Otolaryngology online journal

ISSN :2250-0359

Volume 5 Issue 3.5 2015

# ROLE OF ULTRASOUND IN THYROID DISORDERS

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Abstract:

Ultrasonography has established itself has a useful tool in evaluating and managing thyroid disorders. This article provides an overview of basic principles of ultrasound, how it is used in different thyroid disorders, different sonographic pattern of thyroid disorders, comparative features of malignant and benign nodule, ultrasound features of diffuse thyroid disorders and congenital thyroid disorders, ultrasound guided FNAC, advanced techniques of ultrasound in thyroid imaging.

Introduction:

Ultrasonography (US) is the most common and most useful way to image the thyroid gland and its pathology, as recognized in guidelines for managing thyroid disorders published by the American thyroid Association (26). In addition to facilitating the diagnosis of clinically apparent nodules, it also helps in discovering large number of clinically unapparent nodules.it has high sensitivity for nodules but poor specificity for cancer. The advent of ultrasonography has permitted confirmation of older autopsy data showing that 18% of clinically normal thyroid glands had nodules of >2cm at autopsy and many single palpable nodule were actually multinodular (25).

Although previously modalities like scinti scanning were used for imaging of thyroid, which uses radioactive iodine, now ultrasound has largely replaced scintiscanning in majority of patients because of following reasons:

√ Higher resolution

√ Correlation of true thyroid dimension with the image

√ Less expensive

√ Simple to do

√ Not need for any radioisotope administration

Ultrasound should be used to refine a differential diagnosis to arrive at specific diagnosis based on clinical history and physical examination. The image must then be integrated into patient management and correlated precisely with the other data.

Figure showing Ultrasound machine

History:

Acoustics, the science of sound, starts as far back as Pythagoras in the 6th century BC, who wrote on the mathematical properties of stringed instruments. Sir Francis Galton constructed a whistle producing ultrasound in 1893.

Piezoelectricity discovered by Pierre Curies and Jacques in 1880 using natural quartz.

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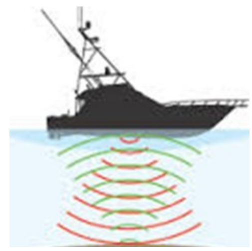


Figure showing sonar in use

SONAR was first used in 1940's war time.it was used in world war I and II in the location of submarines. Sonar was not only able to precisely measure the depth of a reflecting surface under water, but can identify an object in motion.

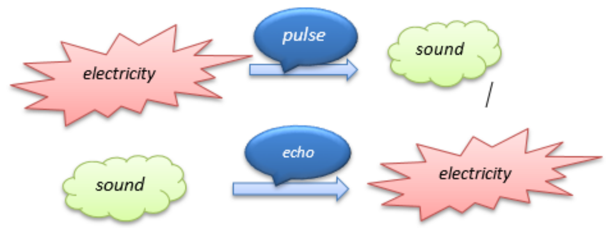
In 1950, ultrasound was introduced into medicine as a research tool in the USA; and in 1965, the Jutendo Medical Ultrasound Research Centre in Japan was founded. [3]

Echolocation in bats was discovered by Lazzaro Spallanzani in 1794, when he demonstrated that bats hunted and navigated by inaudible sound and not vision.

WHAT IS ULTRASOUND?

Physical definition: sound waves greater than 20000 hertz or cycles per second.

Diagnostic medical ultrasound is the use of high frequency sound wave to aid in the diagnosis and treatment of patients.




Frequency Range:

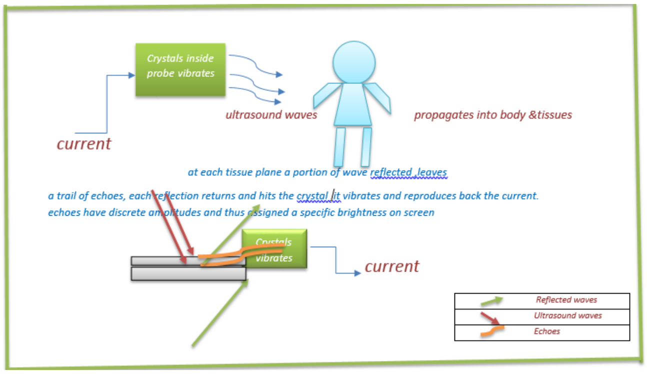

It works on principle of piezoelectric effect.it is nothing but converting energy by applying pressure to a crystal. The reverse of the piezoelectric effect converts the energy back to its original form.

HOW THE ULTRASOUND TRANSDUCERS MAKE USE OF THIS PIEZOELECTRIC EFFECT:

A transducer converts one type of energy into another based upon the pulse –echo principle occurring in the ultrasound piezoelectric crystals, transducers converts:

A probe that contains piezoelectric crystals called transducer is applied to neck. Air does not transmit ultrasound hence some liquid medium like gel is used between skin and probe. This transducer rapidly alternates itself as generator of waves and receiver of signal that is reflected from tissues. When current is applied to probe. Crystals inside probe vibrates and produces ultrasound waves. These waves propagates into body tissues. The wave reflection occurs at the interface of tissues with different acoustic impedance. The greater the difference in impedance of each tissue, greater the amount of energy reflected back. When the piezoelectric crystal absorbs the mechanical energy of ultrasound waves, it produces an electric current. This ability is used for the detection and display of the reflected waves.

Tissues with frequent interfaces such as normal thyroid gland display as hyper echogenic area; in contrast, structures with no interfaces such as cysts full of liquid are anechogenic.




The ultrasound is treated differently by the different anatomic structures. The air-filled trachea does not transmit the ultrasound. Calcified tissues such as bone and sometimes cartilage and calcific deposits in other anatomic structures block the passage of ultrasound resulting in a very bright signal and a linear echo-free shadow distally. Fluid-filled structures have a uniform echo-free appearance whereas fleshy structures and organs have a ground glass appearance that may be uniform or heterogeneous depending on the characteristics of the structure.

PHYSICAL PRINCIPLES OF ULTRASOUND:

FREQUENCY:

Number of cycles per unit time.

Man made transducer frequency is predetermined by design.

Ultrasound transducers are referred to by the operating, resonant or main frequency.

One cycle per second=one hertz

One thousand hertz=one kilohertz

One million hertz=one megahertz

| | |
|---|---|
| 2.5 mhz | Deep abdomen, in obstetrics and gynecology |
| 3.5 mhz | General abdomen, in obstetrics and gynecology |
| 5.0 mhz | Vascular, breast, gynecology |
| 7.5 mhz | Breast, thyroid |
| 10.0 mhz | Breast, thyroid, superficial veins, superficial masses |

Table showing transducer frequencies used for various area imaging

BANDWIDTH:

All ultrasound transducers contain a range of frequencies, termed bandwidth.

