplex") to facilitate interpretation[35].

**POWER MODE DOPPLER:**

An alternative to the display of frequency information with color flow Doppler imaging is to use a color map that displays the integrated power of the Doppler signal instead of its mean frequency shift. The image does not provide any information related to flow direction or velocity and power mode Doppler imaging is much less angle dependent, there is no aliasing.[35]

**TECHNIQUE OF HRS**

**PATIENT POSITION:**

Thyroid ultrasound is usually performed with the patient in supine position and with a pillow placed between the shoulders to allow hyperextension of the neck and to elevate the thyroid gland away from sternal notch area. This is helpful in visualizing the inferior poles of both thyroid lobes, especially in a patient with a short neck.[39]

**FIG 7: Ultrasound Equipment-SIEMENS ACCUSON X 300**

**PROCEDURE:**

A 7.5 MHz transducer is universal for sonographic thyroid imaging. More superficial lesions with involvement of the strap muscles can be optimally imaged with 10 MHz or higher frequency transducers.[33]

The thyroid gland must be examined thoroughly in both transverse and longitudinal planes. Imaging of the lower poles can be enhanced by asking the patient to swallow, which momentarily raises the thyroid gland in the neck. The entire gland, including the isthmus, must be examined. The examination must also be extended laterally to include the region of the carotid artery and jugular vein in order to identify enlarged jugular chain lymph nodes, superiorly to visualize sub-mandibular lymphadenopathy, and inferiorly to define any pathologic supraclavicular lymph nodes. The thoracic inlet should be evaluated by angling the transducer inferiorly in the area of the sternal notch to look for a substernal goiter.[39]

Sonography of larger goiters may require lower frequency transducers, such as 5 MHz, which allow better penetration at the expense of resolution.[40]

**FIG 8: Technique of HRS of the thyroid**

**HRS ANATOMY OF THYROID GLAND:**

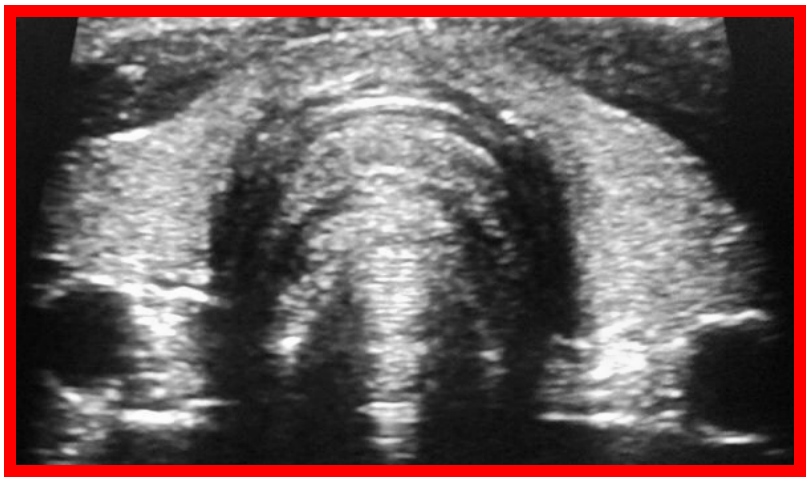


**FIG 9: Transverse gray scale HRS of the normal thyroid gland.**

Normal thyroid parenchyma has a homogeneous, medium-level to high-level echogenicity that makes detection of focal cystic or hypoechoic thyroid lesions relatively easy in most cases. The thin, hyperechoic line around the thyroid lobes is the capsule, which is often identifiable on ultrasound. With currently available high sensitivity Doppler instruments, the rich vascularity of the gland can be seen homogeneously distributed throughout the entire parenchyma. [41]

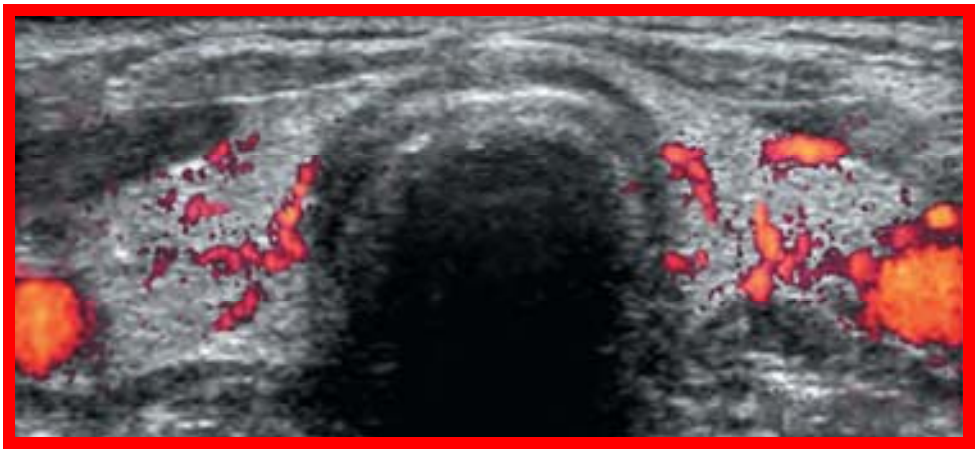


**FIG 10: Normal thyroid vascularity on color Doppler ultrasound**

The superior thyroid artery and vein are found at the upper pole of each lobe. The inferior thyroid vein is found at the lower pole and the inferior thyroid artery is located posterior to the lower third of each lobe.[42]

The sternohyoid and omohyoid muscles (strap muscles) are seen as thin, hypoechoic bands anterior to the thyroid gland. The sternocleido-mastoid muscle is seen as a larger oval band that lies lateral to the thyroid gland. An important anatomic landmark is the longuscolli muscle, located posterior to each thyroid lobe, in close contact with the prevertebral space. [40]

On longitudinal scans, inferior thyroid artery may be seen between the thyroid lobe and esophagus on the left and between the thyroid lobe and longuscolli muscle on the right. [41]

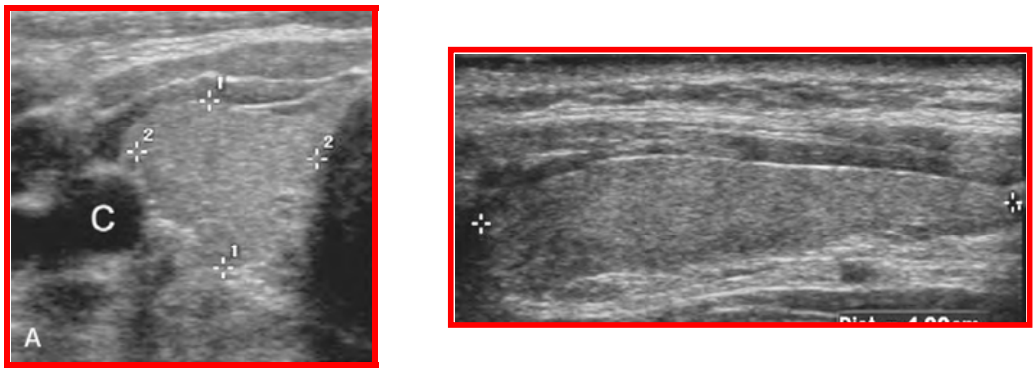
The esophagus, primarily a midline structure, may be found laterally and is usually on the left side. It is clearly identified by the target appearance of bowel in the transverse plane and by its peristaltic movements when the patient swallows.[42]

Sonography is an accurate method for calculating thyroid lobe volume. In about one third of cases, the sonographic measurement of volume differs from the estimated physical size on examination.[43]

The volume of the thyroid gland is calculated using the thyroid dimensions (length, height and depth) for each lobe by means of ultrasound using the formula

V (volume) = (length X height X depth X 0.52).

This summation of volume of both the lobes will be taken as thyroid gland volume.[44]




A) Transverse B) Longitudinal

**FIG 11: Volume measurement of thyroid lobe.**

In the newborn the thyroid gland is 18 to 20 mm long, with an antero-posterior (AP) diameter of 8 to 9 mm. By 1 year of age, the mean length is 25 mm and AP diameter is 12 to 15 mm.

In adults the mean length is approximately 40 to 60 mm, with mean AP diameter of 13 to 18 mm. The mean thickness of the isthmus is 4 to 6 mm.[45]

Among the linear parameters, the AP diameter is the most precise because it is relatively independent of possible dimensional asymmetry between the two lobes. When the AP diameter is more than 2 cm, the thyroid gland may be considered as enlarged.[38]

**The morphological features that are assessed of a thyroid nodule on high resolution sonography is as follows:[40]**

**1) SHAPE:**

AP diameter is equal or less than its transverse diameter of a nodule on a transverse or longitudinal plane is defined as wider than tall in shape and AP diameter is more than its transverse diameter of a nodule is defined as taller than wide.[46]
It is used for differentiating benign nodules from malignant nodules.[47]

Benign nodules grow parallel to normal tissue planes (wider than tall) and malignant nodules grow across normal tissue planes (taller than wide)[48]

**2) ECHOGENICITY:**

Echogenicity of a thyroid nodule is assessed in respect to the thyroid parenchyma is classified as hyperechoic, isoechoic, markedly hypoechoic and hypoechoic.[47]

Hyperechogenicity and isoechogenicity are commonly seen in benign nodules and markedly hypoechogenicity and hypoechogenicity are commonly seen in malignant lesions.[48]

As the echogenicity of a thyroid nodule increases, the risk of malignancy decreases and hypoechoic nodules have a higher tendency of being malignant compared to iso/ hyperechoic nodules.[49]

**3) COMPOSITION:**

Internal contents are classified as solid, purely cystic, cyst with thin septa, mixed (solid and cystic) and spongiform. Approximately 70% of thyroid nodules are solid, whereas the remaining 30% exhibit various amounts of cystic change.[48]

Solid nodule may be seen as hyperechoic, isoechoic and hypoechoic on HRS and seen in both benign and malignant nodules. Cyst is defined as anechoic, thin walled with posterior enhancement. Purely cystic nodule is characteristic of benign nodule. Cyst with thin septa (< 1mm) is commonly seen in benign nodules. Mixed nodule contains both solid and cystic. They are classified as predominantly solid and predominantly cystic. Predominantly cystic is defined as more than 50% nodule volume is cystic and as associated with small solid component. Predominantly solid is defined as more than 50% nodule volume is solid and associated with small cystic component.[49]

Mixed nodule (both solid and cystic component) is commonly seen in benign nodules. A cystic component occurs in 13–26% of all thyroid malignant nodules, but a predominant cystic is uncommon in malignant nodule. Papillary carcinomas may rarely exhibit varying amounts of cystic change and appear almost indistinguishable from benign cystic nodules. The spongiform appearance defined as an aggregation of multiple microcystic components in more than 50% of the nodule volume. It is 100% specific for a benign nodule and is an extremely uncommon finding in malignant nodules.[50]

Comet tail artifact is a tiny echogenic focus causing acoustic enhancement. They are thought to be microcrystals of calcium. The presence of multiple or solitary comet-tail artifacts within a cystic nodule suggests a colloid nodule and requires no further investigation. In a published series of 100 patients presenting with this feature, Fine needle aspiration (FNA) biopsy was benign in all cases.[51]

**4) MARGIN:**

Margin of the nodule are assessed as well-defined, sharp, irregular, poorly defined and spiculated. Sharp, well-defined margins are commonly seen in benign nodule, whereas irregular, spiculated, or poorly defined margins are common in malignant nodule.[47]

**5) PERIPHERAL HALO:**

Halo is a thin, 1-mm, sonolucent rim that surrounds the thyroid nodule, which represents a fibrous capsule.[52]Some authors represent the halo as a blood vessel.[53]
It classified as peripheral complete and peripheral incomplete halo. A peripheral complete halo that completely surrounds a thyroid nodule may be present in 60% to 80% of benign nodules and 15% of malignant nodules. Peripheral incomplete thick and irregular halo seen in malignant nodule Color Doppler study demonstrates that the thin vascular complete peripheral halo, is strongly suggestive of benign nodules and thick avsacular incomplete peripheral halo suggestive of malignant nodule.[50]

**6) CALCIFICATION:**

Calcification may be present in up to 30% of thyroid nodule. They are classified as coarse, microcalcification and peripheral egg shape.

Coarse calcification is defined as calcification more than 2 mm in diameter with posterior acoustic shadowing. Microcalcification is defined as less than 2 mm diameter with or without posterior acoustic shadowing.[54]

Peripheral egg shape calcification is defined as rim of calcification with posterior acoustic shadowing that surrounds the nodule. Coarse calcifications are

commonly seen in benign nodules and if it associated with microcalcification or appearing in the center of a hypoechoic nodule is suspicious for malignant nodule.[55]

The presence of microcalcification is one of the most specific features of malignant nodule, with a specificity of 85.8–95% and a positive predictive value of 41.8%–94.2%. The presence of microcalcification in a predominantly solid nodule increases cancer risk threefold compared to a predominantly solid nodule without any calcification.[55]

Peripheral shell (eggshell) calcification, although rarely present, has traditionally been considered a characteristic of a benign nodule however, thickened and interrupted peripheral calcification, particularly if associated with hypoechoic halo, have very high sensitivity for the diagnosis of malignant nodule.[53]

**7) COLOUR FLOW PATTERN:**

There are two major patterns of vascularity, classified as intranodular and perinodular vascularity. Color flow ultrasound assesses the vascularity of a thyroid nodule to help whether that nodule is benign or malignant. Perinodular vascularity commonly seen upto 80% to 95% in benign nodules, whereas intranodular vascularity, with or without a perinodular component seen upto70% to 90% of malignant nodules.[56]

**8) LOCAL INVASION:**

HRS is able to detect the presence of extracapsular spread but it may not be able to delineate its entire extent (particularly for large thyroid masses). Invasion of prevertebral muscle, esophagus and trachea are better demonstrated on cross-sectional imaging such as CT and MRI.

