THYROID ULTRASOUND

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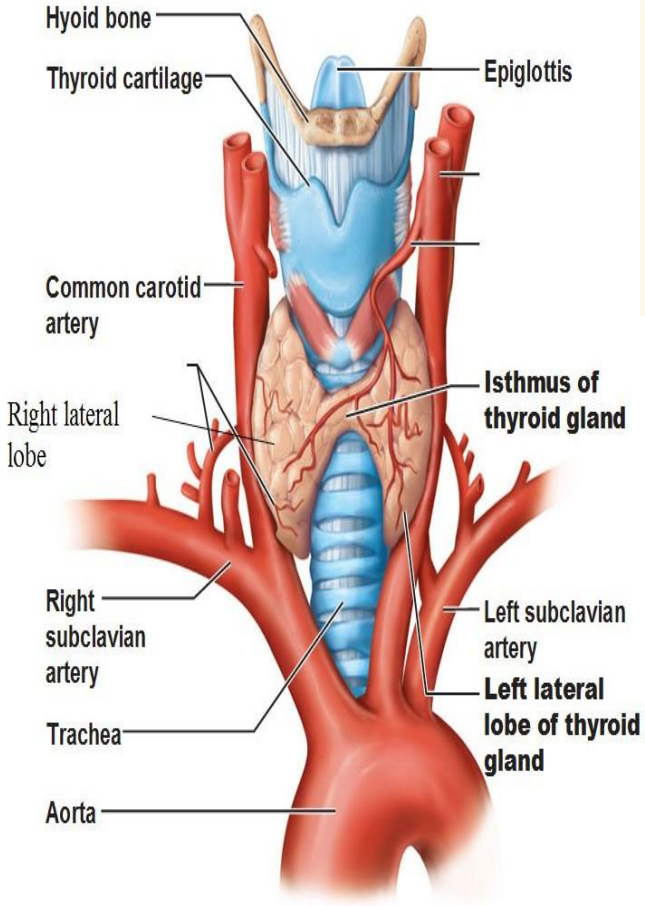
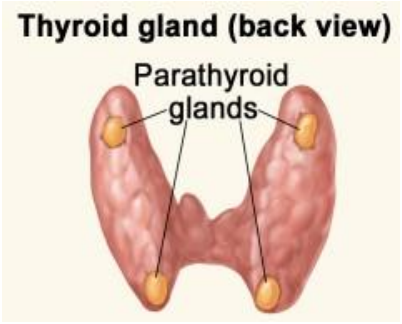
THYROID ANATOMY

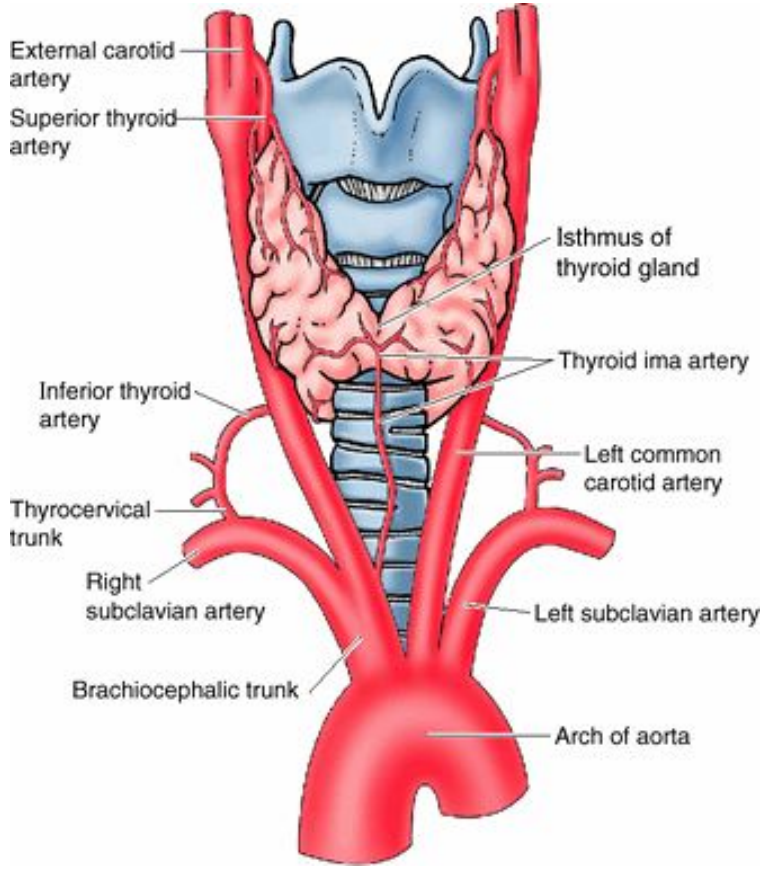
- Superficial, butterfly-shaped gland that is variable in size and weighs approx. 25-35 grams.
- Two lobes in the anterior neck on either side of the trachea inferior to the thyroid cartilage. Each lobe measures approximately 4-6 cm in length.
- Joined by isthmus.
- Variants (Size and shape, pyramidal lobe, ectopic)
- Parathyroid: 4 glands, located behind the upper and lower lobes of the thyroid. They release PTH to regulate serum calcium





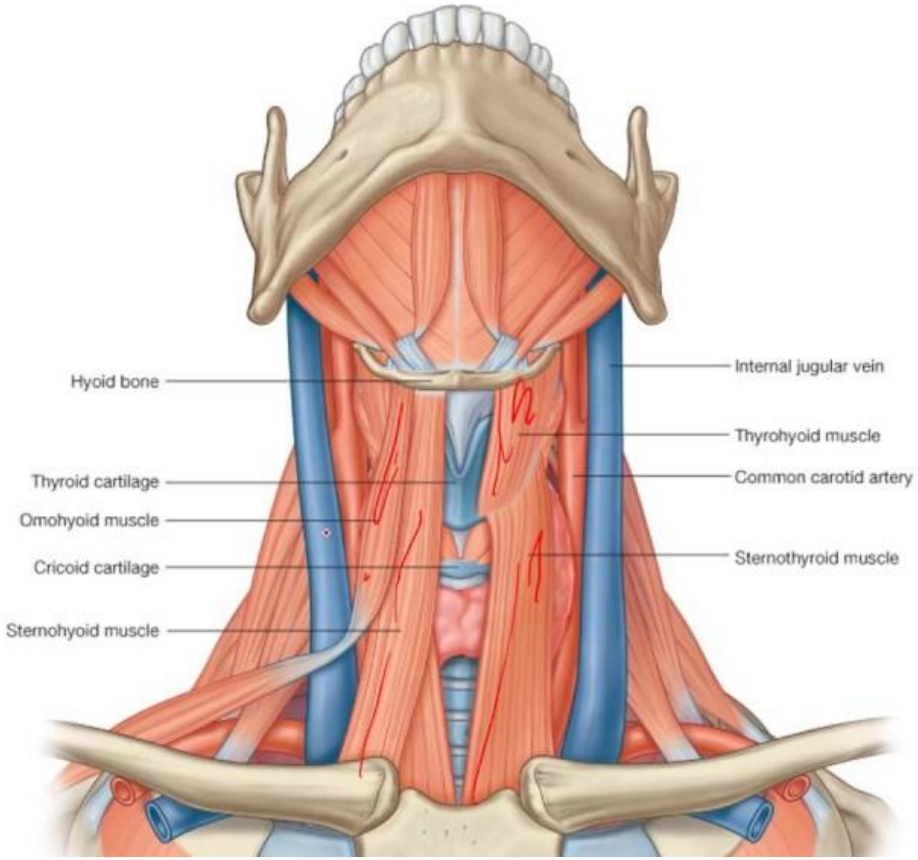
THYROID ANATOMY

- Arterial supply:
- The Superior Thyroid Artery > arises from the External carotid artery.
- The Inferior Thyroid Artery > arises from the thyrocervical trunk.
- Venous supply:
- The Superior and Middle Thyroid Vein > drain into the Internal jugular vein.
- The Inferior Thyroid Vein > drain into the the brachiocephalic vein.

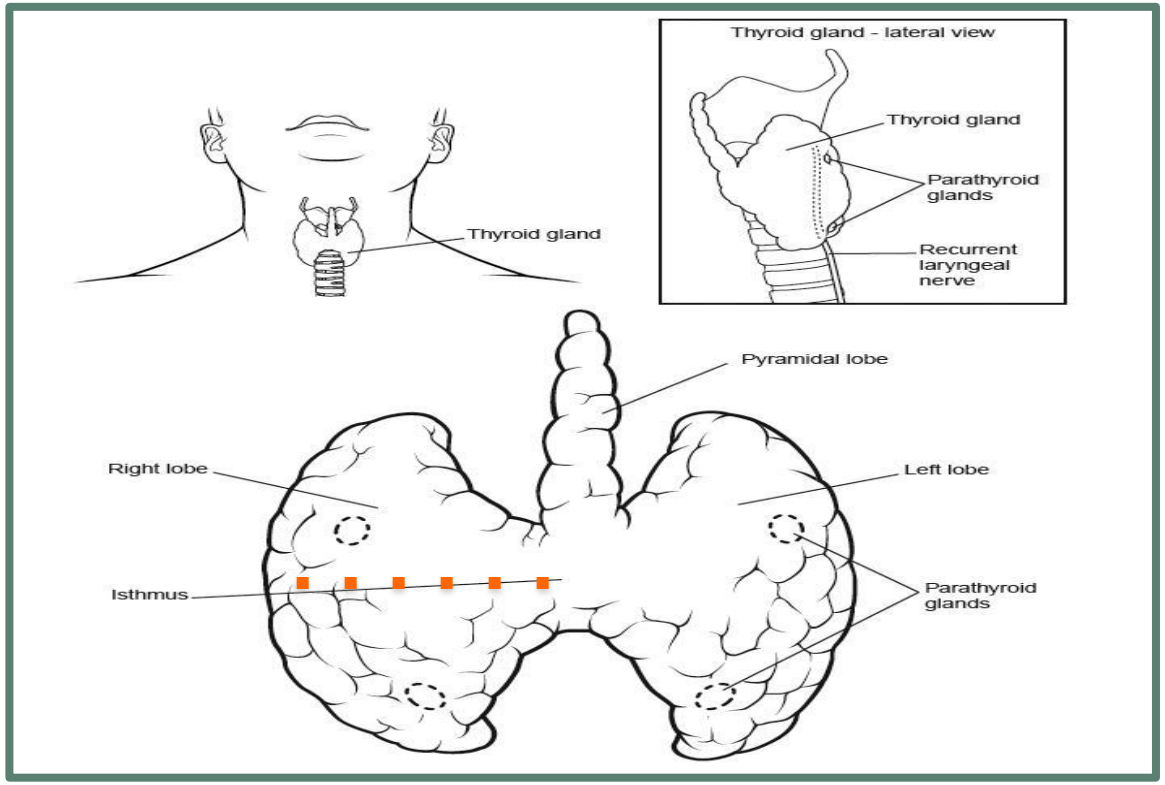


THYROID LOCATION

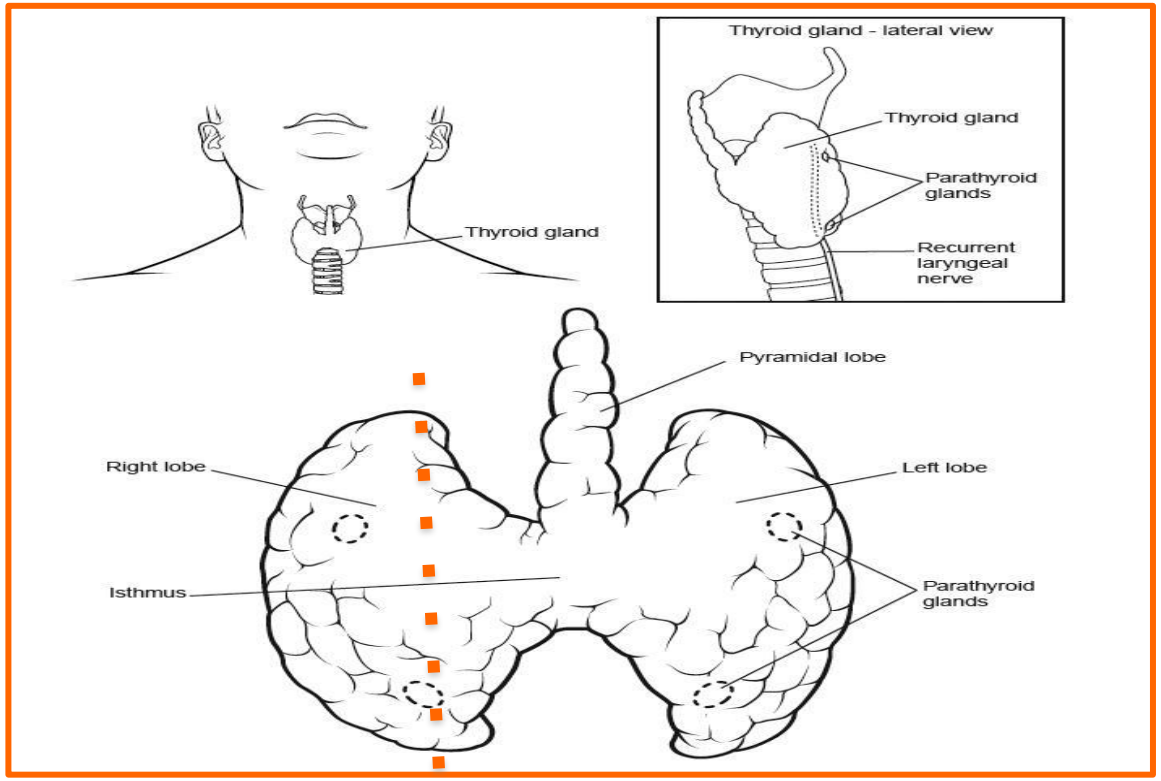
- The thyroid extends from C5 to T1 and lies anterior to the thyroid and cricoid cartilages of the larynx and the first three tracheal rings.
- Bilateral lobes bordered laterally by the CCA and IJV.
- Isthmus unites the lobes at the level of 2nd,3rd and 4th tracheal rings.
- Lies between the ant strap muscles (sternocleidomastoid, sternothyroid and sternohyoid) and posterior longus colli muscle.
- 4 Parathyroid – Posterior aspect of thyroid gland and the longus colli.