Broad bandwidth technology produces medical transducers that contain more than one operating frequency, for example:

2.5 -3.5 MHz for general abdominal imaging

5.0 -7.5 MHz for superficial imaging

ATTENUATION:

Reduction in power and intensity as sound travels through a medium.

| | |
|---|---|
| *As Transducer depth of penetration* ↑ | *Frequency decreases* ↓ |

higher frequencies(>5.0 MHz)

-lose energy faster, so have less depth of penetration

- But provide greater image resolution

-so, higher frequency are better for short depths, good for vessels "vascular probe"

Lower frequency (3.5 MHz) good for deeper depths like abdomen, heart. "general probe"

RESOLUTION:

The ability to differentiate between structures that are closely related, both in terms of space and echo amplitude.

It is frequency dependent

-gray scale resolution

-axial resolution

- Lateral resolution

| | |
|---|---|
| *As transducer image resolution increases* ↑ | *frequency increases* ↑ |

Figure showing the relationship between resolution and probe frequency

| *HIGH FREQUENCY* | *LOW FREQUENCY* |
| --- | --- |
| *-improved resolution* | *-poorer resolution* |
| *- less depth of penetration* | *-higher depth of penetration* |
| *-higher frequency transducers for superficial uses.* | *-lower frequency transducers for general abdominopelvic uses.* |

Table showing the differences between high and low frequency probes

TRANSDUCERS:

Mechanical:

- Oscillating
- Rotating

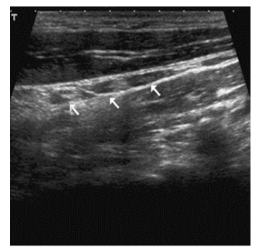
Electronic:

- Linear arrays
- Curved arrays
- Phased arrays

Image showing sector array transducer and the image obtained from it

| *SECTOR ARRAY* | *LINEAR ARRAY* |
| --- | --- |
| *-crystals are placed parallel or in Concentric rings* | *-crystals are placed parallel* |
| *-transducer face is curved* | *–transducer face is flat* |
| *-produces sector or pie shaped image* | *-produces rectangular Image* |

Figure showing the differences between sector and linear array transducers



Images showing Linear array transducer and the image obtained from it

DISPLAY MODES:

B mode

M mode

D mode or Doppler

-spectral

-audio

-color

Color/Doppler/power angio

FIELD OF VIEW:

Display of the echo amplitudes.

Shape dependent on transducer type

| *Sector field of view* | *linear field of view* |
|---|---|
| *- Produced by Oscillating Rotating Curved arrays Phased arrays* | *-produced by linear arrays* |
| *- Used in abdominal imaging* | *- used in superficial imaging* |

ARTIFACTS:

Portions of display which are not true representation of the tissue imaged.

Medical diagnostic ultrasound imaging utilizes certain artifacts to characterize tissues.

Acoustic shadowing and acoustic enhancement are two artifacts that provide most useful diagnostic information.

THYROID ULTRASONOGRAPHY; PRINCIPLE GOALS AND INDICATION;[1]

- Assess palpable nodules and enlargement.
- Assess nonpalpable thyroid nodularity and disease.
- Identify characteristics associated with malignancy.
- Assess thyroid and exthyroidal areas of neck in patients for early evidence of recurrence.
- Monitor nodules, goiters, or lymph nodes in patients undergoing treatment or observation of thyroid disease.
- Screen high risk patients(with familial forms of thyroid cancer, history of radiation exposure, FDG avidity on PET ,etc.)
- Screen for thyroid lesion in patients with other disease in the neck, such as hyperparathyroidism, who are undergoing treatment planning.
- Guide fine needle aspiration biopsy and other interventions.

TECHNICAL ASPECTS

Basically, an ultrasound probe acts as a transmitter and a receiver of ultrasound waves at the same time [3]. Visualization of a structure of an organ is made possible by an analysis of the received altered ultrasound waves that were reflected and refracted at the interfaces of various tissues. Thyroid ultrasound typically uses 7.5-14MHz. The source of these waves is a quartz crystal placed in a transducer probe. Echoes produced and displayed on screen. Two dimensional map of this echogenicity is called B-mode and it is used as the basic display mode in thyroid ultrasound. Another mode used for displaying the vascularization of tissue is the Doppler mode.

The procedure is safe, does not cause damage to tissue and is less costly than any other imaging procedure. The patient remains comfortable during the test, which takes only a few minutes, does not require discontinuation of any medication, or preparation of the patient. The procedure is usually done with the patient reclining with the neck hyperextended but it can be done in the seated position.

The signal is organized electronically into numerous shades of gray and is processed electronically to produce an image instantaneously hence it is known as real time imaging. Although each image is a static picture, rapid sequential frames are processed electronically to depict motion. There is considerable potential for improving ultrasound images of the thyroid by using ultrasound contrast agents.

These experimental materials include gas-filled micro-bubbles with a mean diameter less than that of a red blood corpuscle and Levovist, an agent consisting of granules that are composed of 99.9% galactose and 0.1% palmitic acid. They are injected intravenously, enhance the echogenicity of the blood, and increase the signal to noise ratio.

Other information such as blood flow can be detected by a principle called the Doppler Effect, in which the frequency of a sound wave increases when it approaches a listener and decreases as it departs. The Doppler signals are superimposed on real time gray scale images and may be color coded to reveal the velocity and direction of blood flow as well as the degree of vascularity of an organ. Flow in one direction is made red and in the opposite direction, blue. The intensity of color correlate with the velocity of flow. Venous and arterial flow can be depicted by assuming that flow in these two kinds of blood vessels is parallel, but in opposite directions. Since portions of blood vessels may be tortuous, modifying orientation to the probe, different colors are displayed within the same blood vessel even if the true direction of blood flow has not changed.

Thus, an analysis of flow characteristics requires careful observations and cautious interpretations. The absence of flow in a fluid-filled structure can differentiate a cystic structure and a blood vessel.

Special maneuvers like, various degrees of hyper-extension of the neck, swallowing to the facilitate elevation of the lower portions of the thyroid gland above the clavicles, swallowing water to identify the esophagus, and a Valsalva maneuver to distend the jugular veins may enhance the value of the images.