The presence of direct tumor invasion of adjacent soft tissue and metastases to regional lymph nodes are highly specific of thyroid malignancy.[57]

**9) LYMPH NODE METASTASES:**

Regional nodal metastases have been reported to occur in 19.4% of all thyroid malignancies, most commonly seen in papillary carcinoma and medullary carcinoma. Sonographic features raising the suspicion of metastatic nodes include round shape, loss of echogenic hilum, heterogeneous internal architecture, and presence of microcalcification, cystic necrosis, and abnormal peripheral vascularity on color Doppler.[58]

Classification of lymphnodes according to Daeubler B et al as follows[59]

- Level I: Submental and submandibular nodes
  - Level Ia: Submental triangle
  - Level Ib: Submandibular triangle
- Level II: Upper jugular nodes
- Level III: Middle jugular nodes
- Level IV: Lower jugular nodes
- Level V: Posterior triangle group
- Level VI: Anterior triangle group
- Level VII: Upper mediastinal nodes.

Central and lateral nodal metastases are commonly involved in papillary thyroid carcinoma. Central (Includes level VI lymph nodes.) nodal metastasis was found to be 76%, lateral (Includes level II to level IV lymph nodes) nodal metastasis was found to be 65%.Level VII nodes are commonly involved in medullary carcinoma.

**RELIABILITY OF HRS FEATURES IN DIFFERENTIATION OF BENIGN FROM MALIGNANT THYROID NODULES[19]**

| Feature | Benign | Malignant |
|---|---|---|
| **A) Shape** | | |
| Wider than tall | +++ | ++ |
| Taller than wide | + | ++++ |
| **B) Echogenicity** | | |
| Hyperechoic | ++++ | + |
| Isoechoic | +++ | + + |
| Hypoechoic | +++ | ++ + |
| Markedly hypoechoic | + | + + + + |
| **C) Internal contents** | | |
| Purely cystic | ++++ | + |
| Cystic with thin septa | +++ + | + |
| Mixed solid and cystic | +++ | ++ |
| Comet tail artifact | + + + | + |
| **D) Margin** | | |
| Well defined | + + + | + + |
| Poorly defined | + + | + + + |
| Spiculated | + | + + + |
| **E) Halo** | | |
| Thin complete halo | + + + + | + + |
| Thick incomplete | + | + + + |
| Absent halo | + | + + + |

| | | |
|---|---|---|
| **F) Calcification** | | |
| Egg shell calcification | + + + | + + |
| Coarse calcification | + + + | + |
| Microcalcification | + + | + + + + |
| **G) Doppler** | | |
| Peripheral flow pattern | + + + | + + |
| Internal flow pattern | + + | + + + |

Each nodule can be assigned1 of 10 discrete morphologic groupings by Waters et al[5] which are as follows

1. Spongiform without hypervascularity.
2. Cyst with avascular colloid plug.
3. Giraffe pattern with blocks of hyperechogenicity, or white, separated by bands of hypoechogenicity, or black
4. Uniform hyperechogenicity ("White knight")
5. Intense hypervascularity ("Red light")
6. Hypoechogenicity.
7. Isoechogenicity without halo.
8. Isoechogenicity with halo.
9. "Ring of fire," or nodules with intense peripheral vascularity.
10. Mixed pattern (cystic and solid)

**1) Spongiform without hypervascularity:**

Spongiform configuration is defined as an aggregation of multiple microcystic components in more than 50% of the nodule volume without any abnormal vascularity on color Doppler.

**2) Cyst with avascular colloid plug:**

Nodule is predominantly cystic with small solid component which contains colloid material and does not show any vascularity on color Doppler is defined as cyst with avascular colloid plug.

**3) Giraffe pattern:**

Giraffe pattern is defined as solid nodule with blocks of hyperechogenicity or white, separated by bands of hypoechogenicity or black.

**4) White knight:**

White knight is defined as uniform hyperechoic nodule compared to adjacent thyroid.

**5) Red light:**

Red light is defined as nodule shows intense hypervascularity on color Doppler.

**6) Hypoechogenicity:**

The nodule shows uniform hypoechogenicity compared to the adjacent thyroid.

**7) Isoechogenicity without halo:**

Nodule shows homogenous echogenicity compared to adjacent thyroid without peripheral complete halo.

**8) Isoechogenicity with halo:**

Nodule shows homogenous echogenicity compared to adjacent thyroid with peripheral complete halo.

**9) Ring of fire:**

Nodule with intense perinodular vascularity on color Doppler is termed as ring of fire.

**10) Mixed pattern:**

Nodule contains both cystic and solid component.

Watters et al proposed that four specific morphologic features are predictive of benign thyroid nodules which had 100% specificity for benignity such as,

- Spongiform configuration
- Cyst with colloid clot
- Giraffe pattern
- Diffuse hyperechogenicity

**Sonographic appearances which may be highly predictive of a benign nodule[61]**

- Wider than tall in shape
- Isoechogenicity / Hyperechogenicity
- Solid / Purely cystic nodule / Cystic with thin septa / Spongiform appearance
- Well defined margins
- Peripheral complete halo
- Egg shell / coarse calcification
- Comet tail artifact.
- Perinodular vascularity.

**Sonographic appearances which may be highly predictive of a malignant nodule[62]**

- Taller than wide in shape
- Markedly hypoechogenicity / hypoechogenicity
- Solid / mixed nodule
- Ill-defined margins
- Peripheral incomplete halo
- Microcalcification / coarse calcification in hypoechoic nodule
- Intranodular vascularity

**SONOELASTOGRAPHY:**

Elastography is one of the latest technologies that can be applied to sonography for reconstructing tissue elasticity. The principle of elastography states that tissue compression causes deformation within the tissue; the displacement is smaller in harder tissues than in softer tissues.[63]

Four elastographic patterns of thyroid nodule have been described as follows:

Pattern 1: Elasticity in the whole nodule.

Pattern 2: Elasticity in a large part of the nodule, within constant appearance of inelastic areas.

Pattern 3: Constant presence of large inelastic areas at the periphery

Pattern 4: Uniformly inelastic.

In recent literature reports, pattern of 1 to 2 are commonly seen upto 78% to 100% in benign nodules, whereas pattern of 3 to 4 are commonly seen upto 88% to 96% in malignant nodules.[63]

**RADIOGRAPHY:**

The thyroid gland on plain X-ray is visualized when there is thyroid enlargement as a soft tissue neck mass in the region of the lower cervical vertebra. Associated findings include deviation of trachea, calcification and retrosternal extension.[64]

**COMPUTED TOMOGRAPHY AND MAGNETIC RESONANCE IMAGING:**

CT and MRI have a limited role in the evaluation of thyroid disease. They may occasionally be used to demonstrate the extent of local invasion or local recurrence of thyroid malignancy and to detect the presence of retrosternal and retrotracheal extension of thyroid enlargement.[65]

Classification of thyroid pathology as given by Burch HB et al is as follows:[66]

**BENIGN NEOPLASMS OF THYROID:**

**A) ADENOMAS**

- Follicular

**B) COLLOID NODULE**

**C) HYPERPLASTIC NODULE**

**D) THYROID CYST**

- Simple cyst
- Complex cyst

**MALIGNANT LESIONS OF THYROID:**

A) Papillary carcinoma

B) Follicular carcinoma

C) Medullary carcinoma

D) Anaplastic carcinoma

E) Lymphoma, sarcoma, teratoma etc.,

F) Metastasis

**BENIGN LESIONS OF THYROID:**

**1) FOLLICULARADENOMA:**

Follicular adenomas represent only 5% to 10% of all nodular disease of the thyroid and are more common in women than men. Most follicular adenomas are solitary, but may also develop as part of a multinodular process.

The benign follicular adenoma is a true thyroid neoplasm, characterized by compression of adjacent tissues and fibrous encapsulation. [44]

**Sonographic features of follicular adenoma includes:**[67]

- Round / oval in shape.
- Hyperechogenicity / isoechogenicity / hypoechogenicity
- Solid nodule
- Well defined margin
- Thick, smooth peripheral complete hypoechoic halo resulting from the fibrous capsule and blood vessels, which can be readily seen by color Doppler imaging.
- Perinodular vascularity on color Doppler study

**Histopathology findings:**

Histologically the tumor is surrounded by fibrous capsule that often contains wide vascular spaces. The tumor cells are arranged in different patterns. Various subtypes of follicular adenoma include:

Fetal adenoma : Small follicles containing scanty colloid.

Simple adenoma: Follicles are of same size as those in adjacent normal thyroid.

Embryonal adenoma: Nests of follicular cells with few or no follicles.[68]

**2) COLLOID NODULE:**

Colloid nodules also known as adenomatous nodules which are benign nodules.[69]

They are usually caused by not getting enough iodine in the diet. Females are more common than males.[70]

**Sonographic features of colloid nodule includes:**[69]

- Small to moderate size.
- Purely cystic / cyst with small colloid plug and colloid plug does not show any vascularity on color Doppler study
- Well defined margins,
- A "comet tail sign" is characteristic of colloid within the cyst and is a sign of benignity.
- Small floating echoes, often with mobile debris-fluid levels, are typical of old hemorrhage.

**Histological findings:**

Histologically, typical nodule shows large follicles lined by regular low cuboidal epithelium and distended with colloid. Hemosiderin laden macrophages are commonly found within the follicular lumina or in the interstitium.[70]

**3) HYPERPLASTIC NODULE:**

Most thyroid nodules are benign hyperplastic nodules, but 5-20% of thyroid nodules are true malignant nodule. One of the major goals in the evaluation of STN is to differentiate hyperplasia from true malignant nodule.[71]

**Sonographic features of hyperplastic nodule includes:**[40]

- Multiple oval- to round shaped nodules.
- Isoechogenicity present in 57% of hyperplastic nodules is a good indicator of benignity. However, hypoechogenicity is also seen in34% of benign hyperplastic nodules.

- Predominantly solid (<50% cystic component) occurs in 87% of benign nodules and predominantly cystic in composition (>50% cystic component) with multiple internal septa occurs in13% of benign nodules. A purely cystic nodule is rare.
- Well-defined, smooth margin
- Peripheral complete halo
- Peripheral or egg shell and coarse calcifications.
- Perinodular vascularity on color Doppler study.

**Histopatholoical features:**

Histologically, there are wide ranges of appearances. Some nodules are composed of huge follicles lined by flattened epithelium, others are extremely cellular and hyperplastic, and still others are composed predominantly by Hurthle cells. Some of the dilated follicles have a conglomerate of small active follicles at one pole (so called Sanderson's Polsiers).[72]

**4) Thyroid cysts:**

Cystic lesions of the thyroid gland are common, representing 6% to 35% .They usually are the results of degeneration, hemorrhage or necrosis of an adenomatous nodule. Cystic change occurs more commonly in lesions larger than 4cm.They are classified as,

a. Simple cyst
b. Complex cyst

Simple cyst is defined as anechoic, thin wall with acoustic enhancement. Complex cyst is classified as predominantly cystic and predominantly solid. Predominantly cystic is defined as more than 50% nodule volume is cystic and as associated with

small solid component. Predominantly solid is defined as more than 50% nodule volume is solid and associated with small cystic component. Solid component is often a blood clot due to previous hemorrhage.

**Sonographic features of thyroid cysts include:**

Simple cyst are round, anechoic nodule, well-defined margins and avascular on color Doppler study. The presence of multiple or solitary comet-tail artifacts within a cystic nodule suggests a colloid nodule.

Complex cyst is round to oval, mixed (both solid and cystic) nodule, well defined margins, solid component within nodule is avascular on color Doppler study.