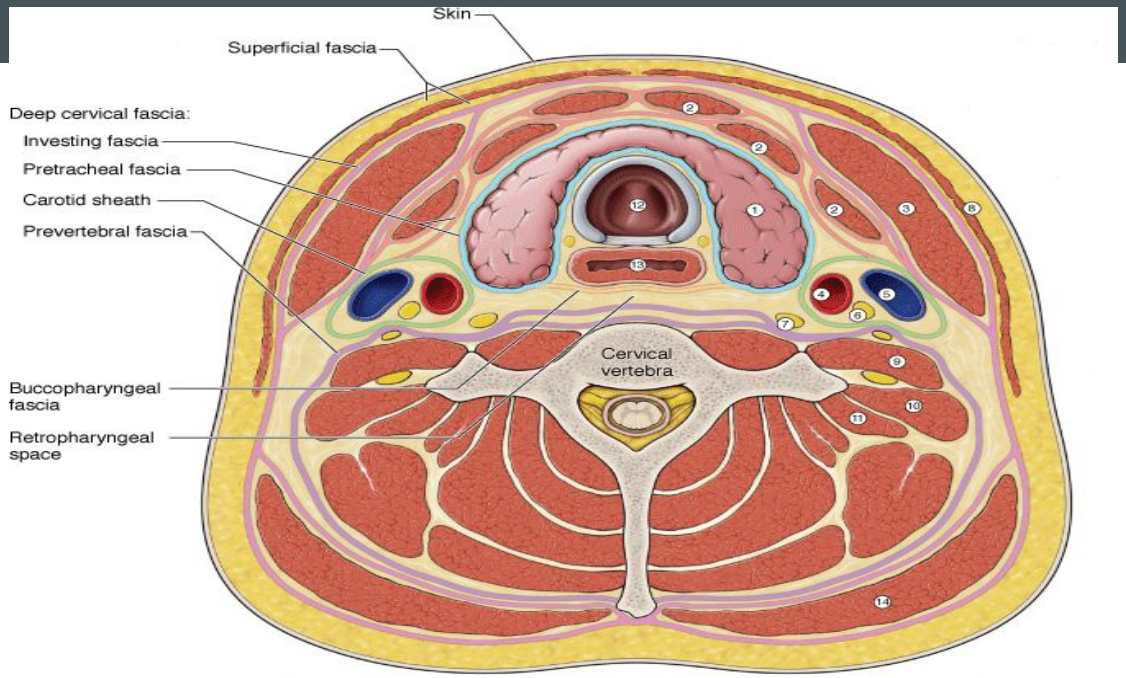
- Average width: 12-15 mm (each lobe)



- Average height: 40-60 mm long



- **Relations**
- anteriorly: strap muscles (sternocleidomastoid, sternothyroid and sternohyoid)
- posteriorly: thyroid cartilage, cricoid cartilage, trachea
- posteromedially: tracheo-esophageal groove(containing lymph nodes, recurrent laryngeal nerve, parathyroid glands)
- posterolaterally: carotid space



Source: Morton DA, Foreman KB, Albertine KH: *The Big Picture: Gross Anatomy:* www.accessmedicine.com

THYROID ULTRASOUND :WHY

- Diagnostic purposes
- FNA for suspicious thyroid nodules
- Therapeutic purposes using US as guidance for RFA of benign thyroid gland nodules, etc.

ULTRASOUND SCANNER

- Mean Frequency of 10 to 14Mhz
- Transducer : Linear

THYROID ULTRASOUND : INDICATIONS

Evaluation of :

- Location and characteristics of palpable neck masses, including an enlarged thyroid.
- Presence, size and location of thyroid gland
- Lab abnormalities
- Abnormalities detected by other lab exams
- Follow-up imaging of previously detected thyroid nodules, when indicated.
- Patients at high risk of occult thyroid malignancy

THYROID ULTRASOUND : INDICATIONS

Including but not limited to :

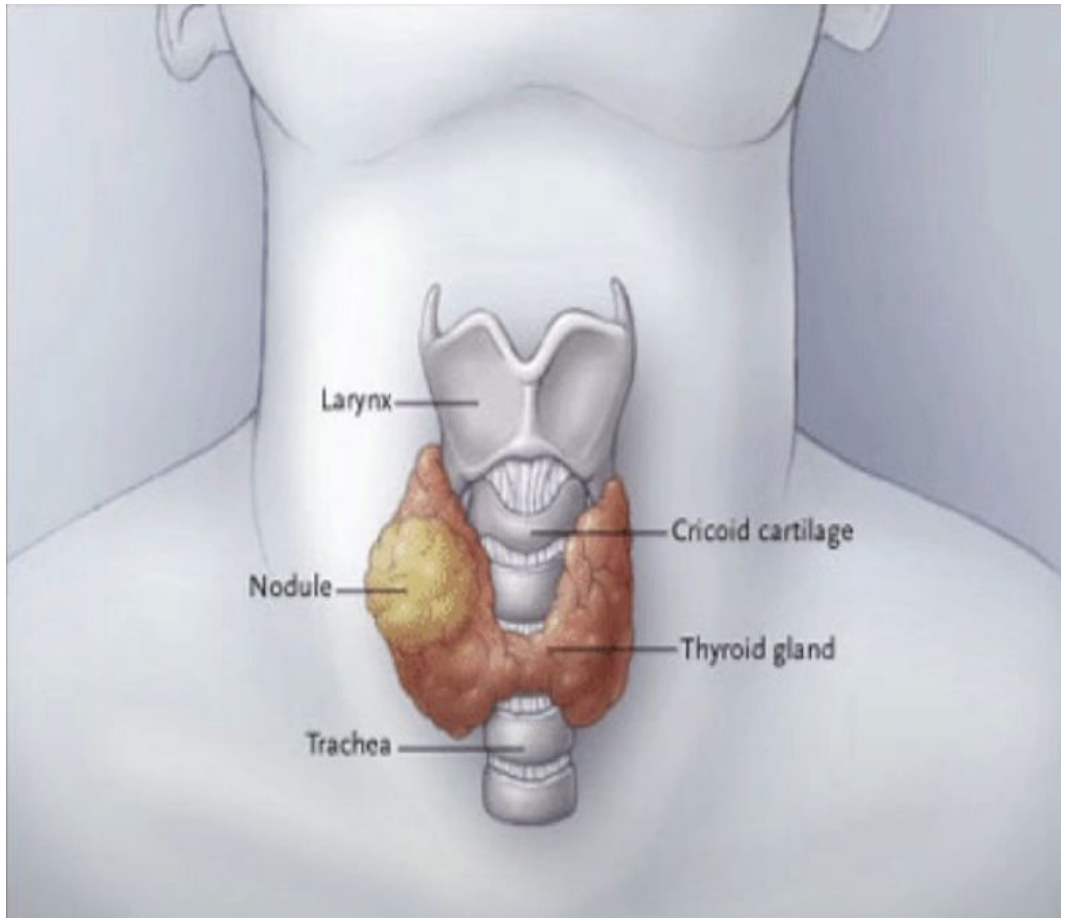
- Evaluation for regional nodal metastases in pts with proven or suspected thyroid carcinoma before thyroidectomy.
- Thyroid gland for suspicious nodules before neck surgery for non thyroid disease
- Evaluation for recurrent diseases or regional nodal metastases after total or partial thyroidectomy for thyroid carcinoma
- Thyroid gland for suspicious nodules before radioiodine ablation of the gland.

THYROID ULTRASOUND : EXAMINATION

- The right and left lobes should be imaged in longitudinal and transverse planes
- The size of each thyroid lobe should be recorded in 3d (AP, Tran, Long)
- Recorded images should include
  - Trans images of sup, mid and inf portions of right and left thyroid lobes.
  - Longitudinal images of the medial and lat portion of both lobes
  - And at least a trans image of isthmus
- The thickness of isthmus on the trans view should be recorded.
- A Color Doppler can be used to supplement the greyscale evaluation of diffuse or focal abnormalities of the thyroid.

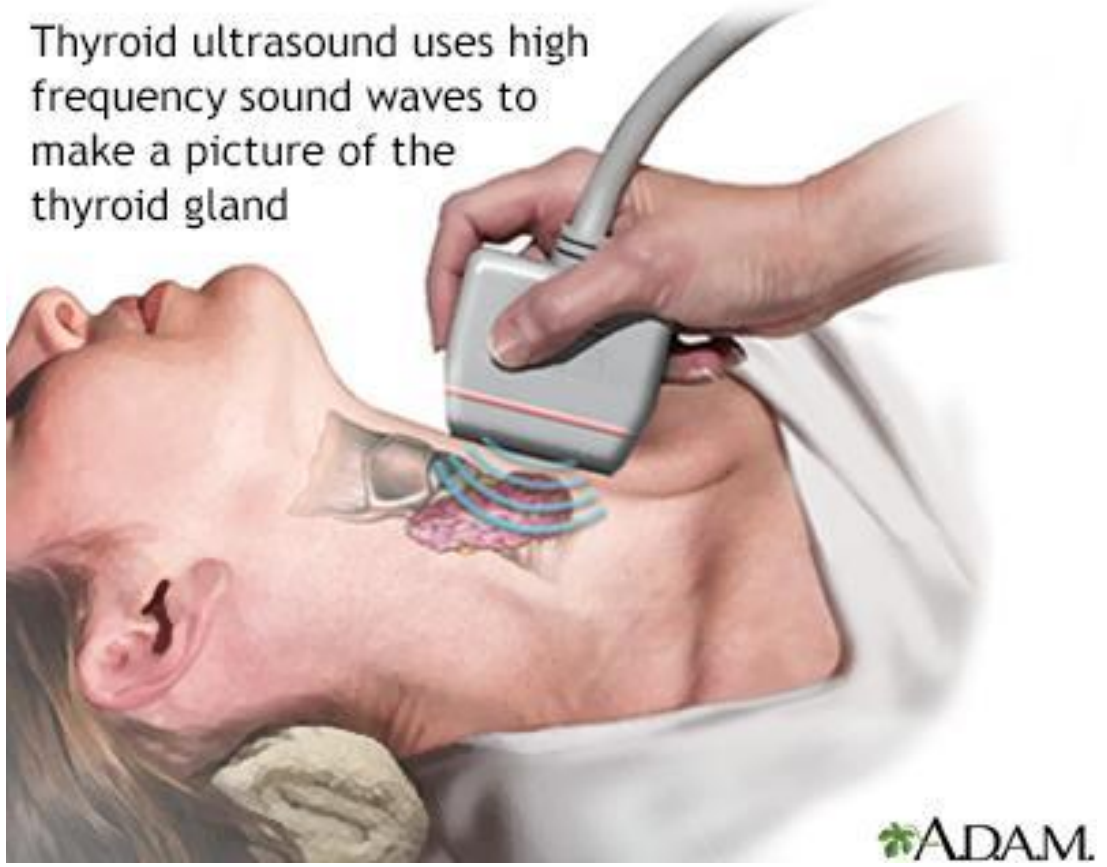
THYROID EXAMINATION : SCANNING FIELDS

- Central Neck
- Often necessary to extend imaging to include
  - The soft tissue above the isthmus (evaluate possible pyramidal lobe)
  - Congenital abnormalities