ULTRASOUND IMAGE OF NORMAL THYROID GLAND:

The thyroid gland consists of two lobes and a bridging isthmus.

Size , shape and volume varies with age and sex.

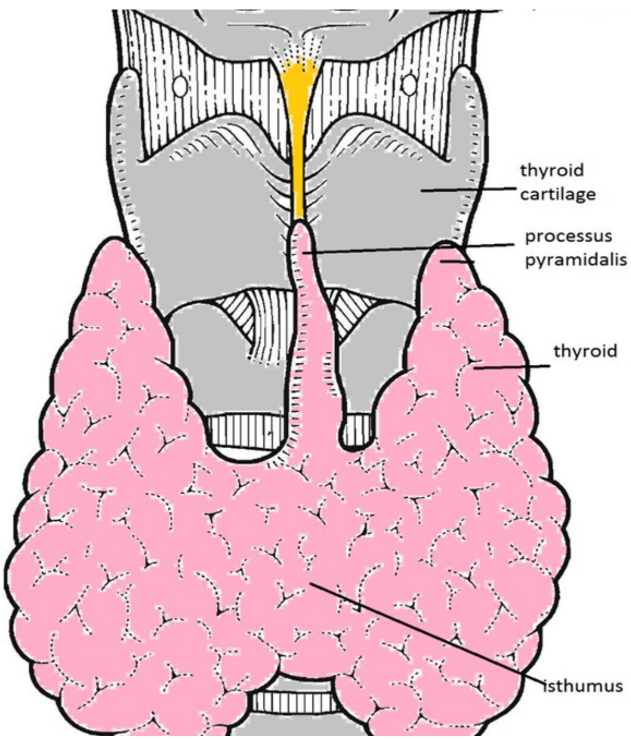
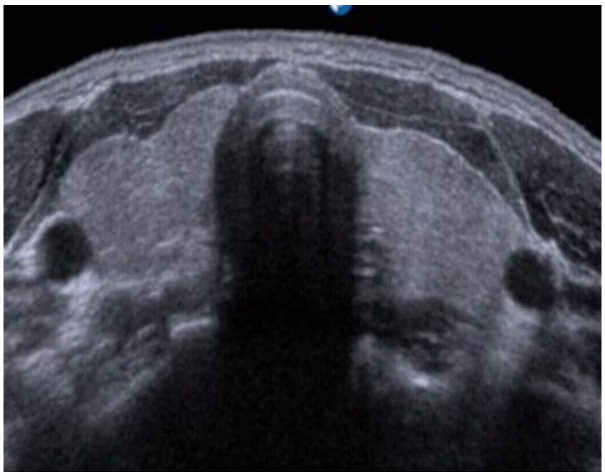



Figure showing the thyroid gland

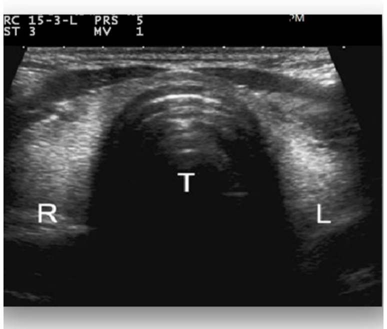
The thyroid gland is situated in the anterior region of the neck, adjacent to the thyroid cartilage with the isthmus located inferior to the cricoid cartilage. In the transverse plane, thyroid lobes are bounded by infrahyoid muscles (anteriorly), trachea (medially), carotid arteries (laterally) and oesophagus (usually on the left) prevertebral fascia (posteriorly). In the elderly, the thyroid gland shifts caudally and often partially retrosternally. In general, the right thyroid lobe is larger than the left one.


Diagrammatic representation of relations of thyroid in transverse plane:

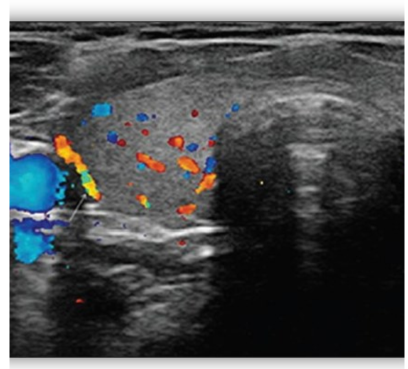


Ultrasound image of normal thyroid gland

Rarely, we may visualize the processus pyramidalis as a thin finger-like structure emerging from the isthmus. It is important to check the presence or absence of the processus pyramidalis especially in patients planned for total thyroidectomy.




Ultrasound picture of transverse section of normal thyroid gland



Doppler image of normal thyroid gland

SIZE:

Normal thyroid lobe dimensions:

18-20 mm longitudinal, 10-12 mm anteroposterior diameter, and 8-9 mm in width, in newborn.[4]

40-60 mm longitudinal ,20-30 mm anteroposterior diameter and 13-18 mm in adult population.[4]

In ultrasonography each lobe measures 4-6 cm in craniocaudal extent,1-1.5 cm width.1 cm depth, isthmus is 0.5 cm in height,2-3 mm depth.

VOLUME:

The volume of the thyroid gland is calculated in millilitres as the sum of the volume of the both the lobes, isthmus is neglected.

V (ml) = width x depth x length x 0.479 (cm)

Normal thyroid volume in females is less than 10 -15 ml and in males less than 12-18ml [4].calculated for each lobe and added.

There may be considerable differences between radiologists in estimating the size of large goiters or nodules. It has been reported that curved-array transducers may avoid significant interob-server variation that may occur when linear-array equipment is employed, especially when the gland is very large[14]. The inter-observer variation may be almost 50% among experienced radiologist for the determination of the volume of thyroid nodules, because it is difficult to re-produce a same two-dimensional image.

TEXTURE:

Medium to high density echoes ,homogenous.

Thin capsule is occasionally seen.

Anteriorly, the lobes are covered by the infrahy-oid muscles and laterally by sternocleidomastoid muscles. These muscles are important for the evaluation of the echogenicity of the thyroid pa-renchyma. A healthy thyroid is relatively hy-perechogenic as compared to the echogenicity of the muscles.

Parathyroid not visible unless enlarged.

BLOOD SUPPLY:

The blood is supplied to the thyroid abundantly by the superior and inferior thyroid arteries.

Superior thyroid artery and vein at the upper pole .

Inferior thyroid vein at the lower pole.

Inferior thyroid artery is posterior to the lower third of each pole.

Thyroid veins form a thick plexus around the gland.

Sometimes, bigger vessels occur also inside the parenchyma and it is important to differentiate them from pseudocysts or small hypoechogenic nodules by the Doppler.