**Histological features:**

Histologically, shows proteinaceous debris, foramy histocytes, blood hemosiderin, ladin macrophages, multinucleated gaint cell and cholesterol crystals.[73]

**MALIGNANT NEOPLASMS OF THYROID:**

**1) PAPILLARY CARCINOMA:**

Papillary carcinomas are the most common type and account for50–80% of all thyroid malignant nodules.[74]

It can occur in patients of any age, prevalence of papillary thyroid carcinoma peaks in both the 3$^{rd}$and the7$^{th}$decade of life. Women are affected more often than men. [75]

**Sonographic features of papillary carcinoma includes:**[76]

- Taller than wide in shape
- Predominantly hypoechogenicity.
- Mostly solid and 13–26% have a cystic component, but a predominantly cystic appearance is uncommon.
- Ill-defined and irregular margin
- Peripheral incomplete halo
- Microcalcifications, appearing as tiny, punctuate hyperechoic foci, either with or without acoustic shadows.
- Intranodular vascularity on color Doppler study.
- Cervical lymph node metastases commonly occur at central (level VI) and lateral(level II to level IV)

**Histological features**:

Histologically, the tumor is multicentric within the thyroid gland in at least 20% of cases. Tumor cells are arranged in papillary pattern. Tumor cells show intranuclear grooves and intranuclear cytoplasmic inclusions called psammoma bodies (Round, laminated calcifications).[73]

The major route of spread of papillary carcinoma is through the lymphatics to nearby cervical lymph nodes.[77]

**2) FOLLICULAR CARCINOMA:**

Follicular carcinoma is the second subtype of well-differentiated malignant nodule. It accounts for 5% to 15% of all malignant nodules, affecting women more often than men.[44]

They are slow-growing but have a tendency to spread via the bloodstream and disseminate to bone, liver, or lung and only rarely metastasize to regional lymph nodes.[78]

**Sonographic features of follicular carcinoma includes:[79]**

- Egg shaped nodule with thin capsule
- Isoechogenicity / Hyperechogenicity
- Predominantly solid and homogeneous
- Irregular margin
- Peripheral thick irregular halo
- Calcification is rare
- Intranodular vascularity on color Doppler study

**Histological features:**

The two variants of follicular carcinoma differ greatly in histology:

1) The minimally invasive follicular carcinomas are encapsulated, and histologically it is more likely demonstrate a micro follicular or trabecular pattern. Significant mitotic activity can also occur which differentiate from follicular adenoma. The diagnosis of follicular carcinoma is dependent upon evaluation of tumor -capsule-thyroid interference, invasion of the capsule, invasion through the capsule and invasion into veins or beyond the capsule. The diagnosis of minimal invasive follicular carcinoma is restricted to those tumors which are encapsulated and show only capsule or transcapsular invasion.[67]

2) The widely invasive follicular carcinomas are not well encapsulated, and invasion of the vessels and the adjacent thyroid is more easily demonstrated. These tumors are more likely to exhibit mitotic activity and areas of pleomorphism.[68]

**3) MEDULLARY CARCINOMA:**

Medullary carcinoma accounts for about 5% of all malignant nodules. It is derived from the parafollicular cells, or C cells, and typically secretes the hormone calcitonin, which can be a useful serum marker.

This cancer is frequently familial (20%) and is an essential component of the multiple endocrine neoplasia (MEN) type II syndromes.[80]

There is a high incidence of metastatic involvement of lymph nodes. The prognosis for patients with medullary cancer is somewhat worse than for follicular carcinoma.[68]

**Sonographic features of medullary carcinoma includes:[69]**

The sonographic appearance of medullary carcinoma is usually similar to that of papillary carcinoma which includes:

- Taller than wide in shape
- Hypoechogenicity
- Solid nodule
- Ill defined margin
- Peripheral incomplete halo
- Calcifications are often seen and tend to be more coarse than the calcifications of typical papillary carcinoma. Calcifications can be seen not only in the

primary tumor but also in lymph node metastases and even in hepatic metastases.

- Intra nodular vascularity on color Doppler study

**Histological features:**

Histologically, the classic presentation is represented by a solid proliferation of round to polygonal cells of granular amphophilic cytoplasm and medium sized nucleus, separated by a highly vascular stroma, collagen and amyloid.[67]

**4) ANAPLASTIC CARCINOMA:**

Anaplastic thyroid carcinoma is typically a disease of elderly persons, it accounts for less than 2% of all malignant nodules.[81]

Anaplastic carcinomas may often be associated with papillary or follicular carcinomas.[82]

**Sonographic features of anaplastic carcinoma includes:[78]**

- Taller than wide in shape
- Hypoechoic nodule diffusely involving the entire thyroid lobe.
- Solid nodule
- Ill defined margin
- Coarse calcifications.
- Intra nodular vascularity on color Doppler study as well as encase or invade blood vessels and neck muscles.
- Nodal or distant metastases in 80% of patients.

**Histological features:**

Histologically, three patterns of growth are seen as squamoid, spindle cell and giant cell features. Common to all three patterns are high mitotic rate, extensive necrosis and marked degree of invasive with the gland as well as to extrathyroid structures.[79]

**5) LYMPHOMAS:**

It account for 10% of thyroid malignant nodules and are mostly non-Hodgkin type. They occur in one third of patients with Hashimoto's thyroiditis. Thyroid lymphoma presents most commonly as a solitary nodule (80%) or as multiple nodules (20%).[77]

**Sonographic features of lymphoma includes:[78]**

- Lobulated mass.
- Hypoechogenicity
- Solid nodule
- Ill defined / well defined margin
- Intranodular vascularity on color Doppler.
- Unilateral/bilateral, enlarged, solid non-calcified nodes.

The adjacent thyroid parenchyma may be heterogeneous as a result of associated chronic thyroiditis.

**Histological features:**

Histologically, the appearance of thyroid lymphomas resembles lymphoma occurring in other sites. The gamut of small, intermediate and large cell lesions are found, sometimes nodular areas are noted, although a diffuse pattern is more common.[69]

**6) THYROID METASTASIS:**[53]

Metastases to the thyroid are infrequent, occurring late in the course of neoplastic diseases as the result of hematogenous spread or less frequently a lymphatic route.

Metastases usually are from melanoma (39%), breast (21%), and renal cell (10%) carcinoma.

**Sonographic features of metastasis includes:**[54]

- Metastasis may appear as solitary.
- Well-circumscribed,
- Homogenously hypoechoic solid nodules without calcifications or as diffuse involvement of the gland.
- Metastatic nodules may show diffuse, disorganized vascularity.

**TNM STAGING FOR THYROID MALIGNANT NODULE[77]**

Primary Tumor (T):

TX - Primary tumor cannot be assessed

TO - No evidence of primary tumor

Tl- Tumor 2 cm or less in greatest diameter, limited to the thyroid

T2 - Tumor > 2 cm and <: 4 cm in greatest diameter, limited to the thyroid

T3 - Tumor > 4 cm in greatest diameter and limited to the thyroid or any tumor with minimal extra thyroidal extension (e.g., extension to sternothyroid muscle or perithyroidal soft tissues)

T4a - Tumor of any size extending outside the thyroid capsule to invade subcutaneous soft tissues, larynx, trachea, esophagus, or recurrent laryngeal nerve

T4b - Tumor invading prevertebral fascia or encases carotid artery or mediastinal vessels.

Regional Lymph Nodes (N):

NX - Regional nodes cannot be assessed

NO - No regional lymph node metastasis

Nl- Regional lymph node metastasis

Nla- Metastasis to level VI (pretracheal, paratracheal, and prelaryngeal nodes)

N1b - Metastasis to unilateral, bilateral, or contralateral cervical or superior mediastinal lymph nodes

Distant Metastasis (M):

MX - Distant metastasis cannot be assessed

MO - No distant metastasis

Ml - Distant metastasis

# MATERIALS AND METHODS

**Study Design**: A comparative study

**Source of data:**

All patients with clinically suspected STN referred for HRS of the thyroid to department of Radiodiagnosis at R.L.Jalappa Hospital and research centre, Kolar.

**Sample size:**

Total 50 cases who were diagnosed clinically with solitary thyroid nodule in R.L.Jalappa Hospital and research centre, Kolar, over a 18 months study period from December 2010 to May 2012.

**Inclusion criteria:**

1. All patients with clinical diagnosis of solitary thyroid nodule who are 18 yrs of age and above.

**Exclusion criteria:**

1. Patient with diffuse thyroid disease.
2. Patients with multi thyroid disease.

## METHOD OF PERFORMING EXAMINATION

HRS of neck was performed by using SIEMENS ACCUSON X 300 & SIEMENS G 50 with 5-10 MHz transducers.

Thyroid ultrasound was performed with the patient in supine position and with a pillow placed between the shoulders to allow hyperextension of the neck and to elevate the thyroid gland away from sternal notch area. The entire thyroid was

scanned from upper to the lower pole and the isthmus in the longitudinal and transverse planes.

Sonographic features of thyroid nodule were noted in the prepared proforma, with these sonographic features the thyroid nodule was predicted as benign or malignant, later these patients underwent surgery.

The data collected from these patients was analyzed using descriptive tools like specificity, sensitivity and predictive value of sonographic diagnosis in comparison with histopathological diagnosis.

# RESULTS

The present study deals with results of HRS of the thyroid nodule regarding prediction of benign and malignant nodule in comparison with histopathological diagnosis.

**TABLE 1: INCIDENCE OF NODULES ON HRS**

| | Number of cases (n=50) | Percentage (%) |
|---|---|---|
| **Benign** | 33 | 66% |
| **Malignant** | 17 | 34% |
| **Total** | **50** | **100** |

Benign nodules were more common (70%) when compared to malignant nodules (30%).

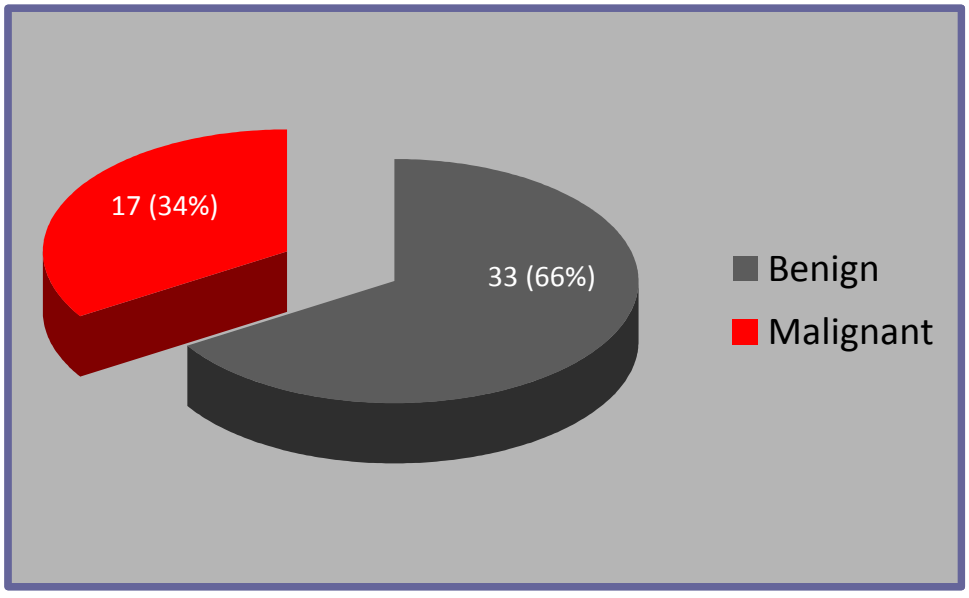



**CHART 1: INCIDENCE OF NODULES ON HRS**

**TABLE 2: AGE INCIDENCE OF STN ON HRS**

| Age (years) | Number of cases (n= 50) | Percentage (%) |
|---|---|---|
| **21-30** | 10 | 20% |
| **31-40** | 19 | 38% |
| **41-50** | 12 | 24% |
| **51-60** | 8 | 16% |
| **61& above** | 1 | 2% |
| **Total** | **50** | **100%** |

The commonest age group with thyroid nodules is between 31-40 years (54%)

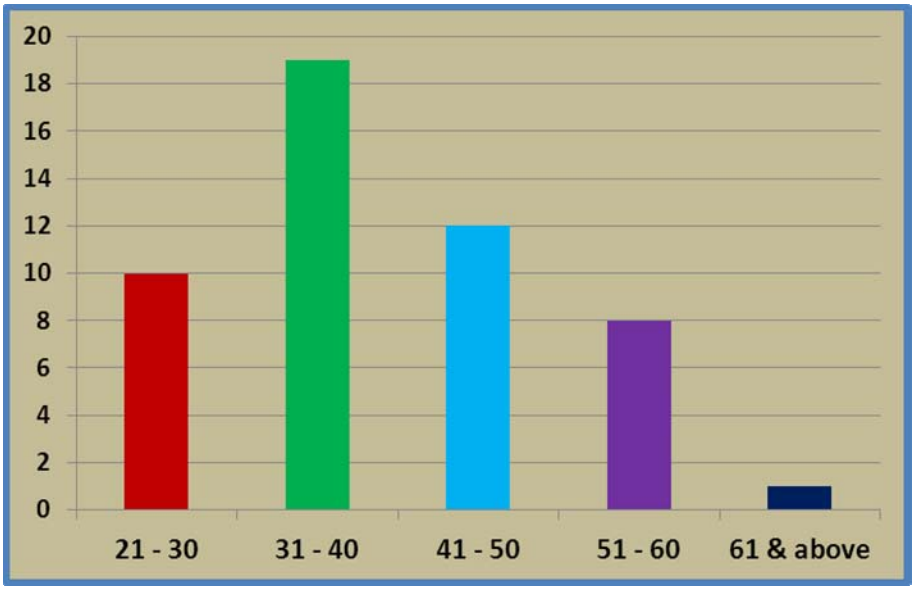



**CHART 2: AGE INCIDENCE OF STN ON HRS**

**TABLE 3: SEX RATIO**

| Sex | Number of cases(n=50) | Percentage (%) |
|---|---|---|
| **Female** | 41 | 82% |
| **Male** | 9 | 18% |
| **Total** | **50** | **100%** |

Out of 50 cases, 9 (18%) cases were males and 41(82 %) cases were females with male to female ratio of 1:4.5

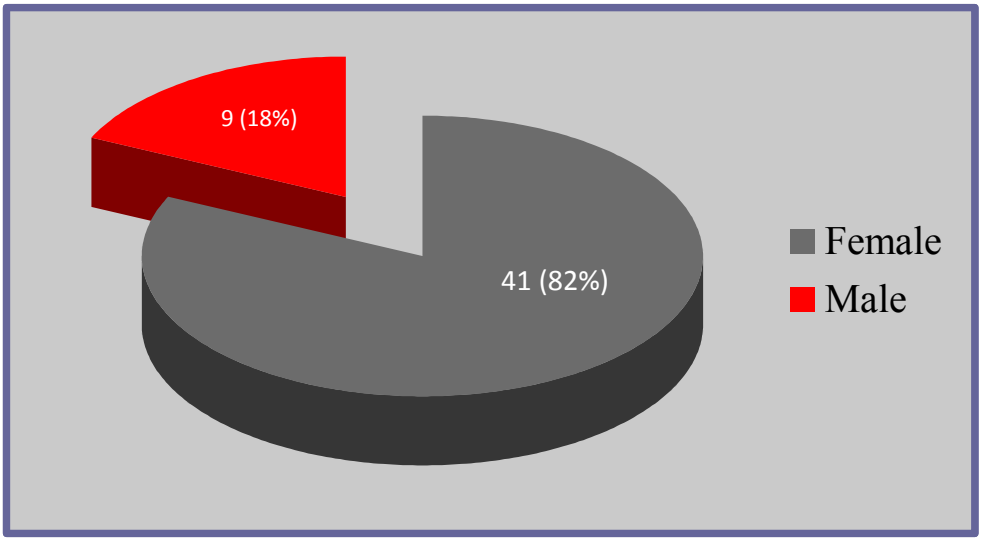



**CHART 3: SEX RATIO**

**TABLE 4: LOCATION OF NODULES ON HRS**

| Location | Number of cases(n=50) | Percentage (%) |
|---|---|---|
| **Right lobe** | 33 | 66% |
| **Left lobe** | 15 | 30% |
| **Isthmus** | 2 | 4% |
| **Total** | **50** | **100%** |

Nodules in the right lobe were more frequent and seen in 33(66%) cases as compared to the left lobe 15(30%) cases. Isthmus lesions were seen in 2(4%) cases.