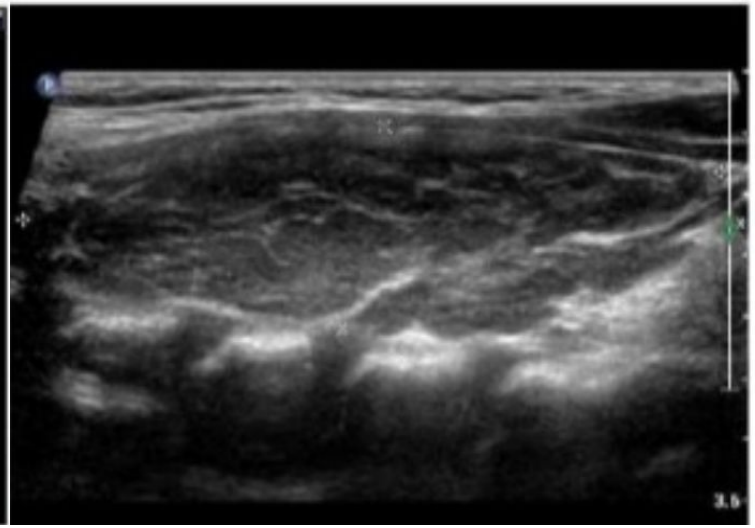
THYROID ULTRASOUND :ADVANTAGES

- Painless, quick (real-time), no contrast material, no radiation.
- Chances of missing something during palpation.
- Can be used in pregnancy,
- Can detect thyroid nodules as small as 2-3mm and provide guidance for FNA biopsy

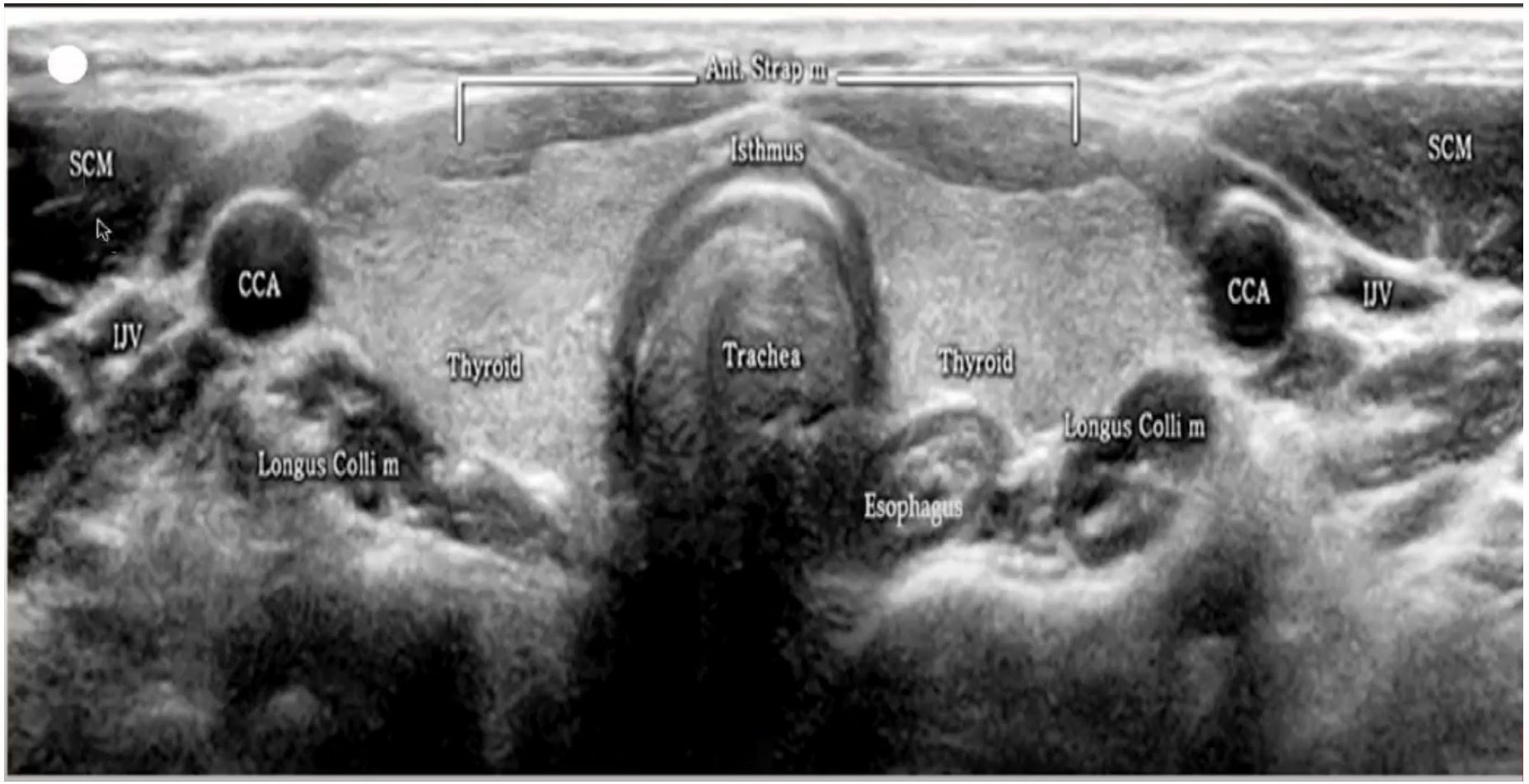


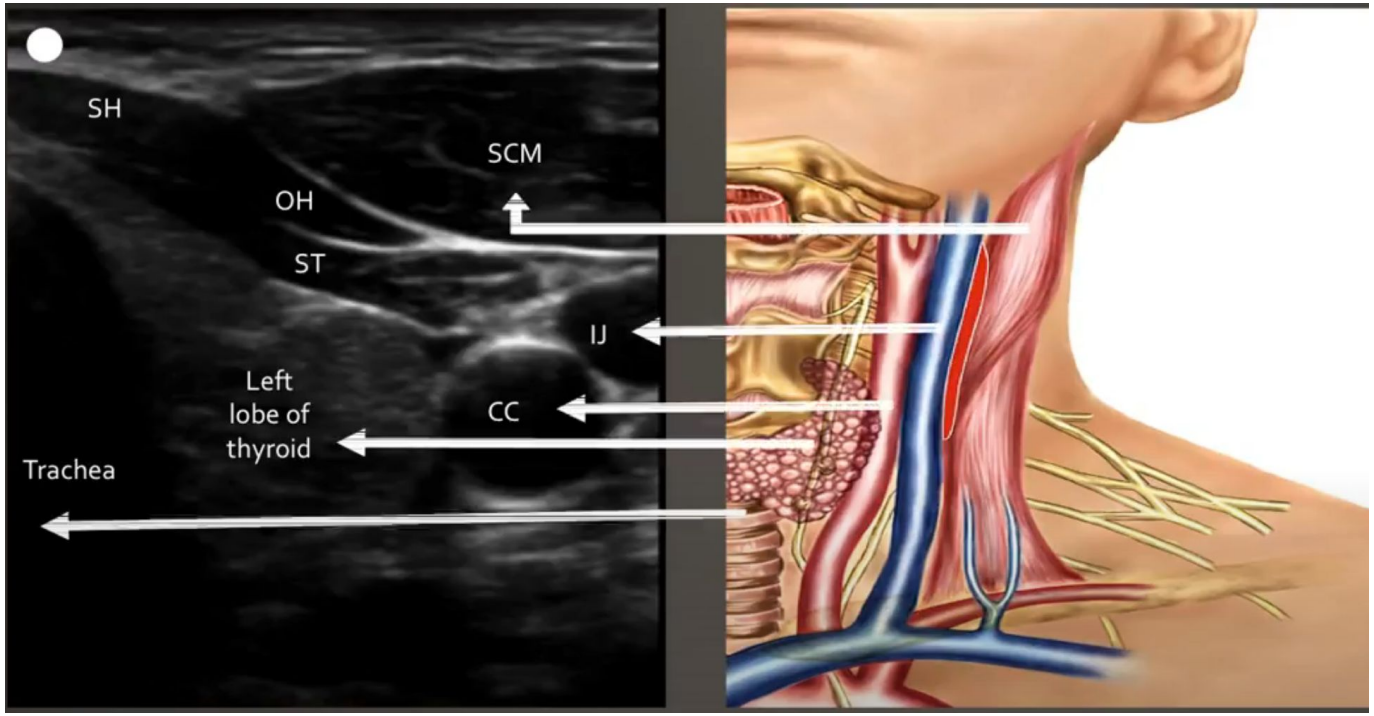
NORMAL THYROID US :

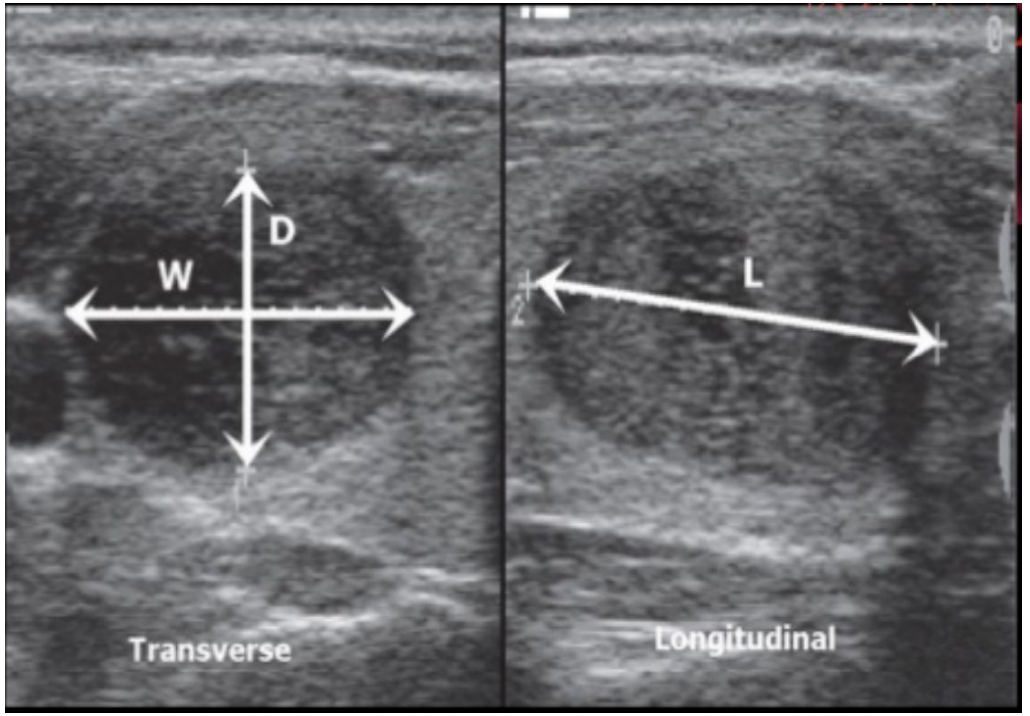
- Normal thyroid gland appears homogenous and moderately echogenic.
- Similar appearance to normal liver and testes parenchyma.
- It is hyperechoic relative to adjacent musculature.
- Parathyroid appear flat, hypoechoic structures lying between the thyroid gland anteriorly and longus colli muscle posteriorly.