DISEASES OF THYROID GLAND:

Incidence of thyroid disorders is more in females compared to males. Nodular thyroid disease is most common thyroid disorders. Broadly thyroid disorder classified into three categories:

Benign thyroid disorders

Malignant thyroid disorders

Diffuse thyroid enlargement

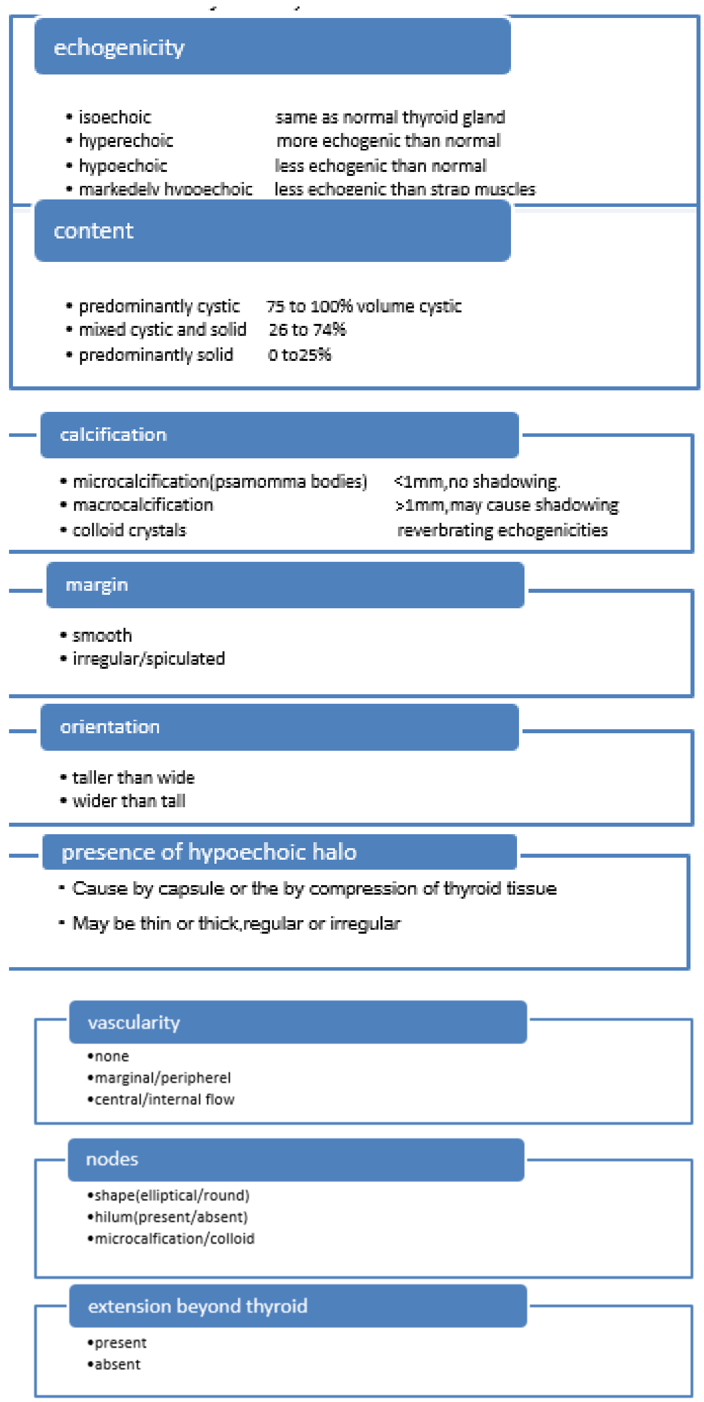
THYROID NODULE:

The development of nodule within thyroid correlate directly age and it is a process of maturation of normal thyroid gland. Hence nodularity within thyroid gland may be normal.

Incidence of nodule in thyroid gland is very high about 50 to 70% [4].

The ultrasonic appearance of a thyroid nodule does not reliably differentiate a benign thyroid lesion and cancer but it gives strong clues regarding further management.

The most reliable USG indicator that a nodule is malignant is observing vascular invasion by tumor, which is rarely seen.

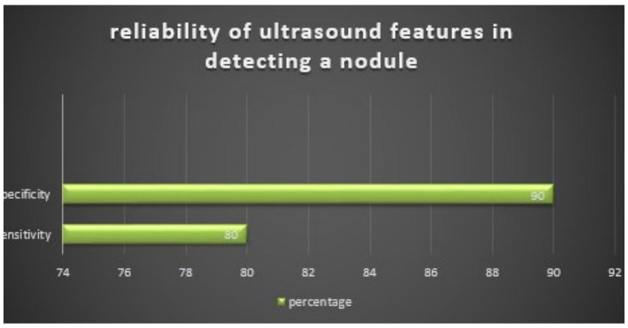



Features to look for in a thyroid nodule

How reliable are these features:

Sensitivity-80 % [12]

Specificity-90% [12]




Graph showing reliability of ultrasound features in detecting thyroid nodule

BENIGN THYROID DISORDERS:

The most common cause of benign thyroid nodule is nodular hyperplasia. Other common cause of benign thyroid enlargement is thyroid adenoma, mostly solitary enlargement, but it can be part of multinodular disease. Although usg features of benign and malignant nodule overlap, some features help in differentiating the both.

Benign follicular nodule

Nodular goitre

Adenomatoid/hyperplastic nodule

Colloid nodule

Follicular adenoma

Hurthle cell adenoma

USG feature of Benign thyroid nodule:[4]

Iso or hyperechogenicity

Cystic, cystic with thin septa,

Size <1cm

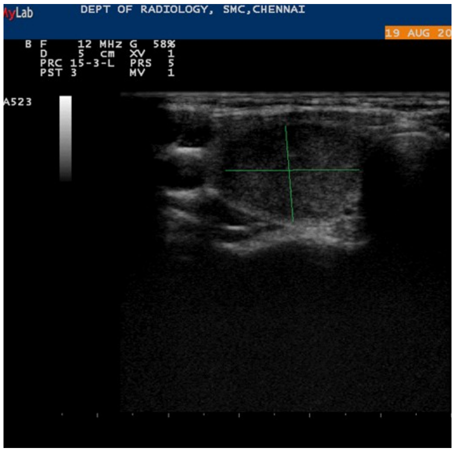
Presence of hypoechogenic halo around the nodule