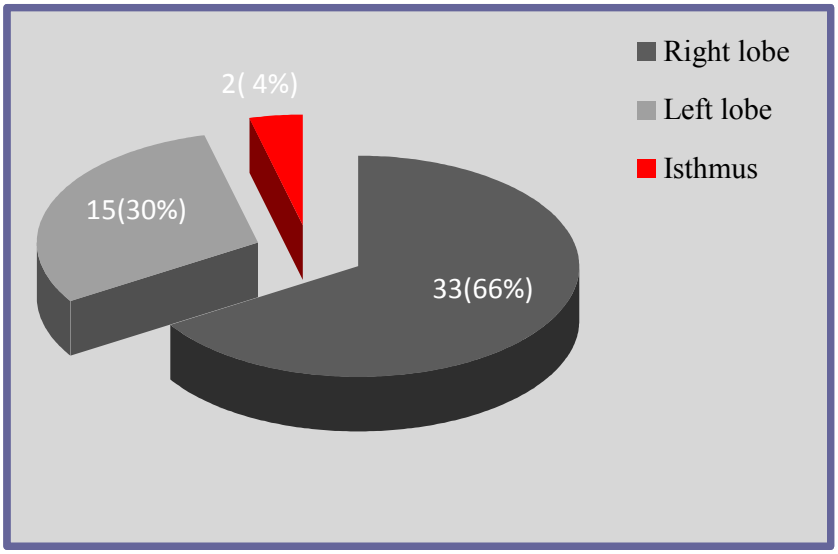



**CHART 4: LOCATION OF NODULES ON HRS**

**TABLE 5: MORPHOLOGIC PATTERN ON HRS AS DESCRIBED (By waters et al)[5]**

| S.L.No | Morphologic Pattern | No. of cases | Benign | Malignant |
|---|---|---|---|---|
| 1. | Spongiform | 2 | 2 | - |
| 2. | Cyst with colloid clot | 3 | 3 | - |
| 3. | Giraffe | - | - | - |
| 4. | White knight | 13 | 12 | 1 |
| 5. | Red light | 4 | 1 | 3 |
| 6. | Hypoechoic | 13 | 1 | 12 |
| 7. | Isoechoic without halo | 8 | 2 | 6 |
| 8. | Isoechoic with halo | 9 | 7 | 2 |
| 9. | Ring of fire | 3 | 2 | 1 |
| 10. | Mixed | 2 | 1 | 1 |

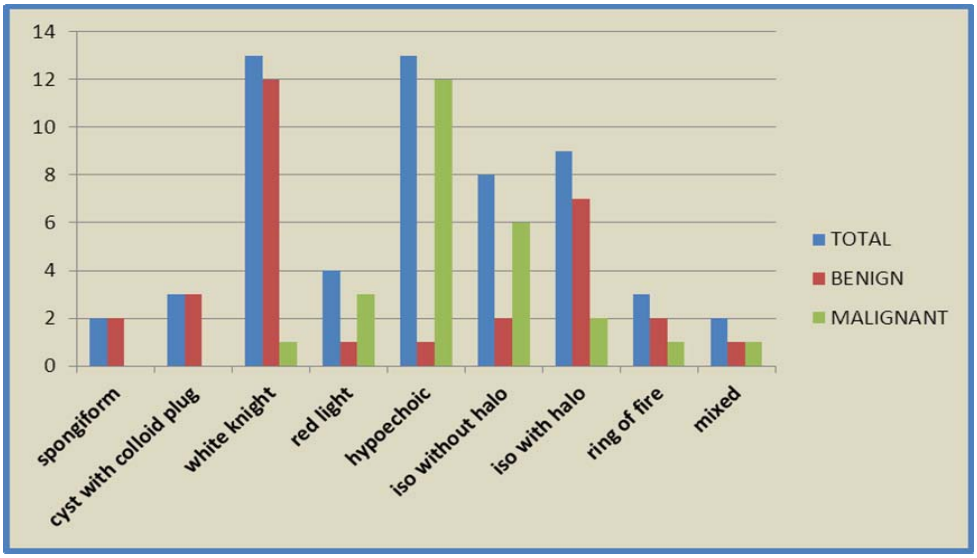



**CHART: 5 DISTRIBUTION OF MORPHOLOGIC PATTERN ON HRS**

**TABLE:6 DISTRIBUTION OF AP/T RATIO ACCORDING TO HRS DIAGNOSIS**

| Category | AP/T ratio | | Total (%) |
|---|---|---|---|
| | ≤1 | > 1 | |
| **Benign** | 31(93.9%) | 2(6.1%) | 33(100%) |
| **Malignant** | 3(17.6%) | 14(82.4%) | 17(100%) |

The shape of the nodule can be assessed by taking the antero-posterior to transverse ratio (AP/T ratio)

AP ≤1 are noted in 93.9% in benign nodules and AP > 1 are noted in 82.4% in malignant nodules.

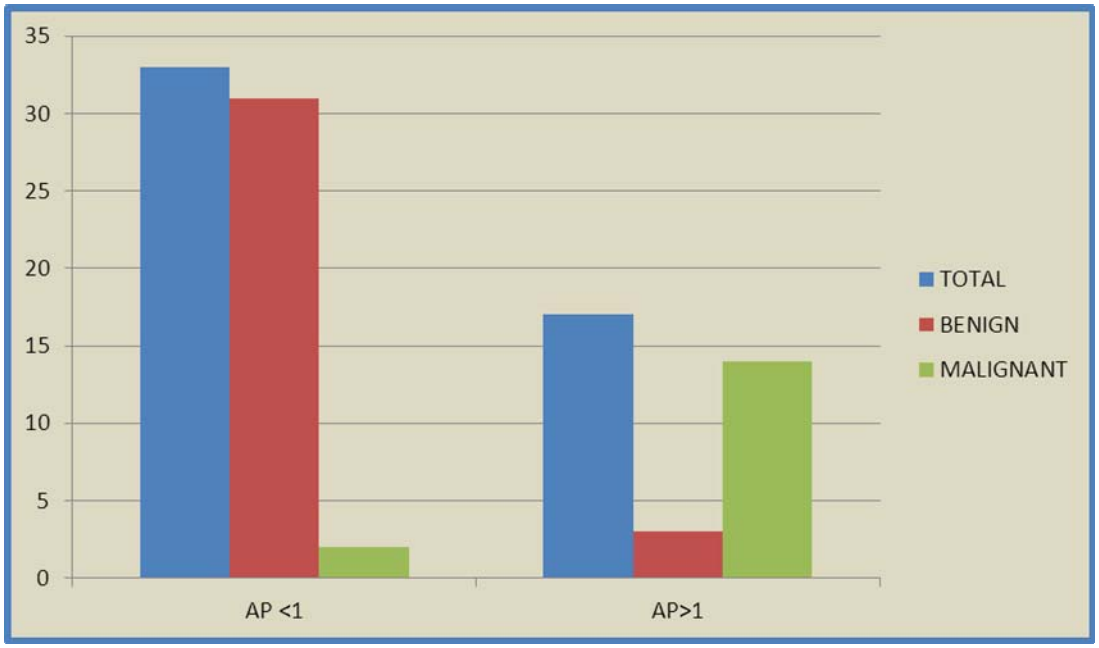



**CHART: 6 DISTRIBUTION OF AP/T RATIO ACCORDING TO HRS DIAGNOSIS**

**TABLE: 7 DISTRIBUTION OF ECHOTEXTURE ACCORDING TO HRS DIAGNOSIS**

| Category | Echotexture | | | | Total (%) |
|---|---|---|---|---|---|
| | Hyperechoic | Isoechoic | Hypoechoic | Anechoic | |
| **Benign** | 12 (36.4%) | 13(39.4%) | 1(3%) | 7(21.2%) | 33(100%) |
| **Malignant** | 1(5%) | 4(24%) | 12(71%) | - | 17(100%) |

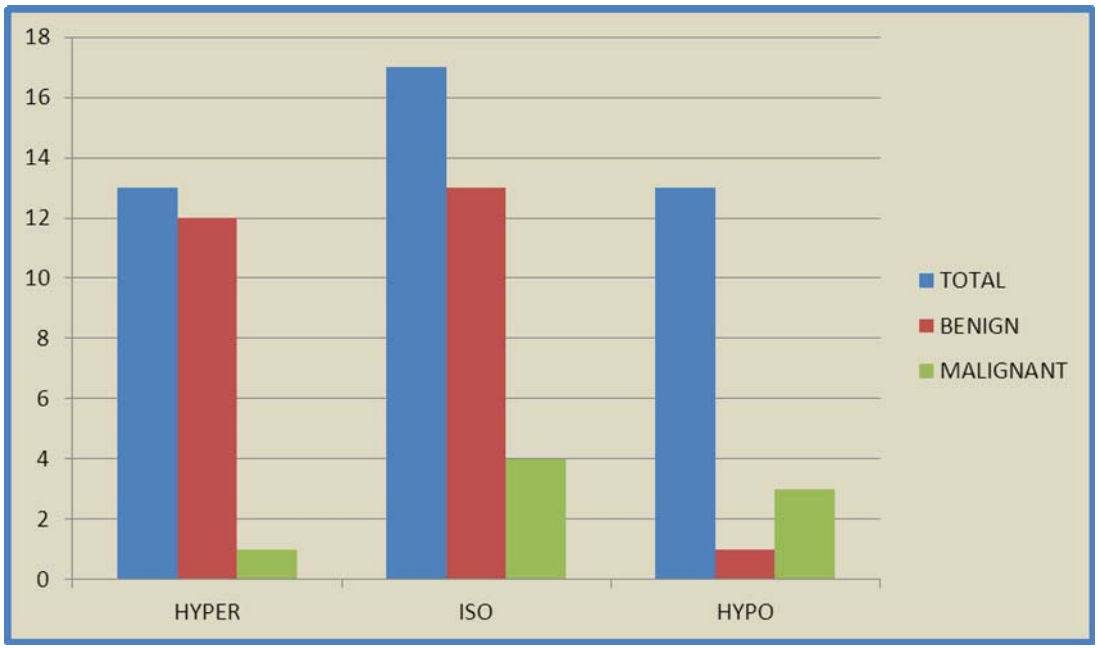



**CHART: 7 DISTRIBUTION OF ECHOTEXTURE ACCORDING TO HRS DIAGNOSIS**

**TABLE: 8 DISTRIBUTION OF COMPOSITION ACCORDING TO HRS DIAGNOSIS**

| Category | Internal contents | | | | | Total (%) |
|---|---|---|---|---|---|---|
| | Solid | Purely cystic | Cyst with thin septa | Mixed | Spongiform | |
| **Benign** | 26(79%) | 1(3%) | 3(9%) | 1(3%) | 2(6%) | 33(100%) |
| **Malignant** | 16(94.1%) | - | - | 1(5.9%) | - | 17(100%) |

The composition of benign nodules revealed 79 % solid, 3% purely cystic, 9% cyst with thin septa, 3% mixed (solid and cystic) and 6% spongiform.

The composition of malignant nodules revealed 94.1% solid and 5.9 % as mixed (solid and cystic).

**TABLE: 9 DISTRIBUTION OF MARGIN ACCORDING TO HRS DIAGNOSIS**

| Category | Margin | | Total (%) |
|---|---|---|---|
| | Well-defined | Ill-defined | |
| **Benign** | 30(91%) | 3(9%) | 33(100%) |
| **Malignant** | 2(11.8%) | 15(88.2%) | 17(100%) |

Well-defined margins are noted in 91% of benign nodules and ill-defined margins are noted in 88.2% of malignant nodules.