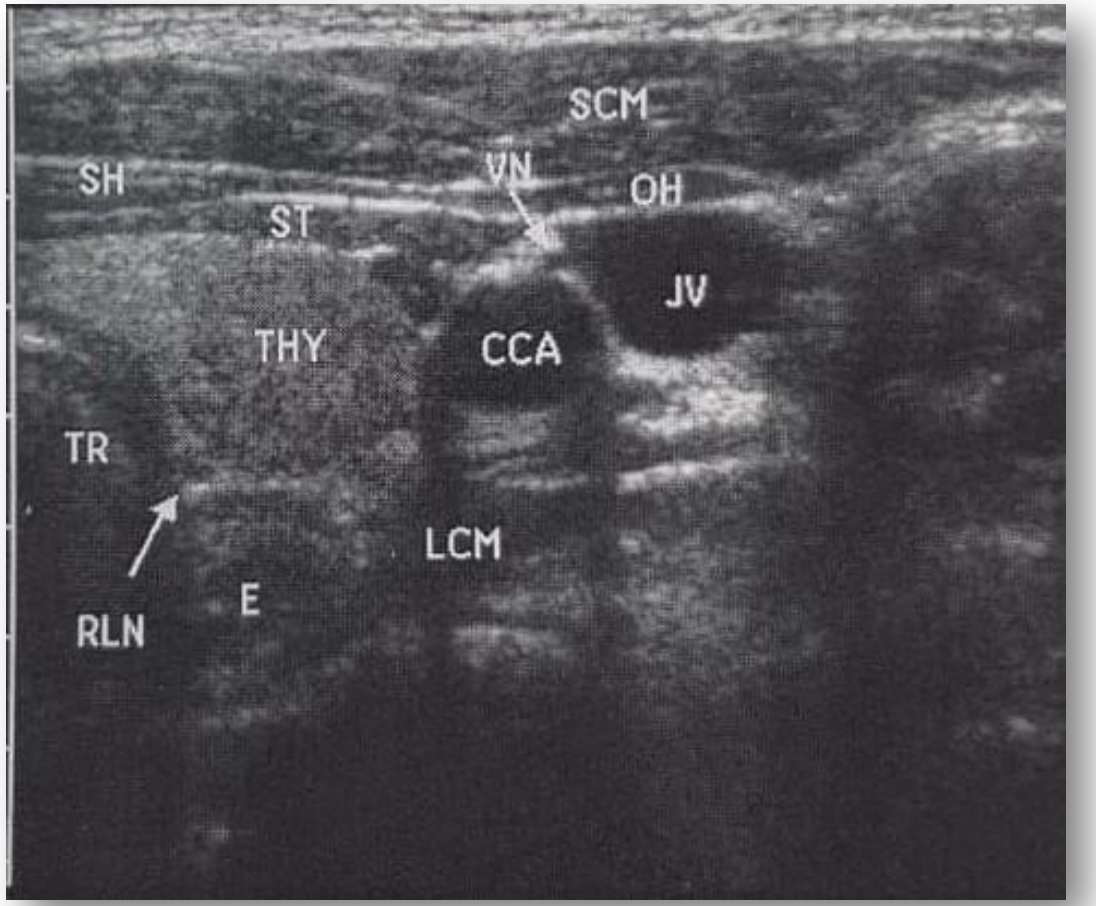


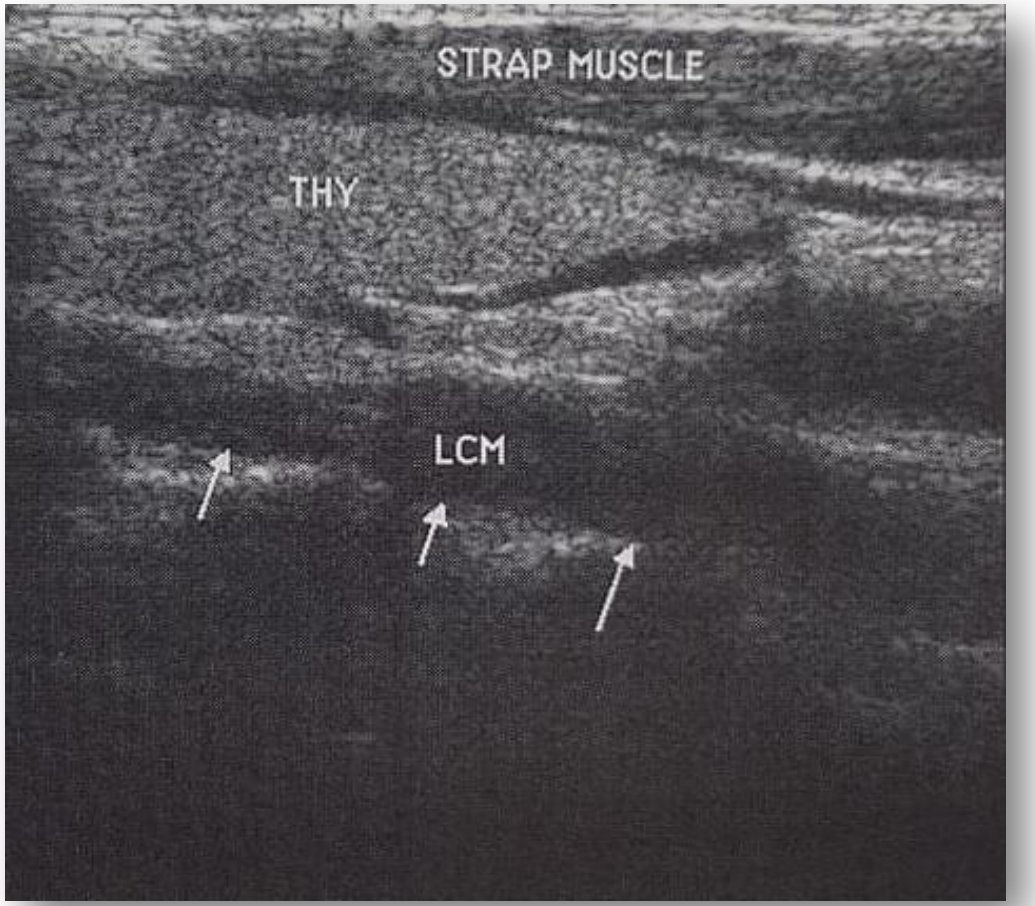
NORMAL THYROID US

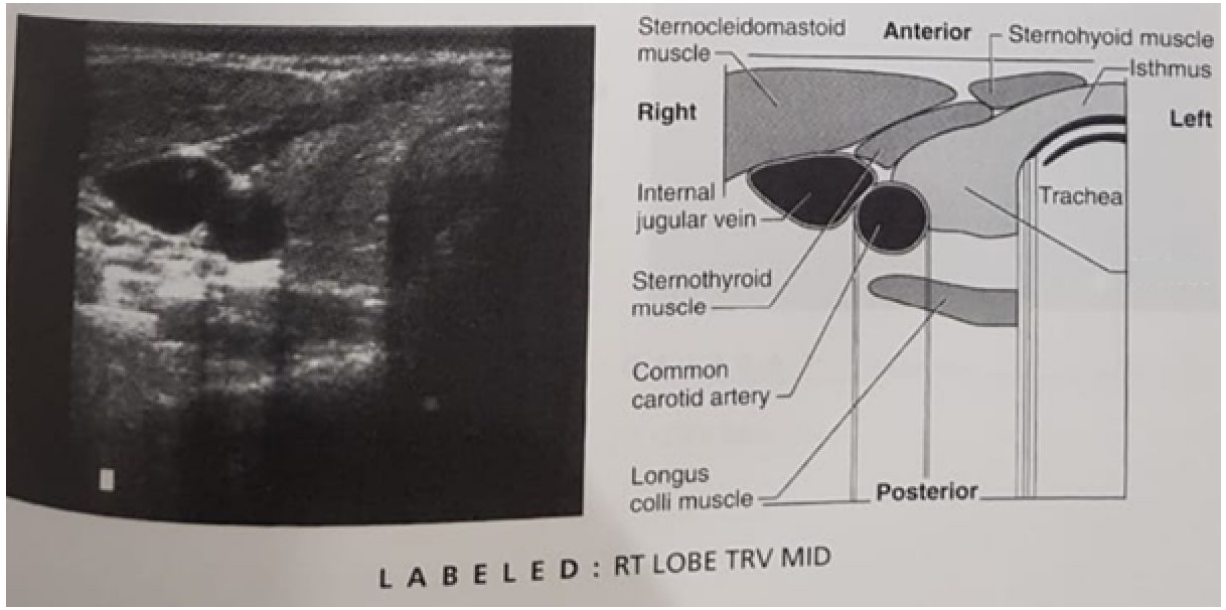



SH
SCM
OH
ST
IJ
Left
lobe of
thyroid
CC
Trachea

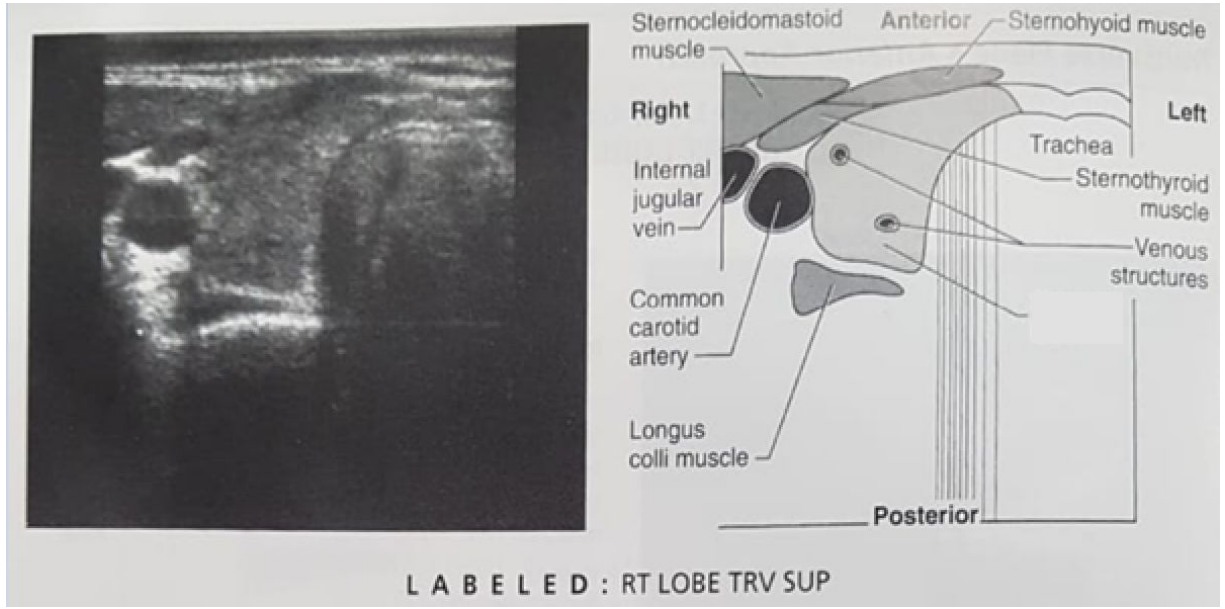

W
D
L
Transverse
Longitudinal


SCM
SH
VN
OH
ST
JV
THY
CCA
TR
LCM
E
RLN

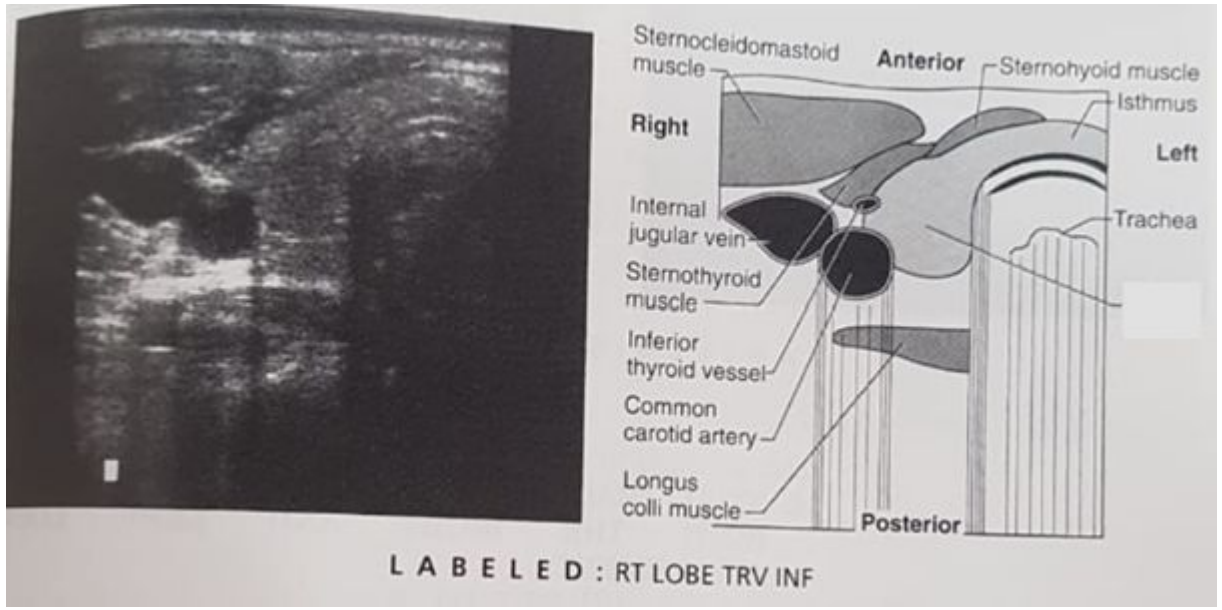

STRAP MUSCLE
THY
LCM



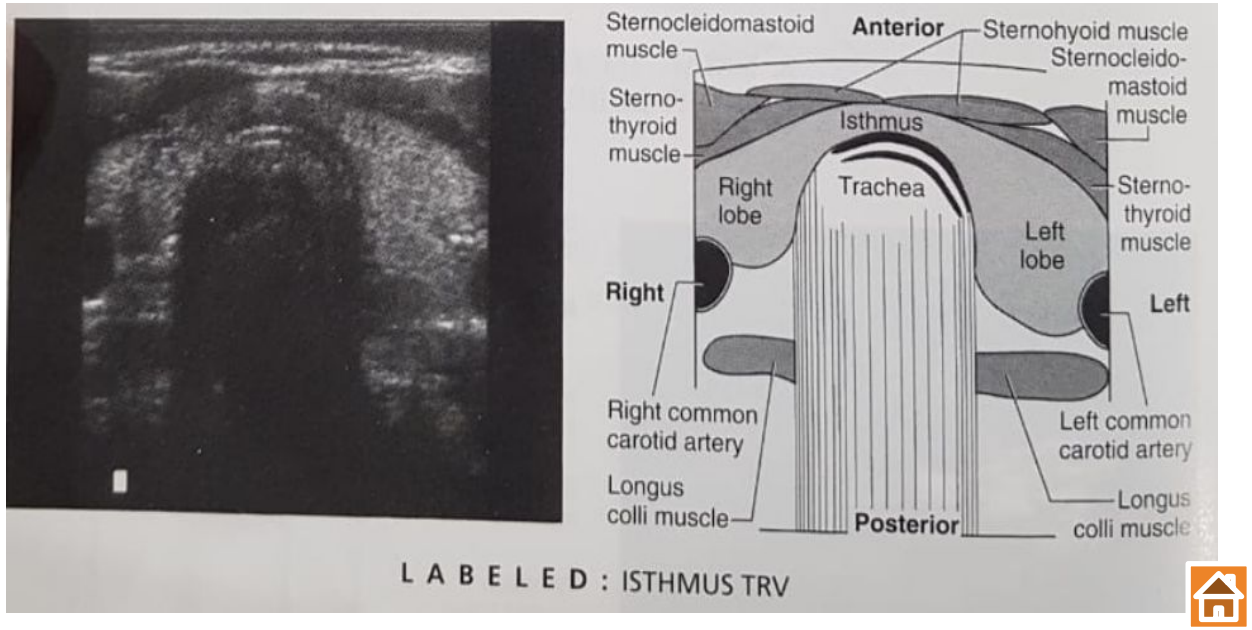
LABELED: RT LOBE TRV MID



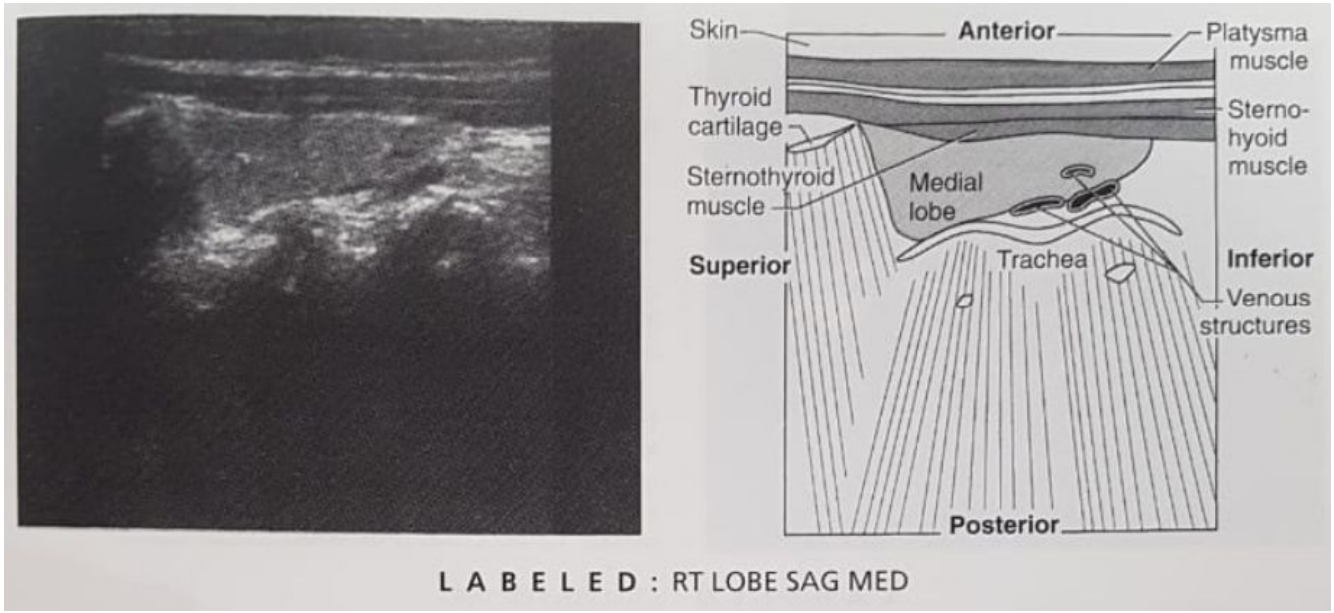
LABELED: RT LOBE TRV SUP



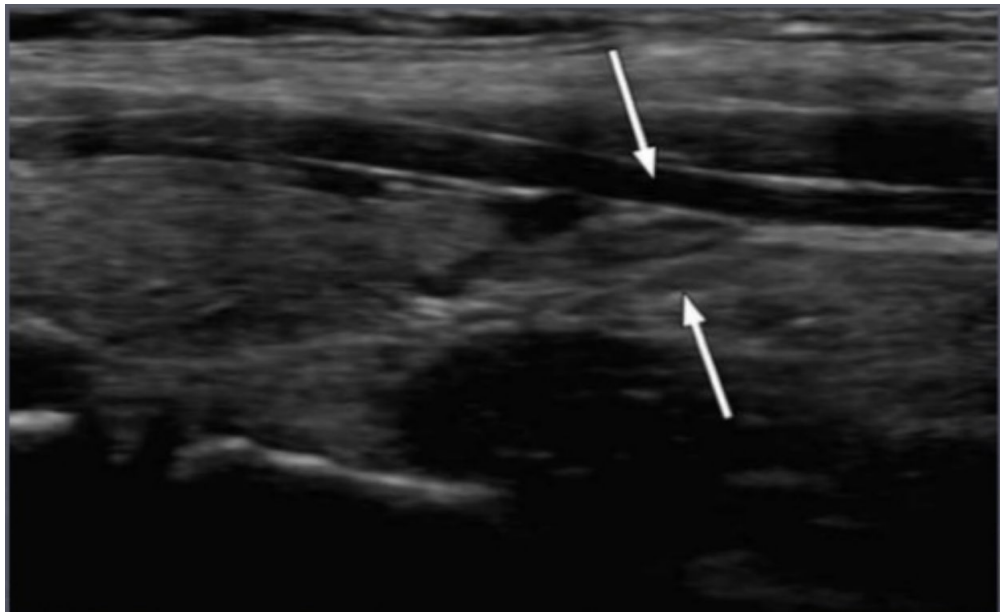
LABELED: RT LOBE TRV INF

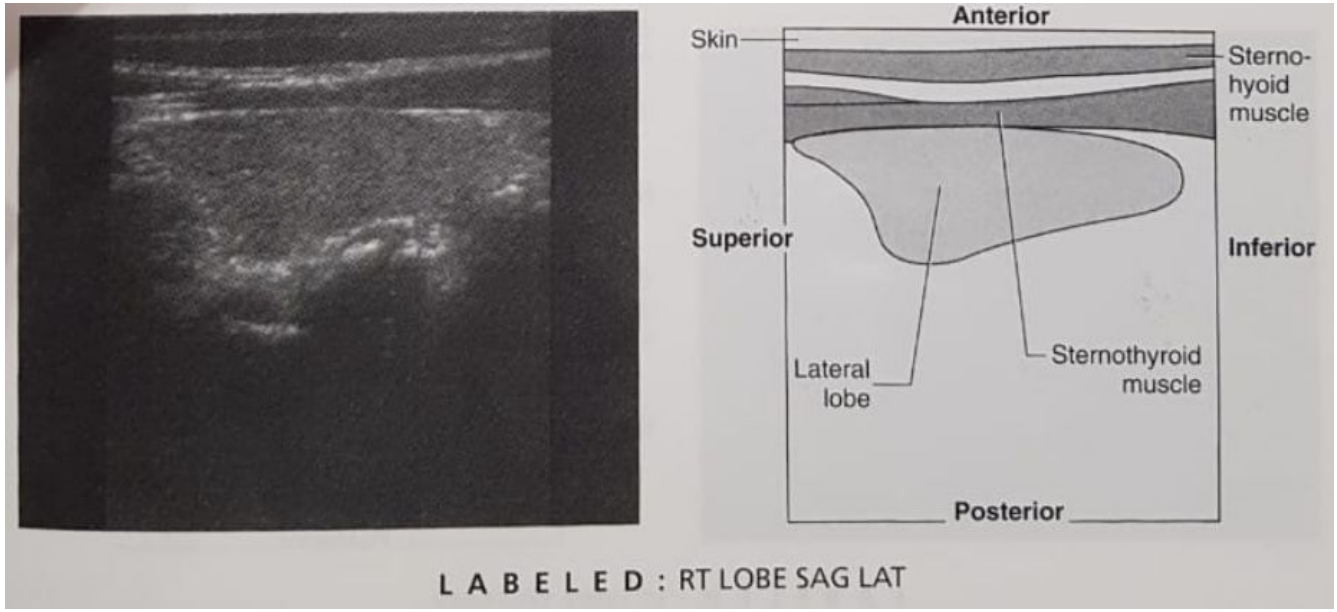


LABELED: ISTHMUS TRV

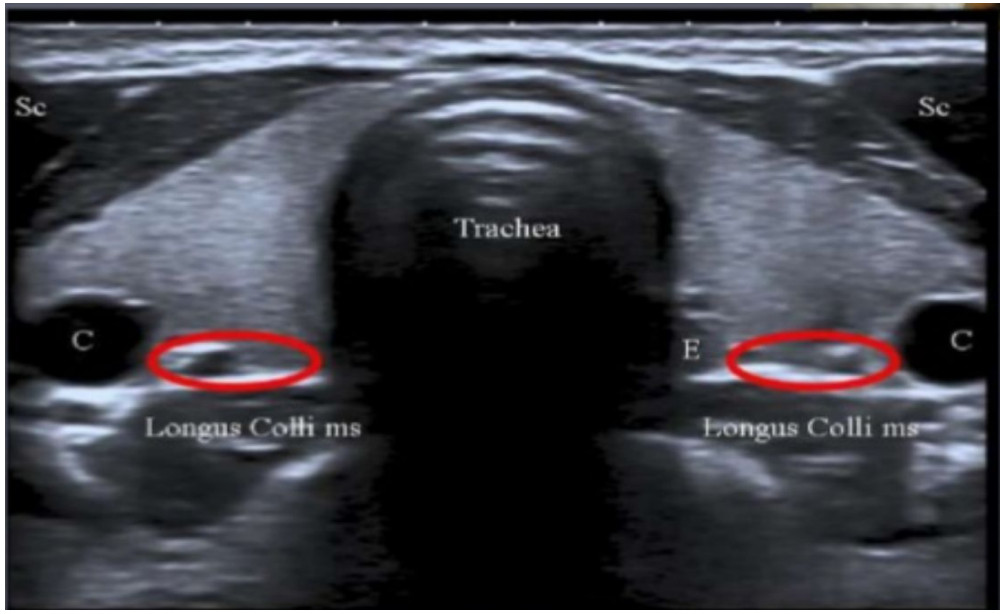


LABELED: RT LOBE SAG MED





LABELED: RT LOBE SAG LAT



THYROID ABNORMALITIES

Should be imaged in a way that allows for reporting and documentation of :

- The location, size, number and character of significant abnormalities, including measurements of nodules and focal abnormalities in 3 dimensions
- The localized or diffused nature of any thyroid abnormality
- The sonographic features of any thyroid abnormality with respect to :
  - Echogenicity
  - Composition (degree of cystic change)
  - Margins (smooth or irregular)
  - Presence and type of calcification (if present) and
  - Other relevant sonographic patterns, peripheral vascularity and color Doppler.
- The presence and size of any abnormal lymph node in the lateral compartment of the neck.