Width>length

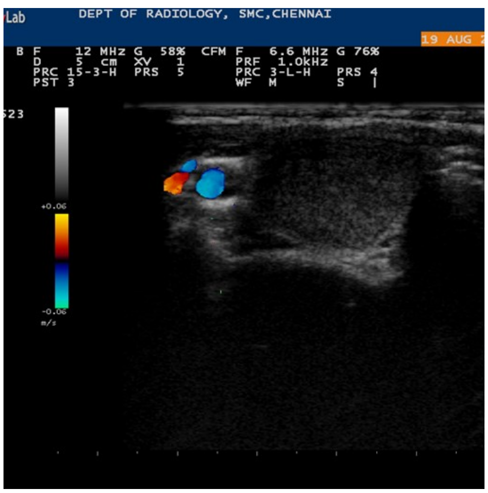
Coarse calcification

Comet tail or ring down artifact is feature of colloid benign nodule

Perinodular or spoke and wheel pattern of blood flow in Doppler




Enlarged hypoechoic nodule  Impression : Solitary nodular goiter




Solitary nodule thyroid in the right lobe

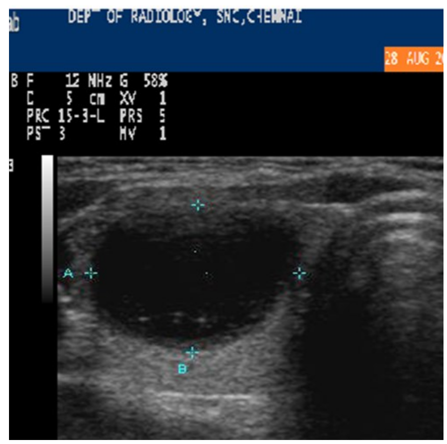
COLLOID GOITRE:

It is a benign, composed mainly of colloid and also contains some follicular cells.

Usg features:

Cystic (anechoic) with internal linear echogenic foci, comet tail artifact may be present secondary to inspissated colloid calcification.

Ultrasonographers have observed that colloid nodules, which are benign with high probability, have a more or less characteristic appearance of a “stack of pancakes”, “puff pastry like a Napoleon”, or sponge.



Anechoic smooth walled lesion in the right lobe of thyroid.  Impression: Colloid goitre

FOLLICULAR ADENOMA:

It is a benign neoplastic proliferation of follicles, surrounded by complete capsule. Manifest as solitary lesion in the background of normal appearing thyroid gland.

HURTHLE CELL ADENOMA:

It is a variant of follicular adenoma with proliferation of oncocytic or hurthle cell. It is important to recognize the features of Hurthle cells to avoid confusing these cells with other similar-appearing cells, such as benign macrophages, parathyroid cells, medullary thyroid cancer, and oncocytic variants of papillary thyroid cancer.

MALIGNANT THYROID DISORDERS :( 5-12%):

- Papillary thyroid cancer (70-80%)
- Follicular thyroid cancer (10-15%)
- Medullary thyroid cancer (5-10%)
- Anaplastic thyroid cancer (<1%)
- Lymphoma
- metastasis

USG features of malignant nodule:[4]

Hypo echogenic or markedly hypo echogenic

Mixed solid and cystic/purely solid

Size >1cm

Irregular or spiculated margin

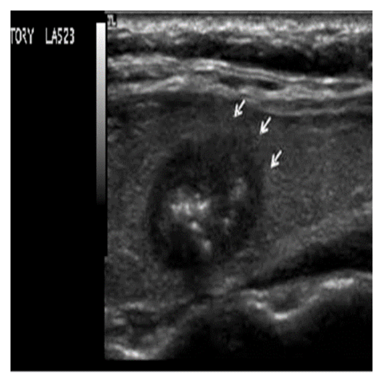
Absence of hypo echogenic halo around nodule

Taller than wide

Micro calcification

Local invasion and lymph node metastasis

Intranodular flow in Doppler




Hypoechogenic, mixed solid and cystic areas, microcalcification, speculated margin suggestive of malignant nodule.

Micro calcification are typical of papillary carcinoma, whereas macrocalcification is seen in both medullary and papillary carcinoma.

USG Features of lymphoma:

USG pattern of thyroid lymphoma have been classified into three types based on internal echoes within the lesion, the border of the lesion, and the intensity of the echoes behind the lesion. The echoes behind the lesion in each type of lymphoma are increased because of enhanced transmission of the ultrasound through the lesion.

In the nodular type of lymphoma, the internal echoes within a nodule are uniform and hypo echoic. The border between lymphoma and non-lymphomatous tissue is well-defined and the borderline is described as “broccoli-like or coast-line-like” irregularity.

The diffuse type of lymphoma looks like goiter. Internal echoes are also extremely hypo echoic but the border between lymphoma and non-lymphomatous tissues is not distinct. It is difficult to differentiate the diffuse type lymphoma from chronic thyroiditis.


Differences between benign and malignant thyroid nodule calcification

The mixed type lymphoma shows multiple, patchy hypo echoic lesions, each with enhanced posterior echoes

LYMPH NODE IN THYROID DISORDERS:

Metastasis to regional cervical lymph nodes occurs in 19% of thyroid malignancies, especially in papillary and also in medullary carcinoma. Rarely in follicular carcinoma[25].

USG of lymph node:

Even in the thyroid cancer patient, enlarged benign thyroid lymph nodes are more common than malignant ones. A high-resolution ultrasound system equipped with a high-energy linear probe, a 12 -14 MHz transducer, B-Mode and Doppler capability are required to detect lymphadenopathy.

NORMAL LYMPH NODES: Normal lymph nodes are depicted by USG as approximately 1 X 3 mm, well-defined, elliptical, uniform structures that are slightly less echo-dense than normal thyroid tissue and that have an echo-dense central hilum. Lymphadenopathy that is reactive to infection may be larger but tend to maintain an oval shape while malignant ones more often have a "plump" rounded shape.

Feature of malignant lymph node:

Large Cystic space

micro calcification

Spherical

Loss of hilum

Neovascularization, blood vessels penetrating from periphery.

70 % of metastatic lymph node from papillary carcinoma are cystic and it is important to distinguish it from cystic thyroid nodule [25].

In Doppler malignant nodes demonstrate enhanced color flow signals compared to benign nodes. There may be some diagnostic value in examining the ratio of systolic and a diastolic blood flow in a lymph node, which is called the resistive index.

It has been reported that cancerous lymph nodes have a high resistive index (mean 0.92) while reactive nodes have a considerably lower value (<0.6). metastatic nodes from papillary carcinoma frequently demonstrate prominent hilar vascularity similar to reactive nodes.