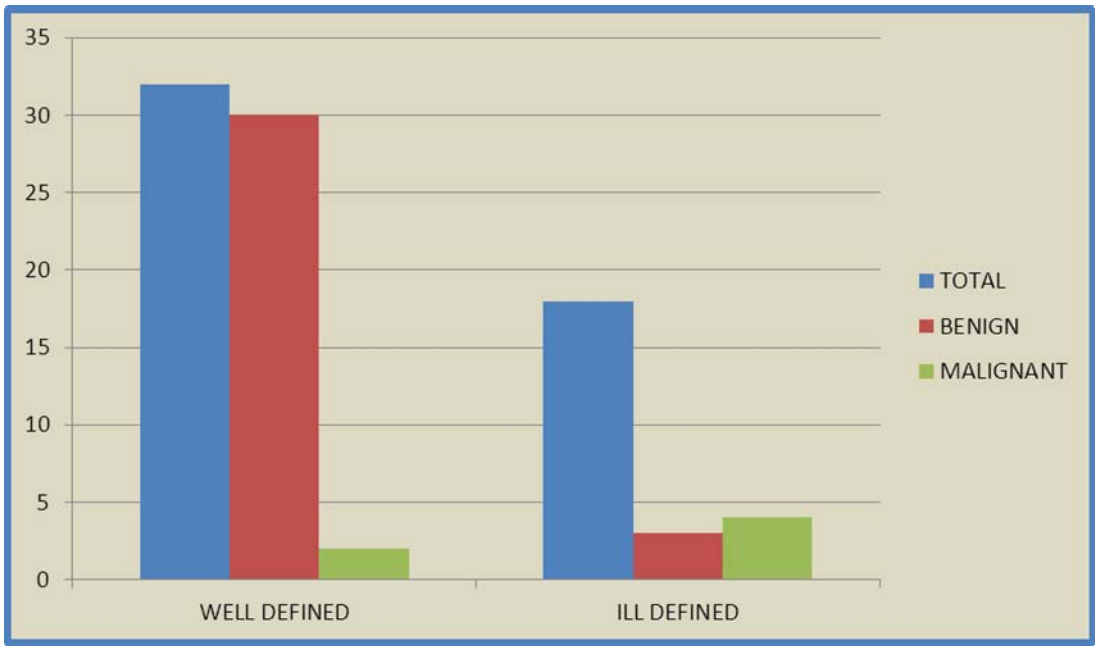



**CHART: 8 DISTRIBUTION OF MARGIN ACCORDING TO HRS DIAGNOSIS**

**TABLE: 10 DISTRIBUTION OF HALO ACCORDING TO HRS DIAGNOSIS**

| Category | Halo | | Total (%) |
|---|---|---|---|
| | Peripheral complete halo | Peripheral incomplete halo | |
| **Benign** | 23 (88.5%) | 3(11.5%) | 26(100%) |
| **Malignant** | 5(29%) | 12(71%) | 17(100%) |

Halo was noted in only 43 (26 benign and 17 malignant) cases out of the total 50 cases.

Peripheral complete halo was noted in 91% of benign nodules.

Peripheral incomplete halo was noted in 71% of malignant nodules.

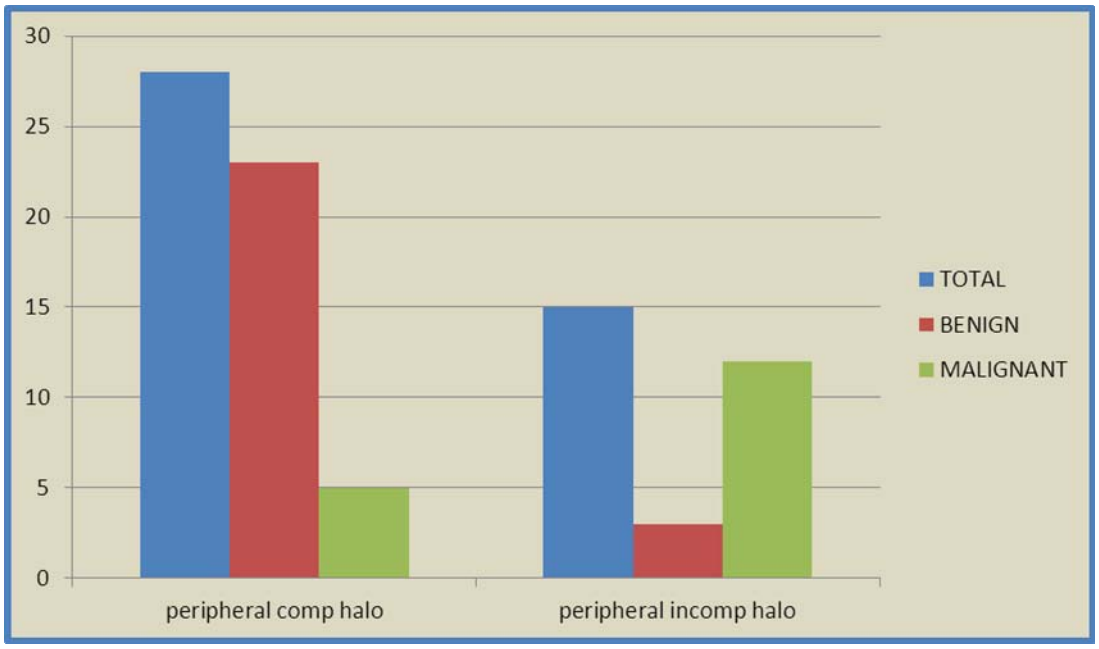



**CHART: 9 DISTRIBUTION OF HALO ACCORDING TO HRS DIAGNOSIS**

**TABLE: 11 DISTRIBUTION OF CALCIFICATION ACCORDING TO HRS DIAGNOSIS**

| Category | Calcification | | | Total |
|---|---|---|---|---|
| | Coarse | Micro | Peripheral EGG shell | |
| **Benign** | 6(67%) | 1(11%) | 2(22%) | 9(100%) |
| **Malignant** | 1 (7.7%) | 12(92.3%) | - | 13(100%) |
| **Total** | **7** | **13** | **2** | **22** |

Out of 50 cases, only 22 cases showed calcifications.

Coarse calcification was noted in 91% of benign nodules, peripheral EGG shell calcification was noted in 33% of benign nodules and microcalcification was noted in 12 % of malignant nodules.

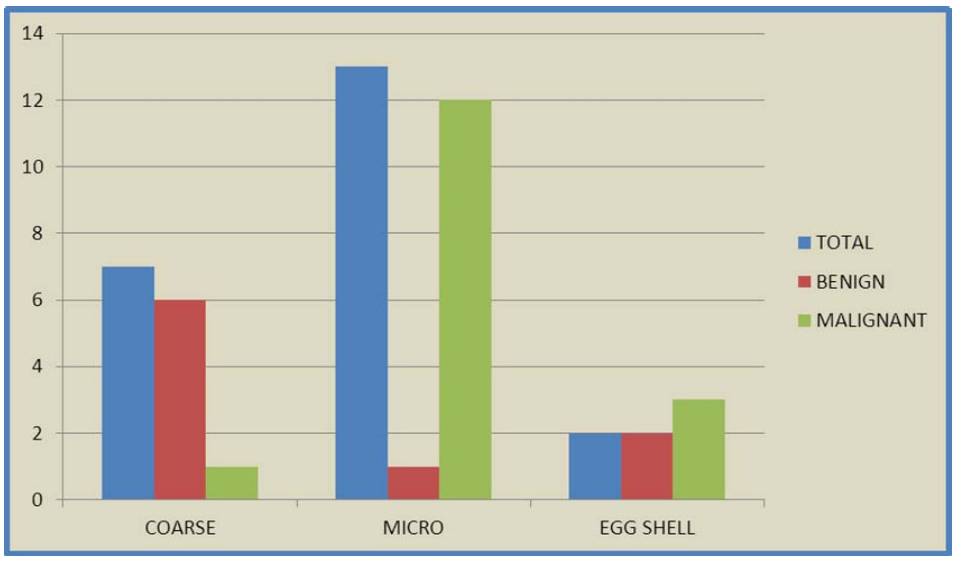



**CHART: 10 DISTRIBUTION OF CALCIFICATION ACCORDING TO HRS DIAGNOSIS**

**TABLE: 12 DISTRIBUTION OF ASCULARITY ACCORDING TO HRS DIAGNOSIS**

| Category | Vascularity | | Total (%) |
|---|---|---|---|
| | Intranodular | Perinodular | |
| **Benign** | 2 (7.7%) | 24 (92.3%) | 26(100%) |
| **Malignant** | 13(76.5%) | 4 (23.5%) | 17(100%) |
| **Total** | **15** | **28** | **43** |

Out of 50 cases, only 43 cases showed vascularity. Perinodular vascularity was noted in 92.3% of benign nodules, intranodular vascularity was noted in 76.5% and perinodular vascularity was noted in 23.5% of malignant nodules.

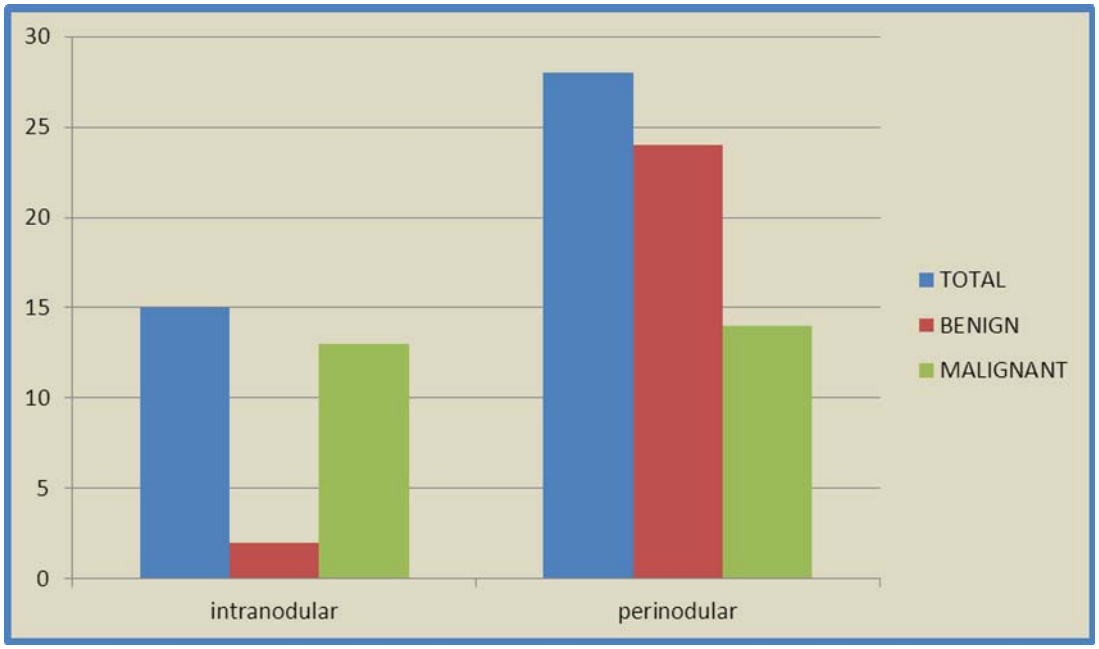



**CHART: 11 DISTRIBUTION OF VASCULARITY ACCORDING TO HRS DIAGNOSIS**

**TABLE: 13 DISTRIBUTION OFLYMPHNODES ACCORDING TO HRS DIAGNOSIS**

| | **Present** | **Absent** | **Total(50)** |
|---|---|---|---|
| Lymphnode | 9 | 41 | 50 |
| Percentage | 18 % | 82 % | 100% |

Out of 50 cases, involvement of cervical lymphnodes was seen in 9 cases (18%) of papillary carcinoma at the level of II and IV.