THYROID DISEASES

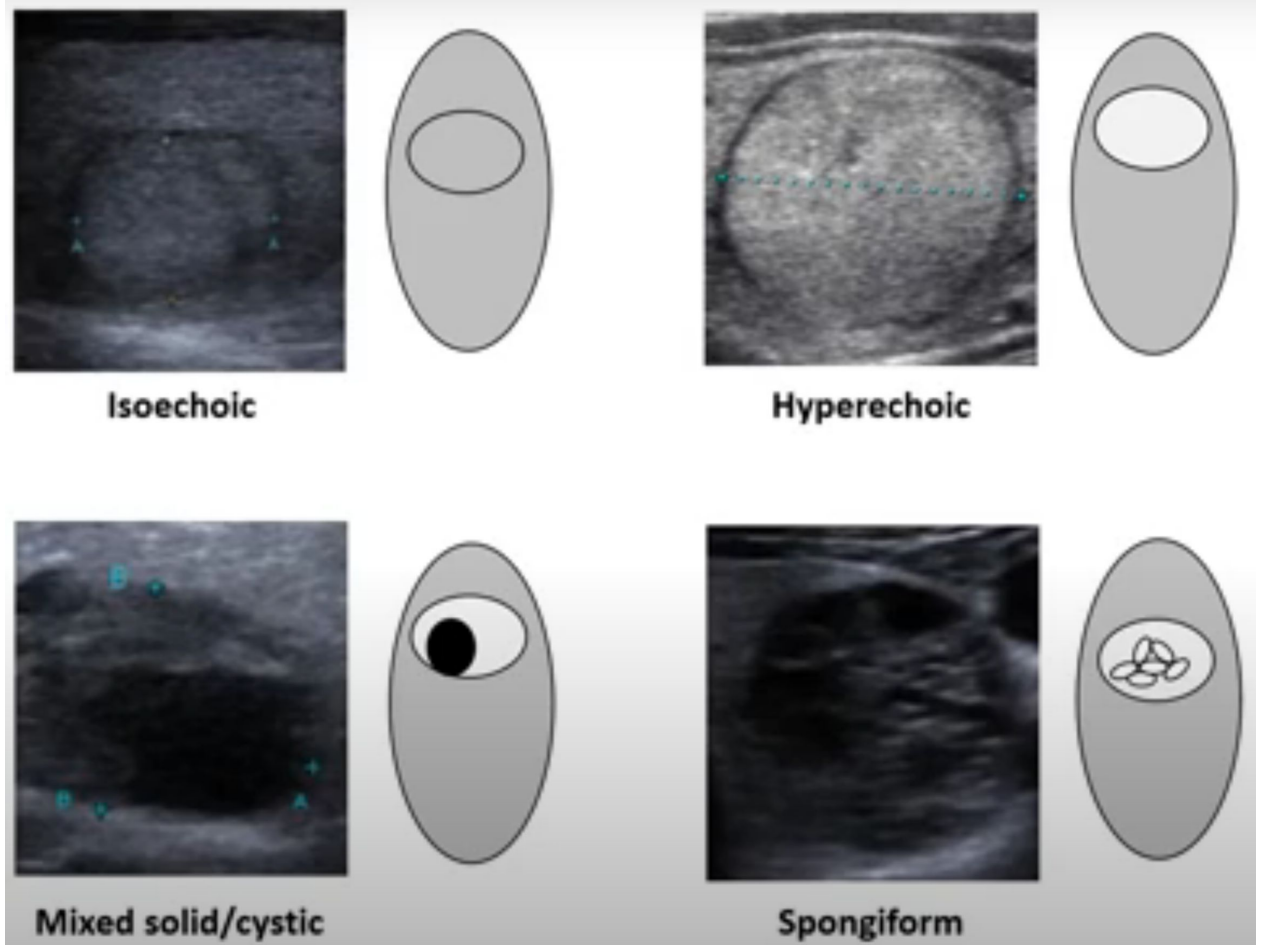
THYROID NODULES

- Thyroid nodules are any lesion delineated on imaging studies. They can be benign or malignant.
- Thyroid nodules are common incidental findings, more in female with a ratio of 4:1.
- Benign Nodules such as:
  - Colloid adenoma
  - Follicular adenoma.
  - Thyroid cyst.
- Malignant Nodules such as:
  - Primary thyroid cancer.
  - Thyroid lymphoma.
  - Metastasis.

THYROID NODULES

- Nodule Location
- Nodule size in 3 dimensions
- Nodule sonographic features:
  - Composition
  - Echogenicity
  - Shape
  - Margin
  - Halo
  - Calcifications
  - Vascularity

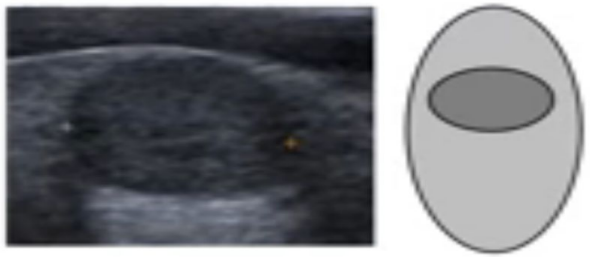
THYROID NODULES : BENIGN CHARACTERISTICS



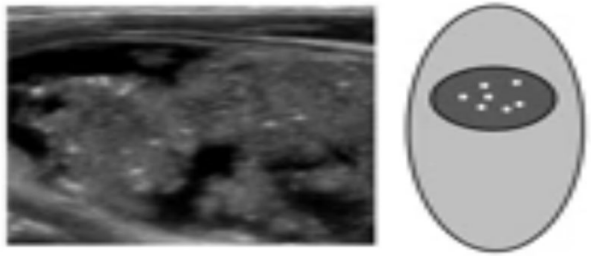
Others include:

- Smooth or regular margins
- Positive halo
- Peripheral vascularity
- Anechoic
- Wider than tall

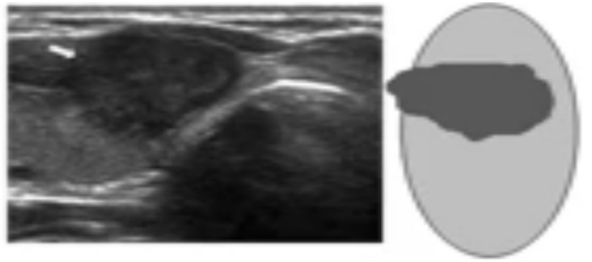
THYROID NODULES : SUSPICIOUS CHARACTERISTICS



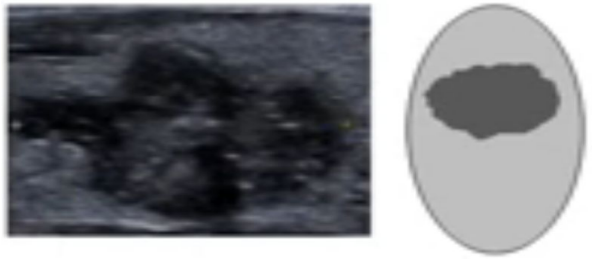
Hypoechoic



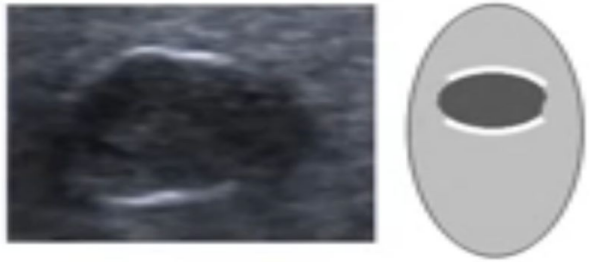
Microcalcifications



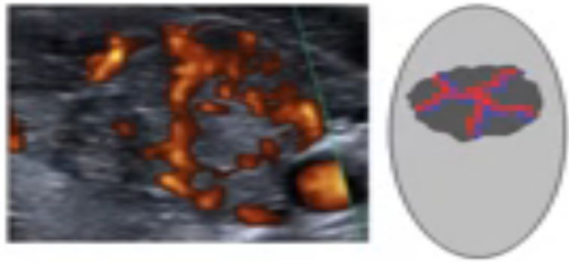
Extrathyroidal Extension



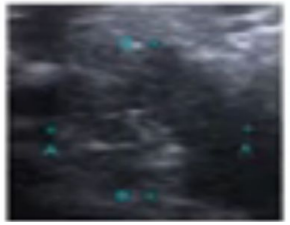
Irregular Margins



Disrupted Halo sign



Increased Vascularity



Taller than wide

@DJCSu

GRADING/SCORING SYSTEM

Some US systems for thyroid nodule risk stratification

2009	**First TI-RADS** Horvath E et al. Clin Endocrinol Metab 2009;94(5):1748–51.
2011	**Korean TI-RADS** Kwak JY et al. Radiology 2011;260(3):892–899.
2016	**U classification of British Thyroid Association (BTA)** Die C et al. Insights Imaging 2016;7:77–86.
2016	**American Thyroid Association (ATA)** Haugen BR et al. Thyroid 2016;26(1):1–133.
2017	**ACR TI-RADS** Tessler FN et al. J Am Coll Radiol 2017;14:587–595.
No one system has achieved universal acceptance This leads to some confusion for practitioners of sonography	

ACR: American college of radiology
TI-RADS: Thyroid imaging reporting and data system

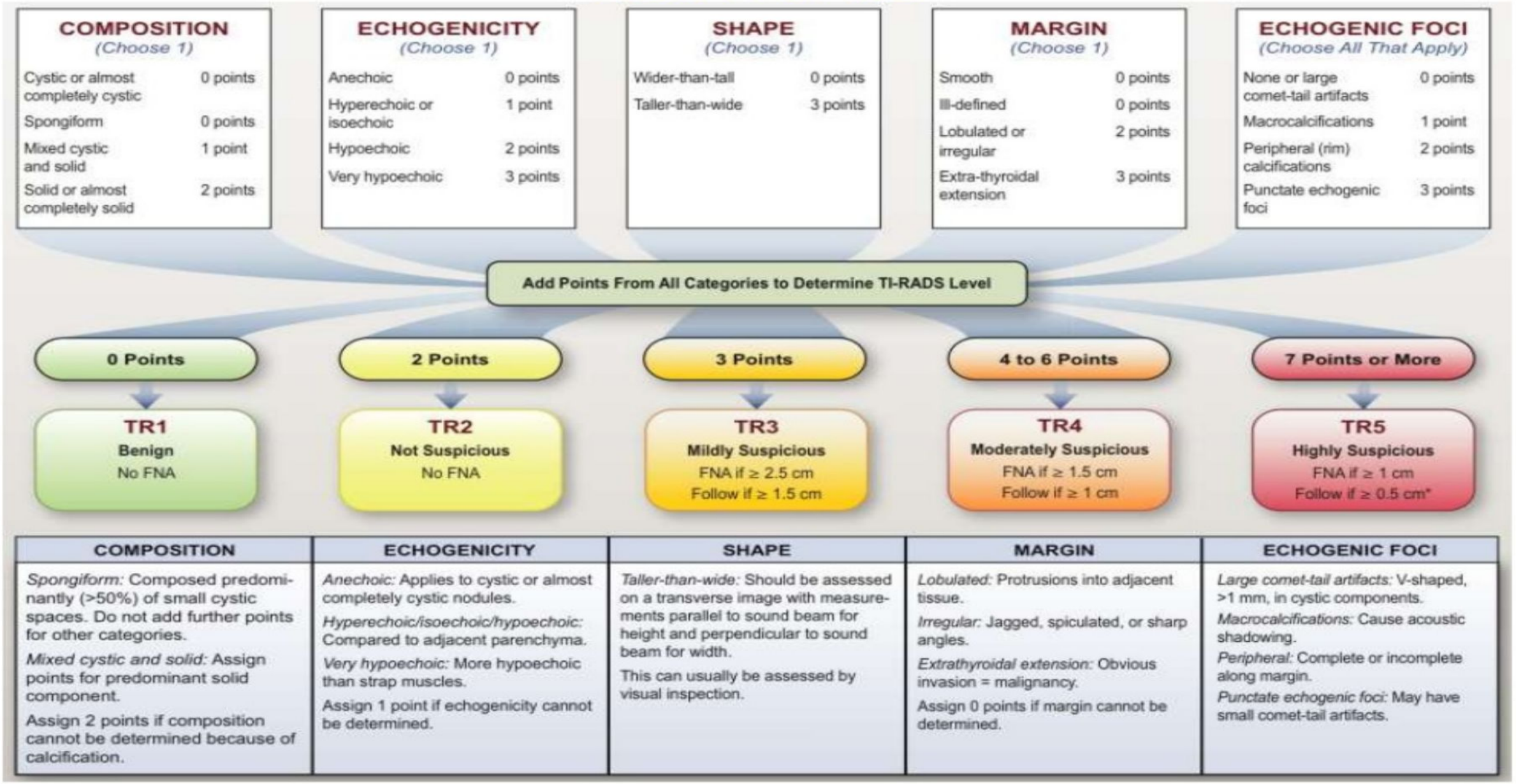
ACR TI-RADS

- Less concerning features are awarded less or no points.
- More suspicious features are awarded higher points.
- Add points of all categories to determine ACR TI-RADS

Categories of nodule features in ACR TI-RADS

Category	Ultrasound features	Points
Composition: choose only one	Cystic or almost completely cystic	0 point
	Spongiform: > 50% of small cystic spaces	0 point
	Mixed cystic and solid	1 point
	Solid or almost completely solid	2 points
Echogenicity: choose only one	Anechoic	0 point
	Hyperechoic or isoechoic	1 point
	Hypoechoic	2 points
	Very hypoechoic	3 points
Shape: choose only one	Wider-than-tall	0 point
	Taller-than-wide	3 points
Margins: choose only one	Smooth or ill-defined	0 point
	Lobulated or irregular	2 points
	Extra-thyroidal extension	3 points
Echogenic foci: all that apply	No echogenic foci or large comet-tail artifacts	0 point
	Macrocalcifications	1 point
	Peripheral (rim) calcifications	2 points
	Punctate echogenic foci (microcalcifications)	3 points