DIFFUSE THYROID DISORDERS:

- Multinodular goiter
- Hashimoto thyroiditis
- Graves' disease
- De quervain's thyroiditis (sub-acute thyroiditis)

An important application of USG in patients with thyroiditis is to assess for coincidental tumor or lymphoma of those thyroid glands that have focal firm consistency, or are enlarged or painful . In patients with thyrotoxicosis, USG can assess the size of the thyroid gland to facilitate I-131 dosimetry.

MULTINODULAR GOITRE:

Common cause of diffuse asymmetric enlargement of thyroid gland. Commonest histological form is colloid or adenoma.

USG features:

Diffusely enlarged thyroid gland with multiple nodules

Most nodules are iso or hyper echoic, when enlarged it gives a heterogeneous echo pattern to the gland.

These nodules may undergo degenerative changes:

Cystic degeneration–appears anechoic

Hemorrhage or infection-appears as moving internal echoes or septations.

Colloidal degeneration-comet tail artifact

Dystrophic calcification-coarse or curvilinear


Figure showing Diffusely enlarged left lobe of thyroid with multiple nodules with cystic degeneration. Probably multinodular goiter

GRAVES DISEASE:

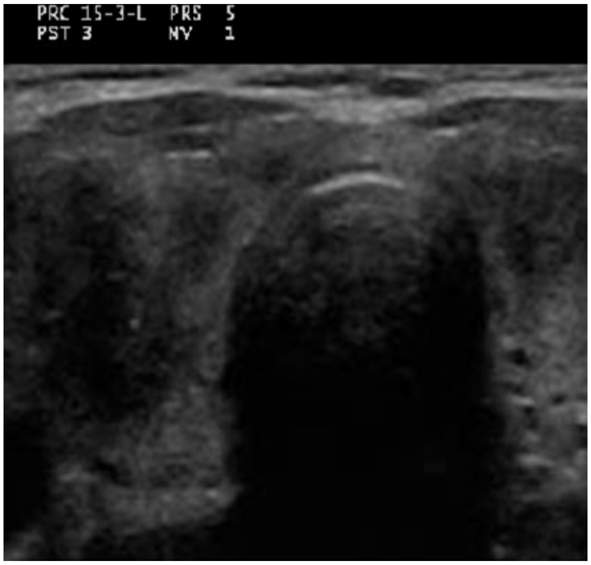
Autoimmune disease, characterized by thyrotoxicosis.

Females between 20 to 50 years of age are most commonly affected.

USG features of graves disease:

Diffusely enlarged, hypo echoic and heterogenous.

Doppler shows marked hyper vascularity known as "THYROID INFERNO". Shows extensive intra thyroidal flow both during systole and diastole. Normal thyroid pattern returns after remission of the disease.




Right lobe 2.7*2.5 Diffusely enlarged and hypoechoic. Note heterogeneity of the nodule

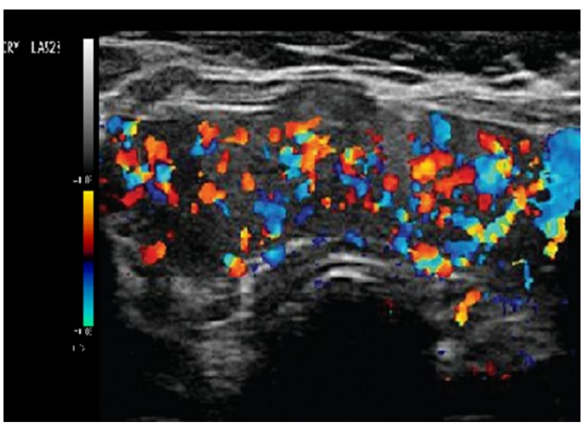


Figure showing thyroid inferno

Normoechoic Graves' hyperthyroid glands seem to be more resistant to therapy with I-131than hypoechoic thyroid [25]. Doppler ultrasound relates to iodide solution that has been used traditionally prior to thyroid surgery for Graves' disease because it was thought to reduce the vascularity of the thyroid gland. Doppler echography has demonstrated a significant decrease in thyroid vascularity in patients with Graves' disease after seven days of Lugol's solution, confirming the rationale of this form of treatment.

HASHIMOTO'S THYROIDITIS:

Autoimmune disease leading to destruction of thyroid gland and hypothyroidism.

Common in females above 40 years of age.

Painless, diffuse enlargement of the thyroid gland is most Common presentation.

Demonstration of serum thyroid antibodies and anti-thyroglobulin antibodies confirms diagnosis.

USG features of Hashimotos:

Focal or diffuse glandular enlargement with coarse, heterogenous and hypo echoic pattern.

Presence of discrete hypo echoic micro nodules (1 to 6 mm) is strongly suggestive of chronic thyroiditis. Fine echogenic fibrous septa may produce pseudolobulated appearance.

Colour Doppler shows extensive hypervascularity.

Variations in presentation of Hashimotos :

Small atrophic gland may be present at end stage of disease.

Nodular form may be present in background of diffuse thyroiditis.

Benign and malignant nodules may coexist in the background of diffuse thyroiditis.

PET scan or FNAC may be required to differentiate them.

This usg pattern of Hashimotos never improves and remains as such for remaining period life.

USG also demonstrates perithyroidal satellite lymph nodes, especially the ‘DELPHIAN’node just cephalad to isthumus.it is very useful in diagnosis but it should be correlated with USG, clinical and laboratory findings. However these lymph nodes may also occur due to underlying malignancy, in which fnac may be required to differentiate benign and malignant lymph nodes.


Right lobe: 2.4*1.7 cm Left lobe: 4.5*1.3 cm. Diffusely enlarged, hypoechoic and heterogenous.  Impression: autoimmune thyroiditis

Hypervascularity seen in lymphocytic thyroiditis

It has been reported that in children US findings of Hashimoto's thyroiditis are present in only a third at the time of diagnosis and half of the Hashimoto's children with normal initial thyroid sonography develop changes within 7 months. In some cases, characteristic Hashimoto's findings may not develop for over 4 years.

DE QUERVAIN'S THYROIDITIS:

Following a viral illness patient develops painful swelling in the neck with constitutional symptoms. There may be thyrotoxicosis or hypothyroidism depending on stage of illness.

USG features of de quervain's:

Diffuse or Focal hypo echoic areas (map like) with enlargement of thyroid lobes. Level VI lymph node (pre tracheal node) enlarged in majority if cases.