## HISTOPATHOLOGICAL DIAGNOSIS

**TABLE 14: TYPES OF BENIGN NODULES**

| Benign nodules | Number of cases(35) | Percentage (100%) |
|---|---|---|
| Follicular adenoma | 18 | 51.4% |
| Nodular hyperplasia | 10 | 28.6% |
| Colloid nodule | 7 | 20% |
| **TOTAL** | **35** | **100%** |

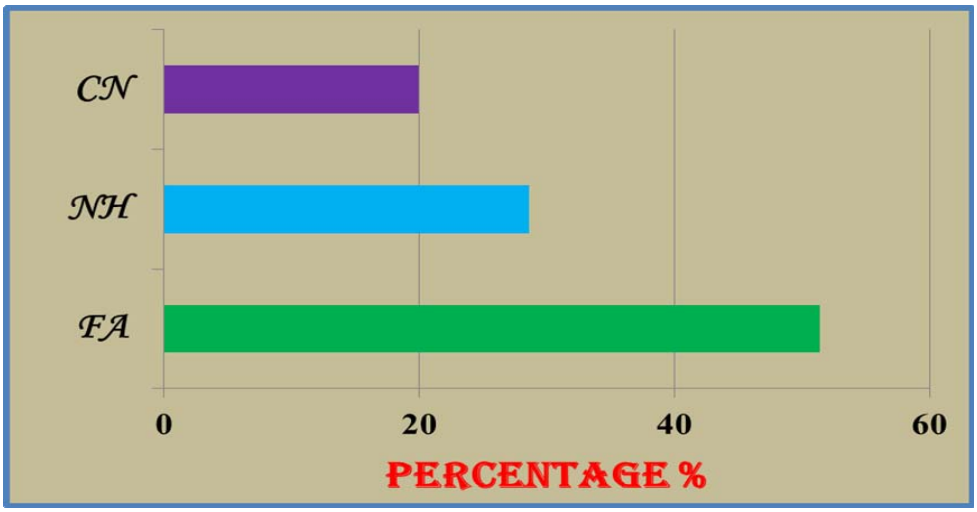



**CHART 12: TYPES OF BENIGN NODULES**

**TABLE 15: TYPES OF MALIGNANT NODULES**

| Malignant lesions | Number of cases(15) | Percentage (100%) |
|---|---|---|
| Papillary carcinoma | 13 | 86.7% |
| Follicular carcinoma | 2 | 13.3% |
| Medullary carcinoma | - | - |

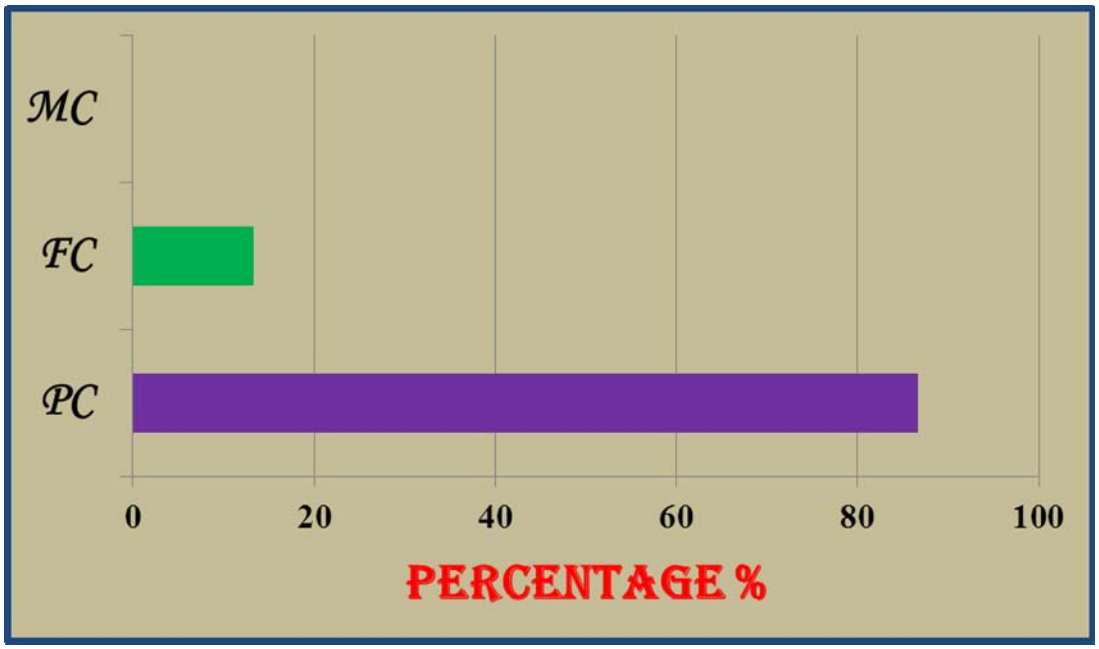



**CHART 13: TYPES OF MALIGNANT NODULES**

Out of 50 cases, histopathology revealed 35(70%) were benign nodules and 15(30%) were malignant nodules.

Follicular adenoma was the most common (18 cases) among benign nodules and papillary carcinoma (13cases) among malignant nodules.

**TABLE 16: TYPES OF SURGERIES PERFORMED**

| S.NO | Type of surgery | No of cases |
|---|---|---|
| 1 | Hemithyroidectomy | 31 |
| 2 | Near total thyroidectomy | 2 |
| 3 | Total thyroidectomy | 17 |
| 4. | Functional neck dissection | 9 |

All cases underwent surgery for cosmetic and compressive indications. The commonest performed surgery in our series is hemithyroidectomy, which accounts to 28(56%) cases. Functional neck dissection was done in 9 cases of papillary carcinoma of thyroid where lymph nodes were palpable.

**TABLE 17: COMPARISION OF HRS WITH HISTOPATHOLOGY**

| **H R S** | **HISTOPATHOLOGY** | | | |
|---|---|---|---|---|
| | | **Benign** | **Malignant** | **TOTAL** |
| | **Benign** | 30 | 3 | 33 |
| | **Malignant** | 5 | 12 | 17 |
| **TOTAL** | | **35** | **15** | **100** |

SENSITIVITY- 85.7%

SPECIFICITY- 80%

POSITIVE PREDICTIVE VALUE-90.9%

NEGATIVE PREDICTIVE VALUE-70.5%

# DISCUSSION

High Resolution Sonography is a choice of investigation in evaluation of thyroid nodules. The high resolution ultrasound has resulted in discovery of large number of thyroid nodules which are obscured clinically. Many sonographic features have been described to differentiate benign and malignant nature of the nodule. The present study was done on 50 patients.

The study done by Burch HB et al showed that highest age incidence thyroid nodule is between 21-50 years, the maximum being 31-40 years.[82]In the present study the commonest age group affected was 31-40 years.

The study done by Tsegaye et al showed that females are more commonly affected than males with male to female ratio was about 1:4.1.[83]In present study female predominance (82%) was noted with a male to female ratio of 1:4.5 and correlates with the above study.

The study done by Horwath E et al showed that 71% of nodules commonly occur in right thyroid lobe.[84] In the present study 66% of nodules occurred in right thyroid lobe and followed by 30% in left thyroid lobe.

The study done by Watters et al showed that four specific morphologic features such as spongiform configuration, Cyst with colloid clot, Giraffe pattern and diffuse hyperechogenicity are predictive of benign thyroid nodules and had 100% specificity for benignity that do not require biopsy.[5] In the present study, nodules with spongiform configuration, cyst with colloid clot and diffuse hyperechogenicity were diagnosed as benign lesions on HRS and were confirmed by histopathology reports which correlates with the above study. There was no giraffe pattern in the present study.

The study done by Grabe SK et al showed that AP/T ratio $\leq$ 1was noted in 95.3 %of benign nodules and AP/T ratio > 1 was noted in 83.7 % of malignant

nodules.[68] In present study AP/T ratio $\leq$ 1 was noted in 93.9 % of benign nodules and AP/T ration > 1 was noted in 82.4 % of malignant nodules which correlates with the above study.

The study done by Kim et al showed that 55% of hyperechoic, 42% isoechoic nodules and 3% of hypoechoic are benign nodules and 80% of hypoechoic nodules and 20% of isoechoic nodules are malignant nodules.[79] In the present study, 52% of hyperechoic nodules, 44% of isoechoic nodules and 4% of hypoechoic nodules were benign.75%of hypoechoic nodules and 25% of isoechoic nodules were malignant.

The study done by Hegde A et al showed that most benign and malignant nodules are solid, making it difficult to use this criterion for differentiating the two.[86] In present study shows 79% of benign nodules were solid, whereas 94.1% of malignant nodules were solid.

The study done by Papini E et al showed that nodule had well defined margin were benign and nodule had ill-defined margin were mostly malignant nodules. [85] In the present study, 91% of nodule had well-defined margins and 9% of nodule had ill defined margins were benign nodules and 88.2 % of the nodules had ill-defined margins and 11.8% well-defined margins were malignant nodules.

The study done by Wienke JR et al showed that 93.7% had peripheral complete halo in benign nodules and 83.3 % had peripheral incomplete halo in malignant nodules.[87] In the present study 91% of the nodules which had peripheral complete halo were benign nodules and 71% of the nodules which had peripheral incomplete halo were malignant nodules.

The study done by Wienke JR et al showed that coarse calcification seen in 72% and peripheral EGG shell calcification seen in 35% of benign nodules, whereas microcalcification seen in 16% of malignant nodules.[87] In present study coarse

calcification were seen in 67 % and peripheral EGG shell calcification in 22 % of benign nodules and microcalcification was seen in 12 % of malignant nodules.

The study done by Propper RA et al showed that perinodular vascularity is seen in benign nodules and intranodular vascularity is seen in malignant nodules.[38] In the present study perinodular vascularity was seen in 92.3 % of benign nodules and 23.5% of malignant nodules, whereas intranodular vascularity was seen in 76.5% of malignant nodules.

In the present study of 50 cases of solitary thyroid nodules, HRS diagnosis was made as benign in 33 cases, 30 cases were confirmed as benign by histopathology. Remaining 3 cases were diagnosed as malignant by histopathology. Sonologically these 3 cases showed features of benign nodule such as AP/T ratio < 1, isoechoic nodule, well defined, peripheral thick complete halo.

In the present study of 50 cases, HRS diagnosis was made as malignant in 17 cases, 12 cases were confirmed as malignant by histopathology. Remaining 5 cases were diagnosed as benign by histopathology. Sonologically these 5 cases showed features of malignant nodule such as AP > 1, isoechoic nodule, peripheral complete halo and intranodular vascularity.

The HRS mismatch of predicting benign and malignant nodules in the present study was mainly noted in cases of follicular adenoma and follicular carcinoma. They both differ only in the vascular and capsular invasion which is very difficult to diagnose on HRS .[79] Hence in such cases histopathological examination only gives the correct diagnosis.

The study done by Jones et al showed HRS has sensitivity of 75 % and specificity of 83 % in differentiating benign from malignant nodules.[50]In present study, HRS was able to differentiate benign from malignant nodules with sensitivity of 80% and specificity of 85.7 % and correlates with above study.

# CONCLUSION

The incidence of STN was more in female population. The peak incidence of STN was found in the age group of 31-40 years.

From the present study it was noted that HRS features such as wider than tall in shape, isoechogenicity / hyperechogenicity, purely cystic nodule / cystic with thin septa / spongiform appearance, well defined margins, peripheral complete halo, egg shell / coarse calcification, comet tail artifact and perinodular vascularity are highly predictive of benign nodules.

HRS features such as taller than wide shape, markedly hyperechogenicity / hypoechogenecity, ill-defined margins, peripheral incomplete halo, microcalcification and intranodular vascularity with or without perinodular vascularity are highly predictive of a malignant nodule.

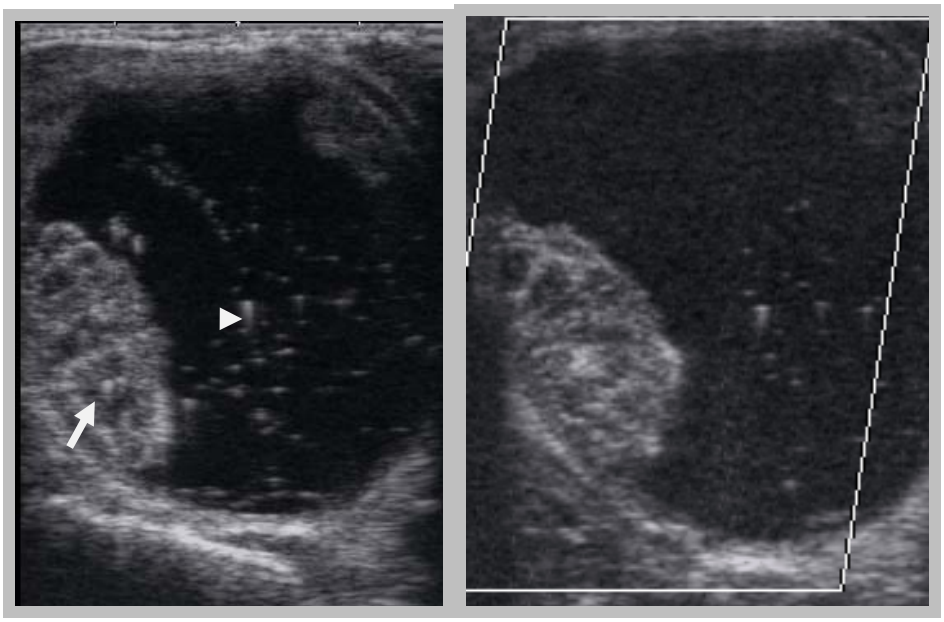
HRS is specific (80%) and sensitive (85.7 %) in differentiating benign nodule from malignant nodule.

# SUMMARY


- The purpose of the study is to identify morphologic patterns on HRS those are predictive of benign and malignant thyroid nodules.
- The study included 50 cases referred to the department of Radiodiagnosis for HRS of thyroid.
- HRS was performed and the sonographic features of the thyroid nodule were noted in the prepared proforma, with these features the thyroid nodule was predicted as benign or malignant and the HRS diagnosis was compared with the histopathological diagnosis.
- Majority of the patients are in the age group of 31-40 years.
- 9 cases (18%) were males and 41 cases (82%) were females with M:F ratio was 1:4.5.
- 93.9 % of benign nodules had an AP/T ratio $\leq$ 1 and 82.4 % of malignant nodules had an AP/T ratio > 1.
- 79% of benign nodules were solid, whereas 94.1% of malignant nodules were solid.
- 91% of benign nodules had well-defined margins and 88.2 % of malignant nodules had ill-defined margins.
- 91% of the benign nodules had peripheral complete halo and 71% of the malignant nodules had peripheral incomplete halo.
- Coarse calcification was seen in 67 % and peripheral EGG shell calcification in 22 % of benign nodules. Microcalcification was seen in 12 % of malignant nodules.