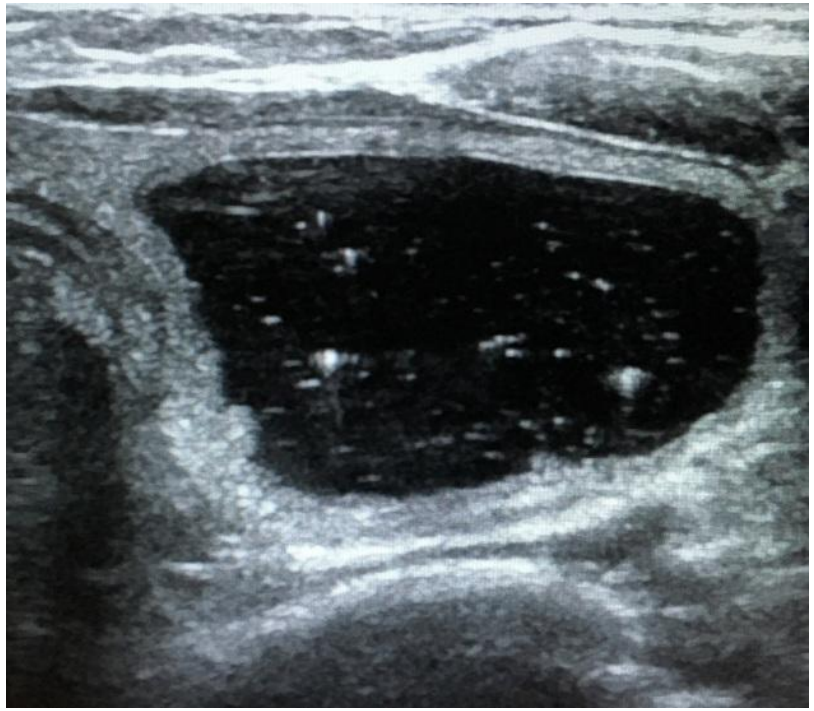
ACR TI-RADS



COMPOSITION	ECHOGENICITY	SHAPE	MARGIN	ECHOGENIC FOCI
Spongiform: Composed predominantly (>50%) of small cystic spaces. Do not add further points for other categories. *Mixed cystic and solid:* Assign points for predominant solid component. Assign 2 points if composition cannot be determined because of calcification.	*Anechoic:* Applies to cystic or almost completely cystic nodules. *Hyperechoic/isoechoic/hypoechoic:* Compared to adjacent parenchyma. *Very hypoechoic:* More hypoechoic than strap muscles. Assign 1 point if echogenicity cannot be determined.	*Taller-than-wide:* Should be assessed on a transverse image with measurements parallel to sound beam for height and perpendicular to sound beam for width. This can usually be assessed by visual inspection.	*Lobulated:* Protrusions into adjacent tissue. *Irregular:* Jagged, spiculated, or sharp angles. *Extrathyroidal extension:* Obvious invasion = malignancy. Assign 0 points if margin cannot be determined.	*Large comet-tail artifacts:* V-shaped, >1 mm, in cystic components. *Macrocalcifications:* Cause acoustic shadowing. *Peripheral:* Complete or incomplete along margin. *Punctate echogenic foci:* May have small comet-tail artifacts.

THYROID NODULE CHARACTERISTICS

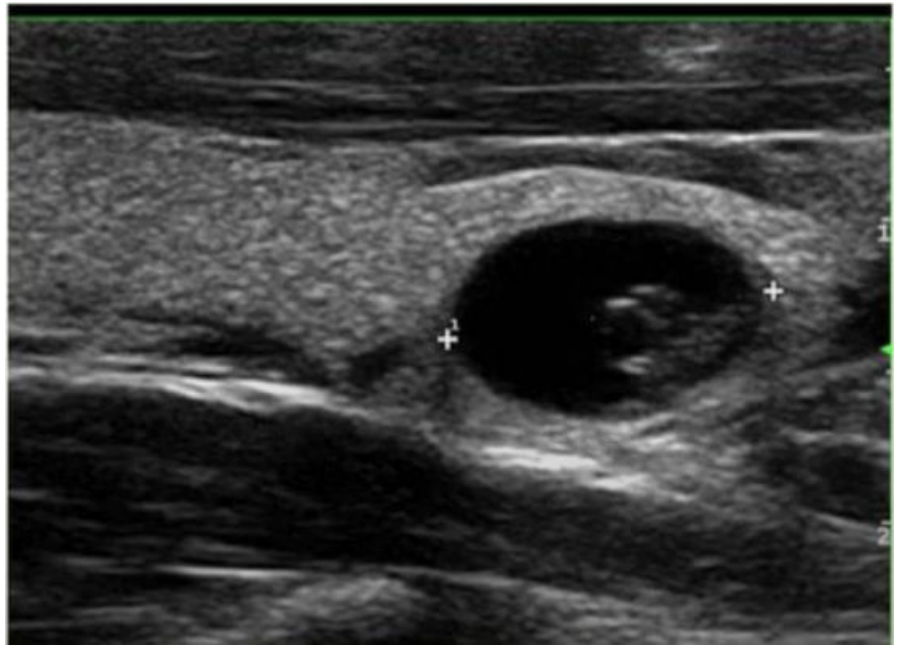
- Composition: Cystic



- Mass in the left side
- 3cm thin walled
- Cystic nodule
- With multiple echogenic foci

THYROID NODULE CHARACTERISTICS

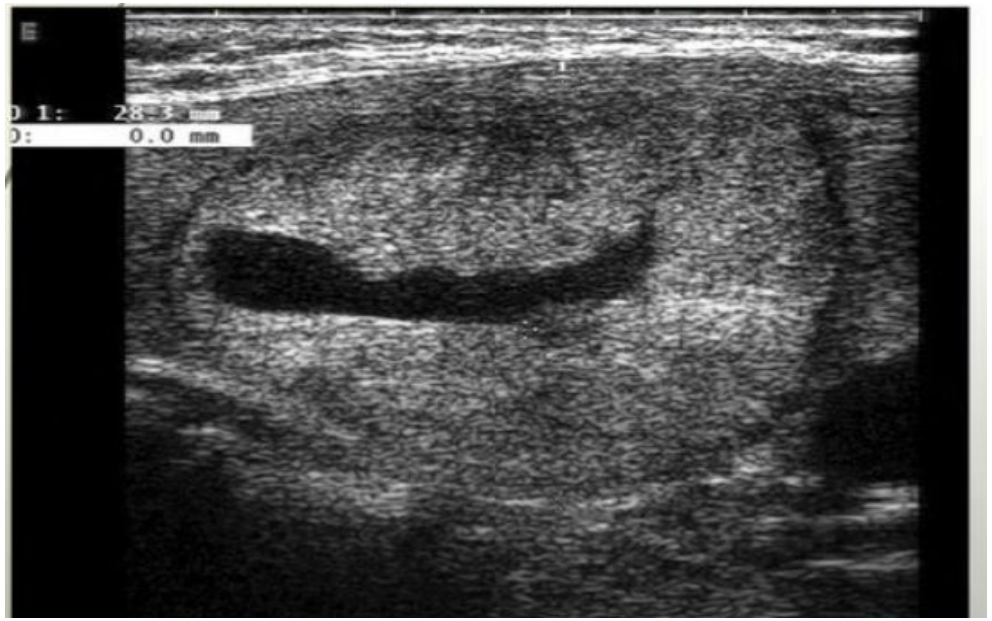
- Composition (degree of cystic change)

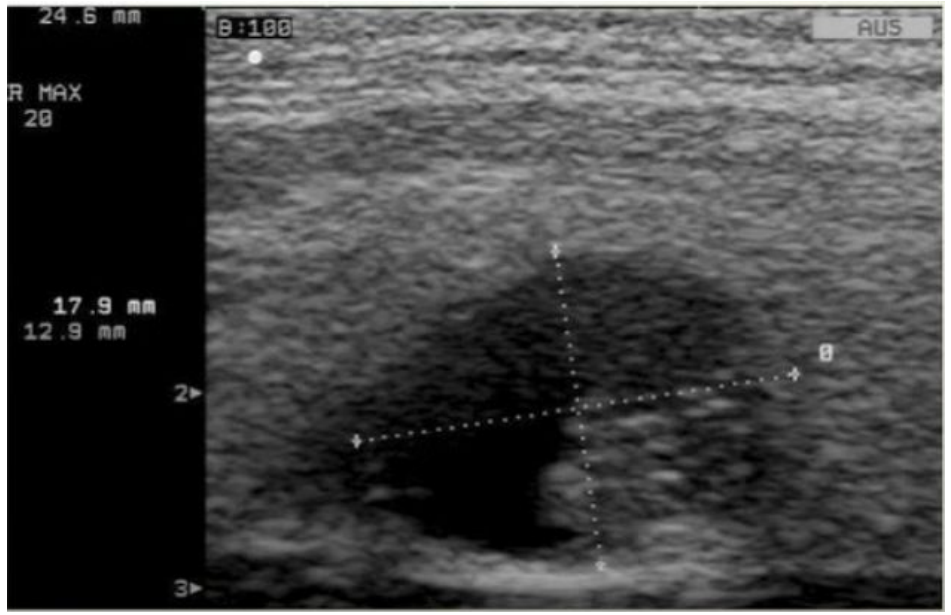


- Marked hypoechoic solid lesion
- Surrounded by normal thyroid tissue.
- Also checking for any acoustic shadow/intense enhancement of the cyst – solid part of the periphery

THYROID NODULE CHARACTERISTICS

- Composition (degree of cystic change)

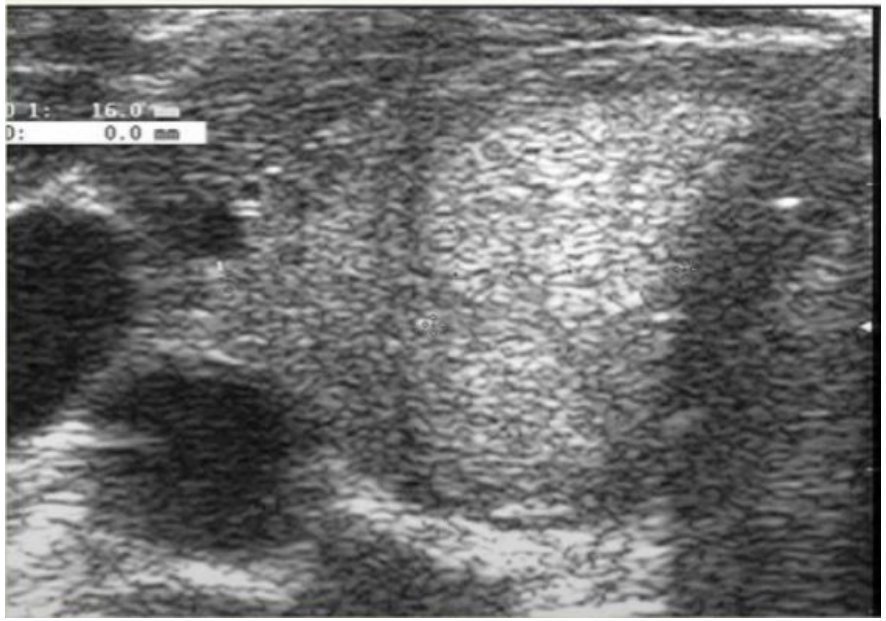




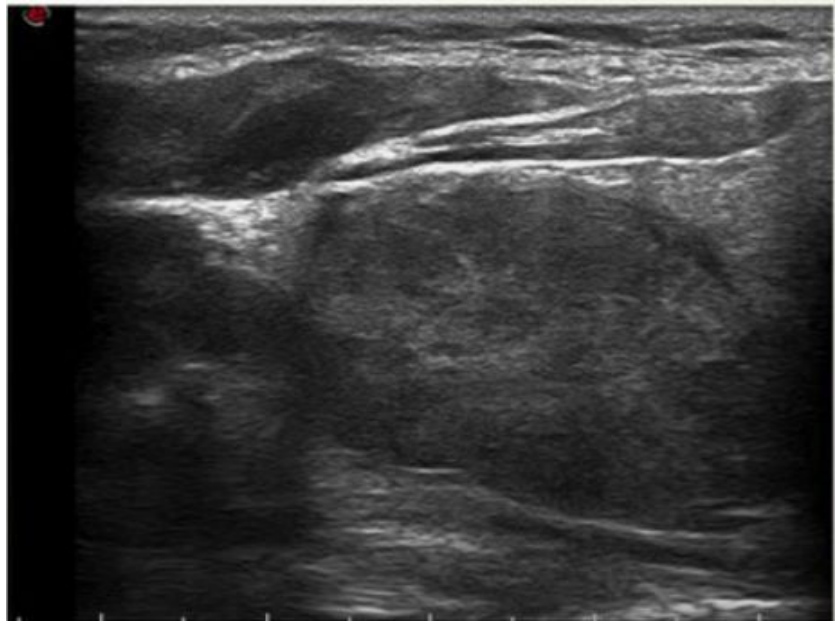
- Mixed density nodule
- With cystic center
- Halo periphery
- Effacement outline