Doppler demonstrates decrease or absent blood flow within abnormal map like hypo echoic areas. Complete recovery occurs in weeks to months.

RIEDEL'S THYROIDITIS:

Type of inflammatory thyroid disease. Glandular tissue is replaced by fibrous connective tissue. Hence it is very hard in consistency. Can compress the adjacent vessels, displace or deform trachea.

USG features Riedel's:

Diffuse hypo echoic areas with ill-defined margins and fibrosis.

Amiodarone induced thyrotoxicosis:

In patients with amiodarone induced thyrotoxicosis, Doppler flow USG has been reported to differentiate two types of disorder with implications for therapy.

Patients with moderate to high vascular flow had underlying thyroid disease, such as latent Graves' disease or nodular goiter. (Type I).

Those who had no demonstrable vascular flow had no apparent prior thyroid disease (Type II).

The clinical value of this observation is that the Type II patients seem to respond to treatment with glucocorticoids. In contrast, the Type I patients were felt to respond to a combined regimen of methimazole and potassium perchlorate.

Congenital conditions:

ECTOPIC THYROID:

Thyroid tissue located other than the normal position anterior to laryngeal cartilages. During embryological development, the thyroid gland migrates down from the foramen caecum at the posterior aspect of the tongue, to its permanent location. This normal migration can be halted at any point, or it can go 'off-target' with thyroid tissue coming to rest in unusual location within the neck.

By far the most common location is near its embryological origin at the foramen caecum, resulting in a lingual thyroid. This accounts for 90% of all cases of ectopic thyroids.

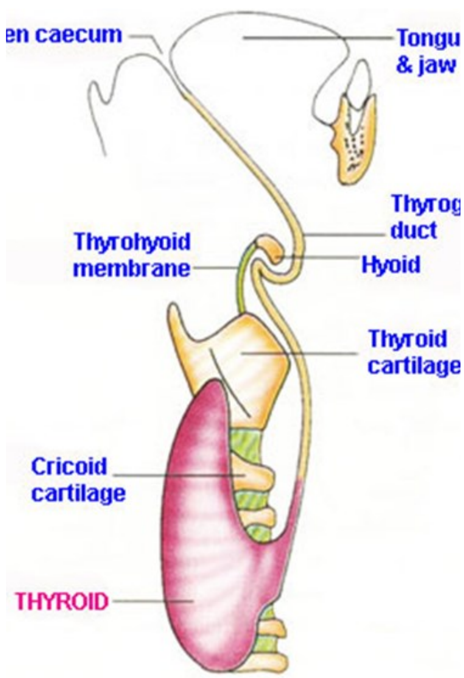



Figure showing embryology of thyroid gland

Lingual thyroid:

Congenital condition

It's a specific type ectopic thyroid and results from lack of caudal migration of the thyroid gland.

Many patients are asymptomatic, diagnosis is made incidentally when attempting to image tongue or noting absence of thyroid gland in normal position.

USG features:

Only use is to demonstrate absence of thyroid in its normal place. Very rarely patient has thyroid tissue both at tongue base and elsewhere in the neck.

THYROGLOSSAL CYST:

Most common congenital neck cyst, typically located in the midline.

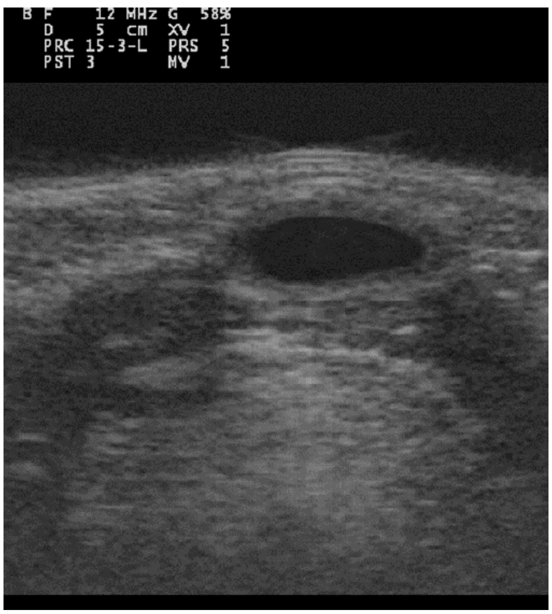
Presentation is typically either as a painless rounded midline anterior neck swelling or, if infected, as a red warm painful lump. It may move with swallowing and classically elevates on tongue protrusion.

Usg features:

The fluid is usually anechoic and the walls are thin, without internal vascularity.

However, in some cases, the internal fluid may contain debris.  This is particularly the case in an adult patient where cysts may be complex heterogeneous masses.

If there is associated infection, there may be surrounding inflammatory change




Picture showing cystic lesion anterior to thyroid gland

Role of ultrasound in FNAC:

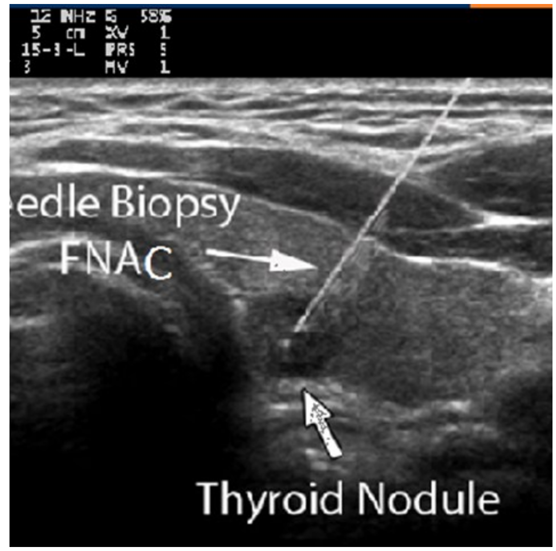



Figure showing ultrasound guided FNAC being performed

ULTRASOUND GUIDED FNAC TECHNIQUE:

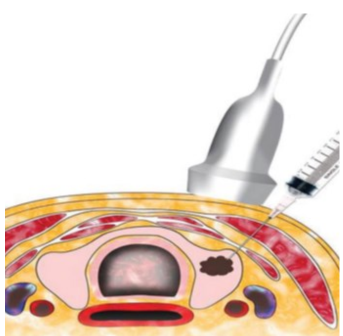
The accuracy of US-guided FNAC (68%) is higher than that of palpation-guided FNAC (48%)[9].The patient is placed on the examination table in the supine position with the neck extended. The radiologist usually stands near the patient's chest, which is considered to be the most anatomically intuitive approach; in some cases, however, the radiologist may need to stand near the patient's head. Preliminary US of the area of interest is performed.