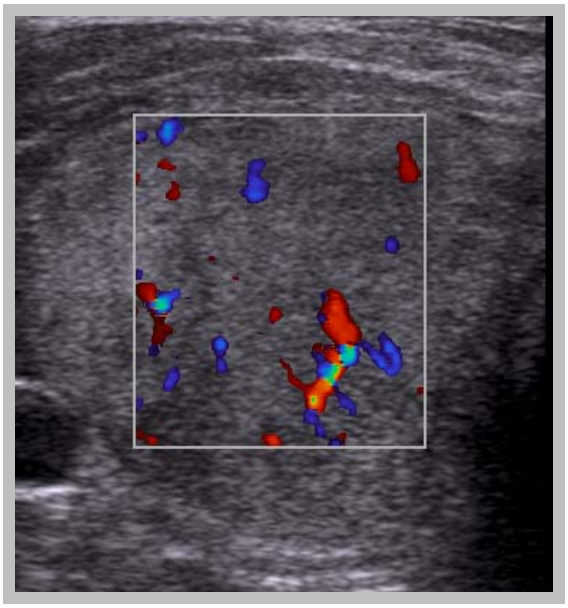
- Of 50 cases of solitary thyroid nodules evaluated at HRS, 33 were diagnosed as benign, 17 as malignant. After histopathological evaluation, 35 cases revealed to be benign and 15 cases to be malignant.
- Among benign nodules, Follicular adenoma formed the largest group in this study accounting for 51.4 %.
- Among malignant nodules, papillary carcinoma was the most common accounting for 86.7%.
- HRS is a safe, fairly reliable investigation to differentiate benign nodule from malignant nodule with sensitivity of 85.7 % and specificity of 80 %.

**FIG 12 : HRS MORPHOLOGIC FEATURES OF BENIGN NODULES**

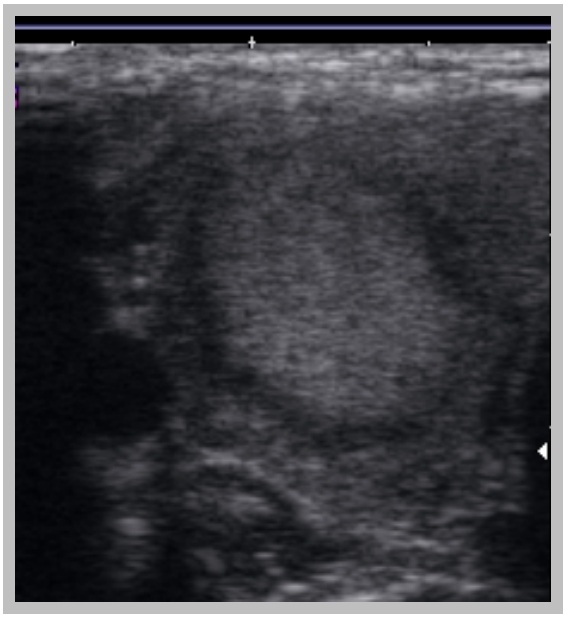


**Case 1: 45 year male with colloid clot. Transverse sonographic image of the left thyroid lobe shows cyst with colloid clot (arrow) which does not shows vascularity on color Doppler image and also showing comet- tail artifacts (arrow head).**

**Case 2: 30 year female. Transverse gray scale sonographic image of the right thyroid lobe shows mixed nodule (both cystic and solid) suggestive of benign nodule.**

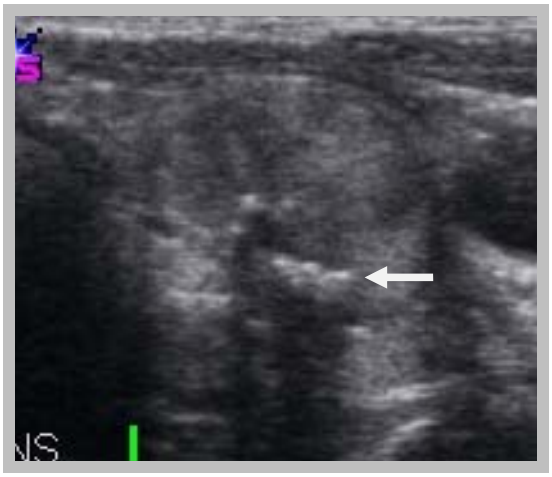


**Case 3: 32 year female with follicular adenoma. Transverse Doppler sonographic image of the right thyroid lobe shows hypervascular nodule.**

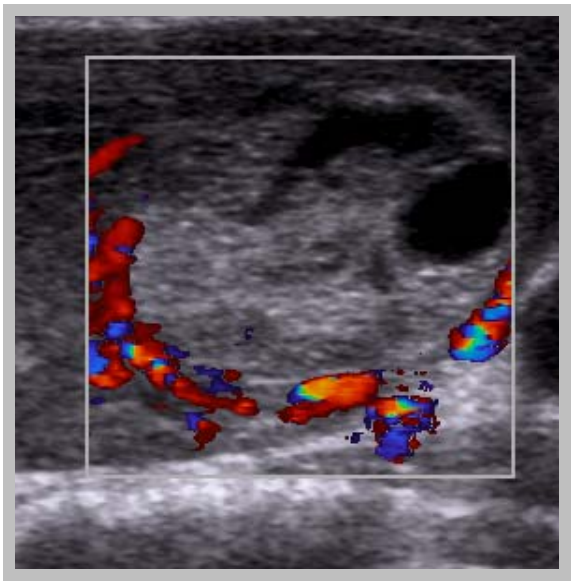


**Case 4: 21 year female with nodular hyperplasia. Transverse gray scale sonographic image of the right thyroid lobe shows circumscribed homogenous isoechoic nodule with complete hypoechoic peripheral halo.**

**Case 5:35 year female. Transverse gray scale sonographic image of the left thyroid lobe shows peripheral EGG shell calcification (arrow) suggestive of benign nodule.**

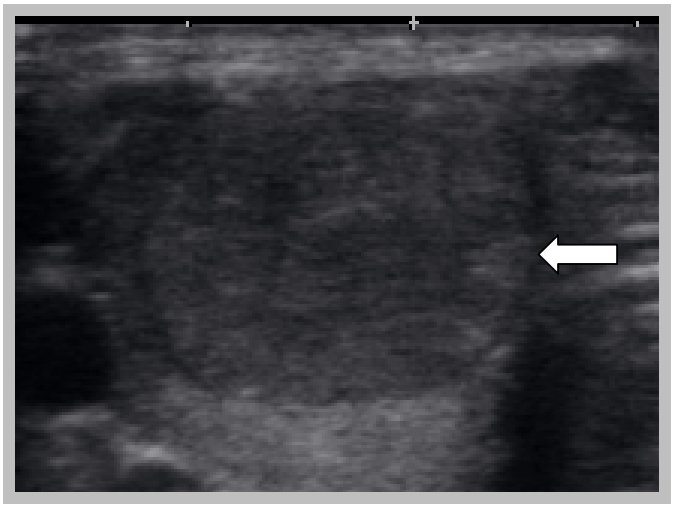


**Case 6:42 year male. Longitudinal gray scale sonographic image of the left thyroid lobe shows circumscribed homogenous isoechoic nodule with coarse calcifications (arrow) suggestive of benign nodule.**



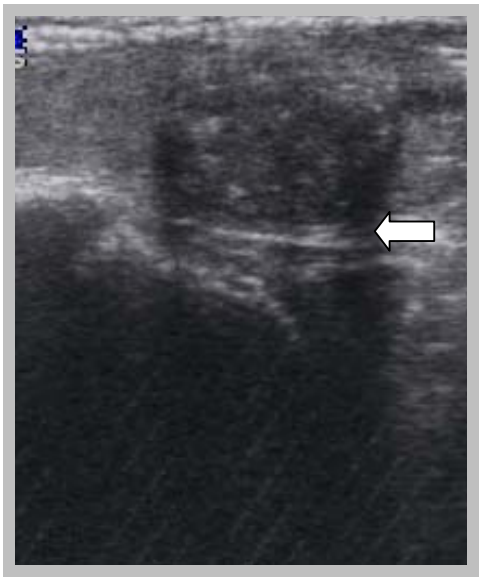
**Case 7:55 year female with hyperplastic nodule. Longitudinal Doppler image of the left thyroid lobe shows peripheral hypervascularity.**

**Fig 13 : HRS MORPHOLOGIC FEATURES OF MALIGNANT NODULES**

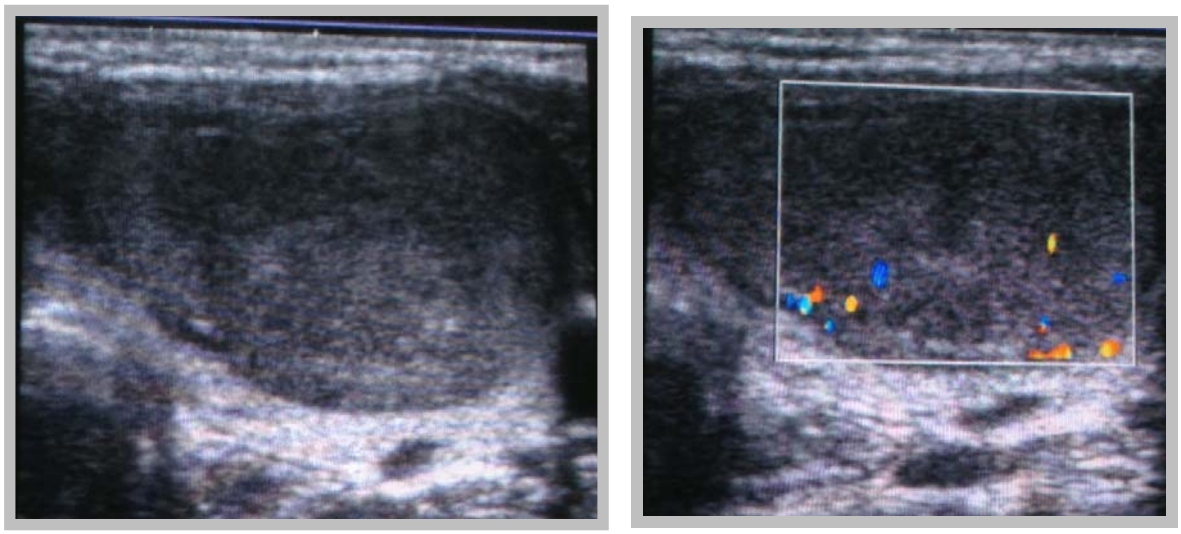


**Case 8: 41 years female with papillary carcinoma. Transverse gray scale sonographic image of the right thyroid lobe shows a circumscribed hypoechoic nodule with incomplete peripheral halo (arrow).**

**Case 9: 62 year male with papillary carcinoma. Longitudinal gray scale sonographic image of the right thyroid lobe shows homogenous hypoechoic nodule with ill-defined borders and shows internodular vascularity..**



**Case 10: 45 year female with papillary carcinoma. Longitudinal gray scale sonographic image of the left thyroid lobe shows micro-calcifications and refractive shadows from edge of a solid nodule (arrow).**



**Case 11: 25 year female with follicular neoplasm. Longitudinal sonographic image of the left thyroid lobe shows solid homogenous egg shaped nodule with thin capsule with intranodular vascularity on color Doppler image which proved to be follicular carcinoma on histopathology.**

# HISTOPATHOLOGY IMAGES

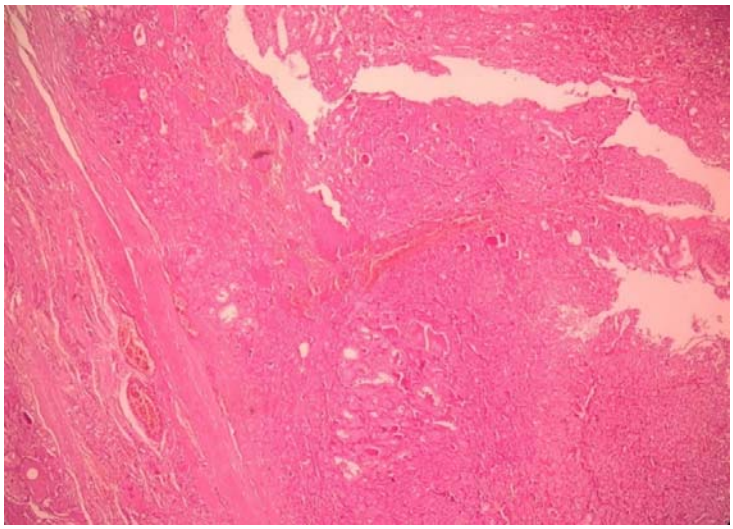


**FIG 14 : Microphotography showing Nodular Hyperplasia.**

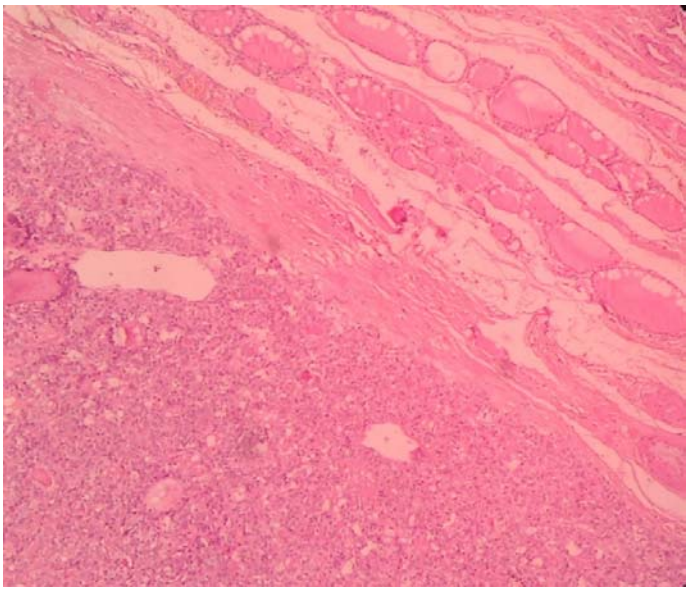


**FIG 15 : Microphotography showing Follicular adenoma.**

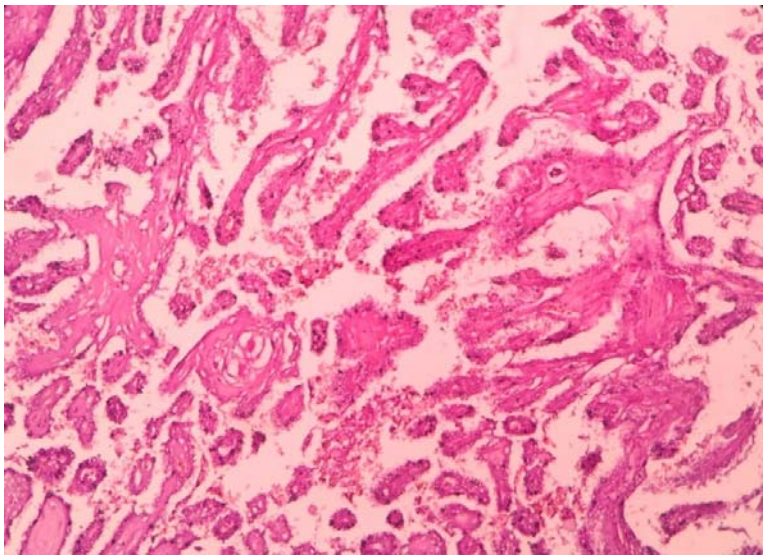


**FIG 16 : Microphotography showing Papillary Carcinoma**

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# ANNEXURES

## PROFORMA

NAME - OP NO. -

SEX – FEMALE /MALE AGE-

MARITAL STATUS - MARRIED / UNMARRIED PHONE NO-

ADDRESS –

CHIEF COMPLAINTS:

HRS OF THYROID:

**THYROID**

1) NODULE:

- SHAPE
- AP/T ratio < 1 or AP/T ratio > 1
- LOCATION
- Right lobe / Left lobe / Isthmus

TEXTURE:

- PONGIFORM CONFIGURATION – Present / absent
- CYST WITH AVASCULAR COLLOID CLOT-present / absent
- GIRAFFE PATTERN – present / absent
- DIFFUSE HYPERCHOGENICITY-present / absent
- HYPOECHOGENICITY-present / absent
- ISOECHOIC WITH HALO-present / absent
- ISOECHOIC WITHOUT HALO-present / absent
- MIXED (BOTH CYSTIC & SOLID) – present / absent

2) MARGINS

-WELL DEFINED

-POORLY DEFINED

3) HALO

-PERIPHERAL THIN COMPLETE HALO – Yes / No

-THICK INCOMPLETE –Yes / No

-THICK COMPLETE – Yes / No

4) CALCIFICATIONS

-EGG SHELL CALCIFICATION - Yes / No

-COARSE CALCIFICATION – Yes / No

-MICRO CALCIFICATION – Yes / No

5) VASCULARITY OF NODULE:

-PERIPHERAL VASCULARITY – Yes / No

-INTRA NODULAR VASCULARITY – Yes / No

6) LYMPH NODES – Yes / No

7) INFILTRATION TO SURROUNDING STRUCTURES:

- Yes / No

8) HRS DIAGNOSIS:

9) TYPE OF OPERATION:

10) HISTOPATHOLOGY DIAGNOSIS:

# KEY FOR MASTER CHART

| | |
|---|---|
| STN | Solitary thyroid nodule. |
| RT | Right Lobe |
| LT | Left Lobe |
| I | Isthmus |
| ANE | Anechoic |
| HYPER | Hyperechoic |
| HYPO | Hypoechoic |
| ISO | Isoechoic |
| WD | Well Defined |
| ID | Ill Defined |
| CH | Complete Halo |
| IH | Incomplete Halo |
| INV | Intranodular Vascularity |
| PNV | Perinodular Vascularity |
| BN | Benign nodule |
| MN | Malignant nodule |

## MASTER CHART

| SI.No | NAME | H.No | DATE | USG No. | AGE | SEX | C/F | LOCATION | SHAPE | ECHOTEXTURE | COMPOSITION | MARGIN | HALO | CALCIFICATION | VASCULARITY | LN | HRS | H/P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | seethamma | 756054 | 28/11/2011 | 32187 | 55 Y | F | STN | RT | < 1 | ANE | PC | WD | - | - | | | CN | CN |
| 2 | banupriya | 758072 | 2/12/2011 | 32595 | 25 Y | F | STN | RT | > 1 | HYPER | S | ID | CH | - | INV | | MN | FA |
| 3 | shardamma | 643950 | 30/12/2011 | 32621 | 35 Y | F | STN | RT | > 1 | HYPO | S | ID | CH | MC | INV | P | MN | PC |
| 4 | tasiya | 865812 | 7/1/2013 | 34745 | 25y | F | STN | RT | < 1 | ISO | S | WD | IH | - | INV | | BN | FC |
| 5 | Jayalakshamma | 866889 | 10/1/2013 | 42694 | 63 y | F | STN | LT | > 1 | ISO | S | ID | CH | - | PNV | | BN | FA |
| 6 | eshwaramma | 849668 | 7/3/2013 | 16963 | 40 y | F | STN | RT | < 1 | HYPO | S | ID | CH | MC | INV | | MN | NH |
| 7 | Chowdamma | 904901 | 8/5/2013 | 12544 | 37 y | F | STN | I | < 1 | HYPO | S | WD | CH | CC | PNV | | BN | NH |
| 8 | Nethravathi | 796643 | 18/05/2012 | 33161 | 26y | F | STN | RT | < 1 | HYPER | S | WD | CH | - | PNV | | BN | FA |
| 9 | Manjula | 770392 | 19/01/2012 | 37849 | 28y | F | STN | RT | < 1 | HYPER | S | WD | IH | PEC | PNV | | BN | NH |
| 10 | Gopal | 785229 | 14/05/2012 | 10455 | 55y | M | STN | RT | > 1 | ISO | S | ID | CH | - | PNV | | MN | FA |
| 11 | Dharani | 800865 | 21/5/2012 | 11875 | 21y | F | STN | LT | < 1 | HYPER | S | WD | CH | - | PNV | | BN | FA |
| 12 | kanthamma | 771073 | 6/2/2012 | 1566 | 45Y | F | STN | RT | < 1 | ANE | CTS | WD | - | - | | | CN | CN |
| 13 | kanthamma | 796267 | 7/3/2012 | 13557 | 46y | F | STN | RT | > 1 | HYPO | S | ID | IH | MC | INV | | MN | NH |
| 14 | Bhagyamma | 833085 | 30/08/2012 | 34093 | 50Y | F | STN | RT | < 1 | ISO | S | WD | CH | - | PNV | | BN | FA |
| 15 | zareena taj | 789505 | 14/06/2012 | 15827 | 42y | F | STN | I | < 1 | ISO | S | WD | CH | CC | PNV | | BN | PC |
| 16 | Ravi kumar | 766232 | 27/04/2012 | 10266 | 36Y | M | STN | RT | < 1 | HYPER | S | WD | CH | - | PNV | | BN | NH |
| 17 | Hanumakka | 717463 | 11/9/2012 | 36987 | 35Y | F | STN | RT | > 1 | ISO | S | WD | IH | - | INV | | MN | FA |
| 18 | Jayamma | 758133 | 14/12/2011 | 12265 | 45Y | F | STN | LT | > 1 | ISO | S | WD | CH | - | INV | | BN | FC |
| 19 | Ramakka | 714864 | 24/11/2011 | 36991 | 35Y | F | STN | RT | < 1 | ISO | S | ID | CH | - | PNV | | BN | FA |
| 20 | krishnamma | 805331 | 16/06/2012 | 43800 | 50y | F | STN | LT | < 1 | ISO | S | WD | IH | MC | INV | P | MN | PC |
| 21 | Najana | 789357 | 2/5/2012 | 43792 | 28Y | F | STN | RT | < 1 | HYPER | S | WD | IH | CC | PNV | | BN | NH |
| 22 | Anand | 761369 | 20/07/2012 | 9895 | 23Y | M | STN | LT | < 1 | HYPER | S | ID | CH | - | PNV | | BN | FA |
| 23 | Lakshmamma | 848094 | 8/10/2012 | 14573 | 25Y | F | STN | LT | < 1 | ANE | SC | WD | - | - | P | | CN | CN |
| 24 | sarojamma | 835015 | 8/9/2012 | 4247 | 45y | F | STN | RT | > 1 | HYPO | S | ID | IH | MC | INV | P | MN | PC |

**MASTER CHART**

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | Venkatarathna | 882553 | 15/2/2013 | 43694 | 26Y | M | STN | RT | < 1 | ISO | S | ID | CH | - | PNV | | BN | FA |
| 26 | Krishnaiah | 805331 | 22/2/2012 | 41963 | 50Y | M | STN | RT | < 1 | ISO | S | WD | CH | CC | PNV | | BN | PC |
| 27 | Sathyamma | 829755 | 22/8/2012 | 41921 | 40Y | F | STN | LT | < 1 | HYPER | S | WD | CH | - | PNV | | BN | FA |
| 28 | Parvathamma | 786661 | 23/11/2011 | 31238 | 35Y | F | STN | RT | < 1 | ANE | CTS | WD | - | - | | | CN | CN |
| 29 | Shylaja | 821416 | 25/7/2012 | 43513 | 30Y | F | STN | RT | < 1 | HYPER | S | WD | CH | PEC | PNV | | BN | NH |
| 30 | Munikrishnan | 769240 | 24/01/2012 | 1887 | 39Y | M | STN | LT | < 1 | HYPO | S | ID | IH | MC | INV | | MN | FA |
| 31 | Svithramma | 826589 | 12/11/2012 | 43647 | 32Y | F | STN | RT | > 1 | ISO | S | WD | CH | - | PNV | | BN | PC |
| 32 | Amaravathi | 751753 | 24/11/2011 | 43658 | 24Y | F | STN | LT | < 1 | ANE | SC | WD | - | - | | | CN | CN |
| 33 | Gowramma | 739535 | 17/10/2011 | 43798 | 45Y | F | STN | RT | > 1 | HYPO | S | ID | IH | MC | PNV | P | MN | FA |
| 34 | Bharathi | 784868 | 3/3/2012 | 44767 | 29Y | F | STN | RT | < 1 | ISO | S | WD | CH | CC | PNV | | BN | PC |
| 35 | Rajeshwari | 829776 | 31/08/2012 | 31283 | 27Y | F | STN | LT | > 1 | HYPO | S | ID | IH | MC | INV | | MN | NH |
| 36 | Rathnam | 711716 | 21/10/2011 | 40392 | 35Y | M | STN | RT | < 1 | ANE | CTS | WD | - | - | | | CN | CN |
| 37 | Geetha | 845921 | 1/11/2012 | 11736 | 55Y | F | STN | RT | < 1 | HYPER | S | WD | CH | - | PNV | | BN | FA |
| 38 | Hanumakka | 832340 | 11/9/2012 | 12998 | 56Y | F | STN | LT | < 1 | HYPER | S | WD | CH | - | PNV | | BN | NH |
| 39 | Usharani | 777209 | 17/4/2012 | 13090 | 58Y | F | STN | RT | > 1 | HYPO | S | ID | IH | MC | INV | P | MN | PC |
| 40 | Sharadhamma | 908238 | 10/11/2011 | 892 | 35Y | F | STN | RT | < 1 | HYPER | S | WD | CH | - | PNV | | BN | FA |
| 41 | Asin | 782967 | 12/4/2012 | 10581 | 50Y | M | STN | LT | < 1 | ISO | S | WD | CH | MC | PNV | P | BN | PC |
| 42 | Anjinamma | 903036 | 3/5/2012 | 11357 | 45Y | F | STN | RT | < 1 | HYPER | S | WD | CH | CC | PNV | | BN | NH |
| 43 | Guruswamy | 878863 | 7/6/2012 | 4041 | 60Y | M | STN | RT | < 1 | ISO | S | WD | CH | - | PNV | | BN | FA |
| 44 | Shanthamma | 960082 | 7/7/2012 | 11714 | 37Y | F | STN | LT | < 1 | ANE | M | WD | - | - | | | CN | CN |
| 45 | Chikkavenkatamma | 961309 | 21/9/2013 | 12176 | 60Y | F | STN | RT | > 1 | HYPO | S | ID | IH | MC | INV | | MN | PC |
| 46 | Padmavathi | 849317 | 11/12/2012 | 12860 | 35Y | F | STN | RT | > 1 | HYPO | S | ID | IH | MC | PNV | | MN | FA |
| 47 | Chikkamuniyamma | 959174 | 14/10/2013 | 12939 | 57Y | F | STN | LT | < 1 | ISO | S | WD | CH | - | PNV | P | BN | PC |
| 48 | Venkatarathnamma | 962604 | 21/5/2012 | 12964 | 32Y | F | STN | RT | > 1 | HYPO | M | ID | IH | CC | INV | P | MN | PC |
| 49 | Sujatha | 961946 | 4/6/2013 | 10661 | 26Y | F | STN | RT | < 1 | ISO | S | WD | CH | - | PNV | | BN | FA |
| 50 | Munivenkatamma | 957783 | 7/7/2013 | 1278 | 62Y | F | STN | LT | > 1 | HYPO | S | ID | IH | MC | INV | P | MN | PC |