| Solitary nodule | |
|---|---|
| *Solid nodule with suspicious US features, particularly microcalcifications* | *≥1 cm* |
| *Solid nodule without suspicious US features* | *≥1.5 cm* |
| *Mixed cystic-solid nodule with suspicious US features* | *≥1.5 cm* |
| *Mixed cystic-solid nodule without suspicious US features* | *≥2 cm* |
| *Spongiform nodule* | *≥2 cm* |
| *Simple cyst with none of the aforementioned characteristics* | *FNAC not necessary* |
| *Substantial growth (>50%) since previous US examination* | *FNAC indicated* |
| *Suspicious cervical lymph node* | *FNAC lymph node with or without nodule* |
| *Multiple nodule:* <br> *Normal intervening parenchyma* | *Fnac of upto four suspicious nodule with selection based criteria for solitary nodule;if no suscpicious nodule is present biopsy of largest nodule performed* |
| *No normal intervening parenchyma* | *FNAC not necessary* |
| *Diffuse rapid enlargement of thyroid* | *FNAC required to exclude anaplastic carcinoma,lymphoma,metastasis.* |
| *Clinically high risk for thyroid cancer* | *FNAC required* |

Indications for ultrasound guided FNAC

The patient is asked not to swallow or speak during FNAC, which helps limit thyroid movement. The neck is then cleansed with spirit or povidone -iodine, allowed to dry. Sterile towels are placed around the field. The probe is positioned for optimal visualization of the target nodule. About 5–10 mL of 2% lignocaine solution is infiltrated into the skin . FNAC is subsequently performed under continuous US guidance, with the needle oriented either parallel or perpendicular to the US probe.

FNAC is performed using 27-gauge needle. A total of six passes are made for each nodule selected [9]. First, three passes are made with¬out suction using the capillary technique. Three more passes are then made with continuous 0.5–1-mL suc¬tion applied to an attached 10-mL syringe using the aspiration technique . For solid lesions, multiple peripheral regions should be sampled to increase the adequacy rate. For mixed cystic and solid lesions, the solid component of the lesion is targeted to improve diagnostic yield.



Technique of ultrasound guided FNAC

ADVANCED ULTRASOUND TECHNIQUES IN THYROID IMAGING:

ULTRASOUND ELASTOGRAPHY:

Ultrasound elastography is a dynamic technique that estimates stiffness of tissues by measuring the degree of distortion under pressure [4]. It is used to study the hardness/elasticity of nodule to differentiate malignant from benign lesion.

A benign nodule is soft and deforms easily, whereas malignant nodule is harder and deforms less. Elastography utilizes external pressure to differentiate nodules.it determines the amount of tissue displacement at various depth, by assessing the ultrasound signals reflected from tissues before and after compression.

The elastographic image (elastogram) displayed over B mode ultra-sonogram in a color scale as,

- Very soft ,in blue colour ,for tissue with greatest elastic strain.
- Very hard, in red colour, for tissues with no strain.

Real time shear elastography is latest technique that characterizes and quantifies tissue stiffness better than conventional elastography.

Limitations of elastography:

Cystic lesion and calcified nodule are excluded from study.

It cannot assess lesions which are not surrounded by adequate normal thyroid tissue.

CONTRAST ENHANCED ULTRASOUND:

It is a newly developed technique. Helps in characterizing thyroid nodule. Enhancement pattern are different in benign and malignant nodule.

Ring enhancement seen in benign lesion, whereas heterogeneous enhancement seen in malignant lesion. Use of specific contrast agents and pulse inversion harmonic imaging further improves the efficacy of ultrasound in diagnosing malignant thyroid nodule.

THERAPEUTIC APPLICATION:

US guided percutaneous ethanol injection is used for sclerosation of autonomous and toxic thyroid adenomas. Post injection follow up ultrasound scan demonstrates significant reduction in nodule size on usg and marked reduction or complete absence of intranodular flow on colour Doppler.

Major diagnostic pitfalls of thyroid ultrasound include:

Cystic components of thyroid malignancies may be mistaken for benign cyst or cystic degeneration in a benign nodule. A careful ultrasound assessment to demonstrate solid component with vascularity or  microcalcifications will be of help in differentiating these lesions.

Cystic or calcified lymph node metastases adjacent to the thyroid gland may be mistaken for benign nodule in multinodular thyroid disease. Incomplete rim of thyroid parenchyma around the mass and lack of movement of the mass with the thyroid gland during swallowing favors extra thyroid lymph nodal metastasis.

Diffusely infiltrative hyper vascular thyroid carcinoma like papillary or follicular carcinoma may be mistaken for autoimmune thyroid disease; similarly multifocal carcinoma may be mistaken for benign multinodular goiter. As described earlier, diffuse thyroid enlargement with multiple nodules of similar US appearance and with no normal intervening parenchyma is highly suggestive of benignity. US features that suggest malignancy include irregular or nodular enlargement of the thyroid gland, local invasion and nodal metastases. Co-existing autoimmune thyroid disease and thyroid Carcinoma can further complicate the situation.[5]

CONCLUSION:

Ultrasound has improved in past few years as a screening and diagnostic tool in thyroid disorders.it is the imaging modality of choice for masses in thyroid for children and pregnant females. USG also helps in guiding diagnostic and therapeutic interventional procedure in various thyroid disorders. Recent advances in thyroid ultrasound had further improved the diagnostic accuracy.

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10.Differential Profile of Ultrasound Findings Associated with Malignancy in Mixed and Solid Thyroid Nodules in an Elderly Female Population.

María Inés Vera,1 TomásMeroño,2 María Agustina Urrutia,1 Carina Parisi,1

Yanina Morosan,1 Melanie Rosmarin,1 Marta Schnitman,1 Fernando Brites,2

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21. Differential Profile of Ultrasound Findings Associated with Malignancy in Mixed and Solid Thyroid Nodules inan Elderly Female Population María Inés Vera,1 TomásMeroño,2 María Agustina Urrutia,1 Carina Parisi,1 Yanina Morosan,1 Melanie Rosmarin,1 Marta Schnitman,1 Fernando Brites,2 Silvio Grisendi,3 María Sol Serrano,3 Wilfredo Luciani,4 Leonardo Serrano,4 Carlos Zuk,5 Guillermo De Barrio,5 Claudia Cejas,5 María Cristina Faingold,1 and Gabriela Brent

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