THYROID NODULE CHARACTERISTICS

- Echogenicity



- Hyperechoic lesion
- With a surround hypodense halo



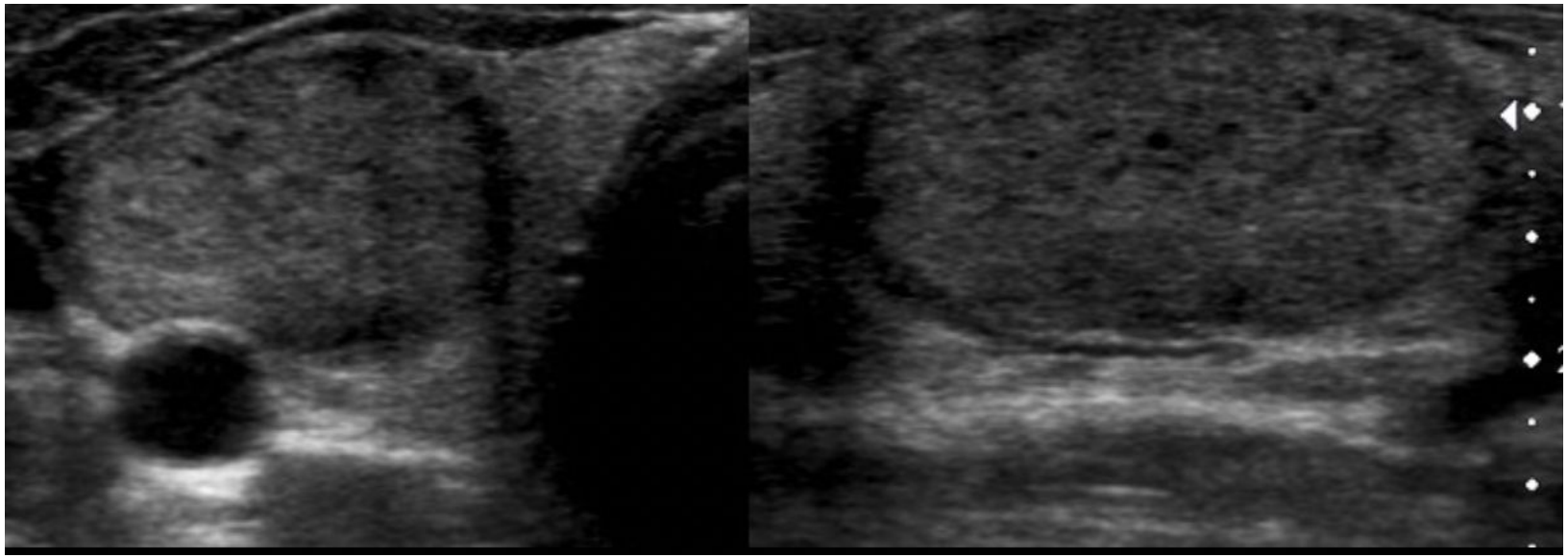
- Hypo echoic lesion
- With regularity

THYROID NODULE CHARACTERISTICS

- Margins (Smooth or irregular)

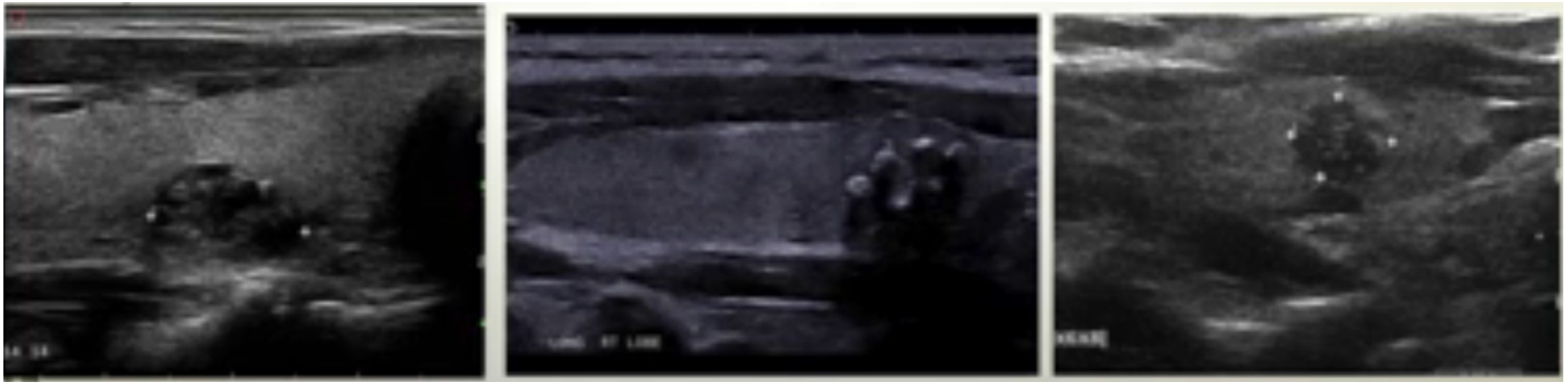
THYROID NODULE CHARACTERISTICS

- Presence of halo:



THYROID NODULE CHARACTERISTICS

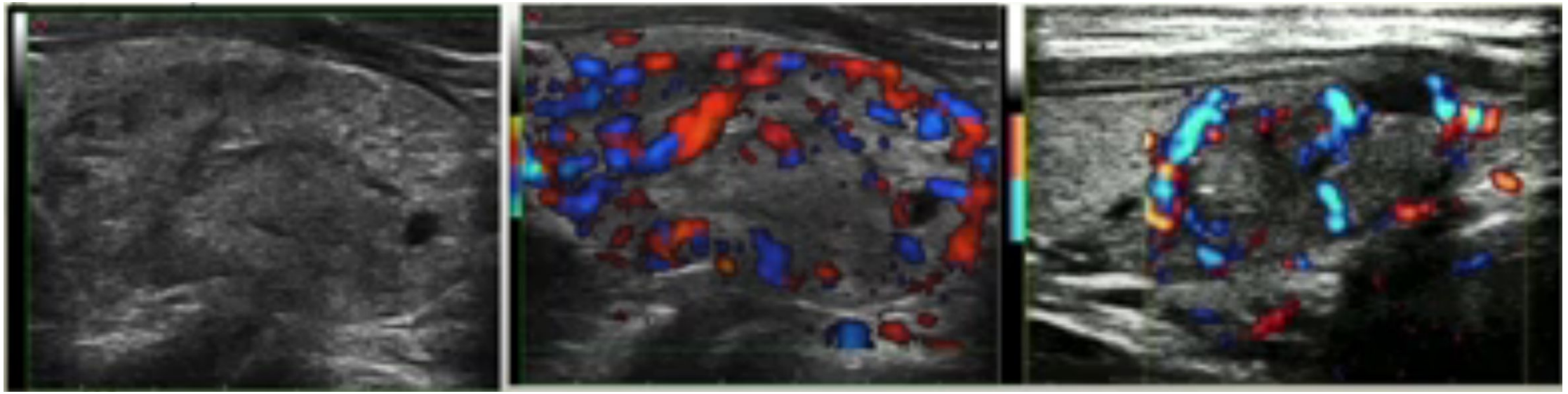
- Presence and type of calcification (If present)



- Possible malignancy
- Describe the location, irregularity, texture etc.

THYROID NODULE CHARACTERISTICS

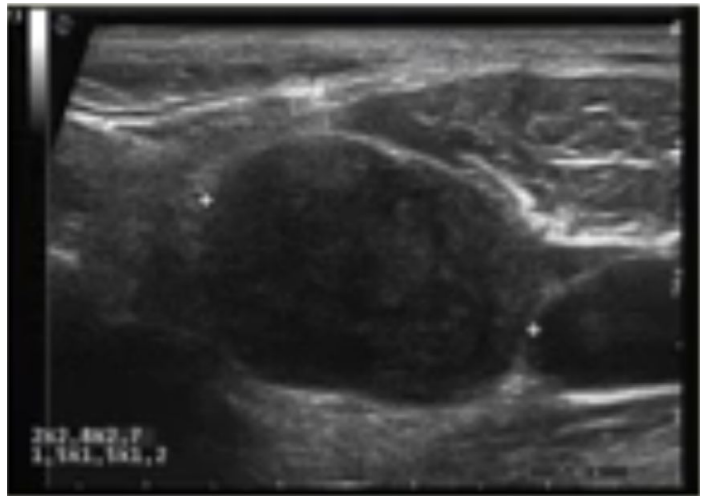
- Other relevant sonographic patterns, peripheral vascularity and Color Doppler

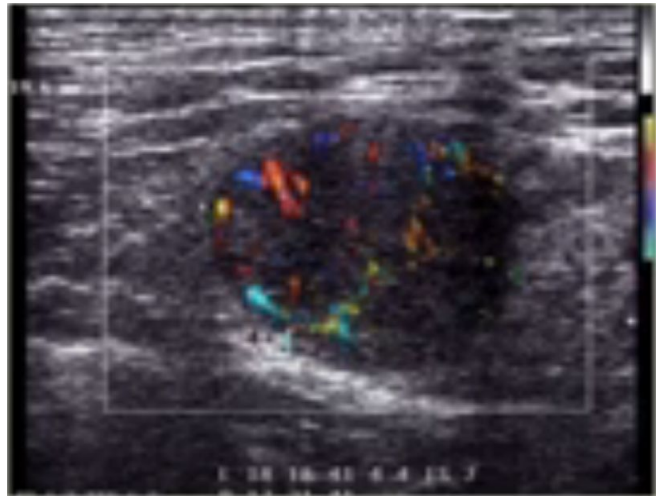


- Confirming malignancy through Color Doppler
- Lesion presenting with central vascularity.
- Check in all 3 dimensions

THYROID NODULE CHARACTERISTICS

- The presence and size of any abnormal lymph node in the lateral compartment of the neck

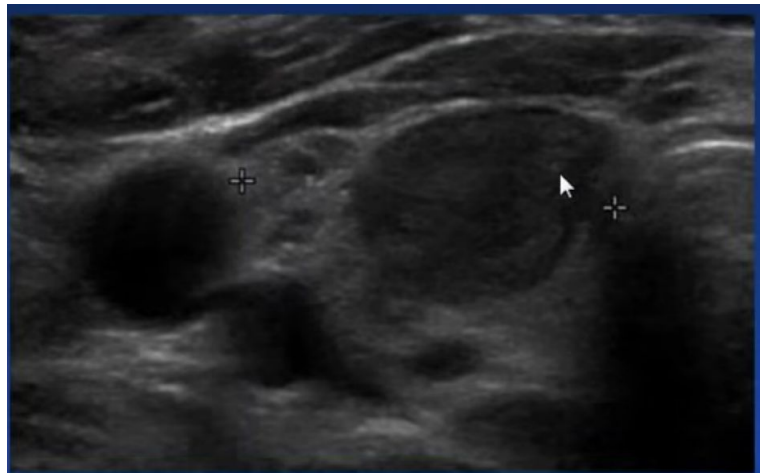




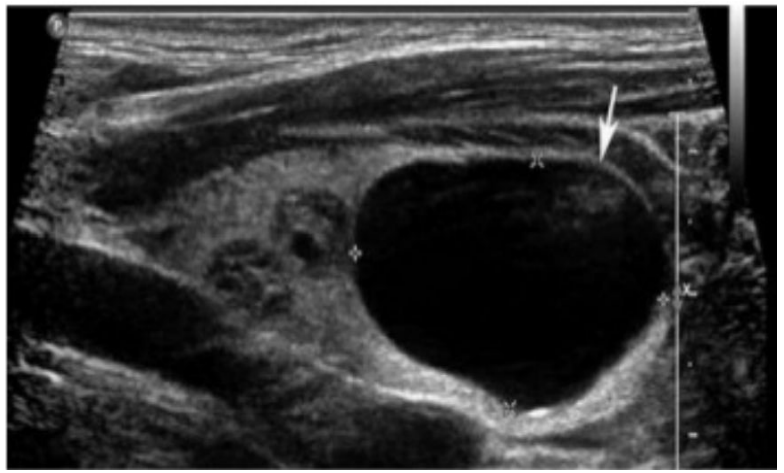
- Oval/Round shaped not regular
- With marked vascularity inside and outside
- Indicating Malignancy

THYROID NODULES : MALIGNANT FEATURES

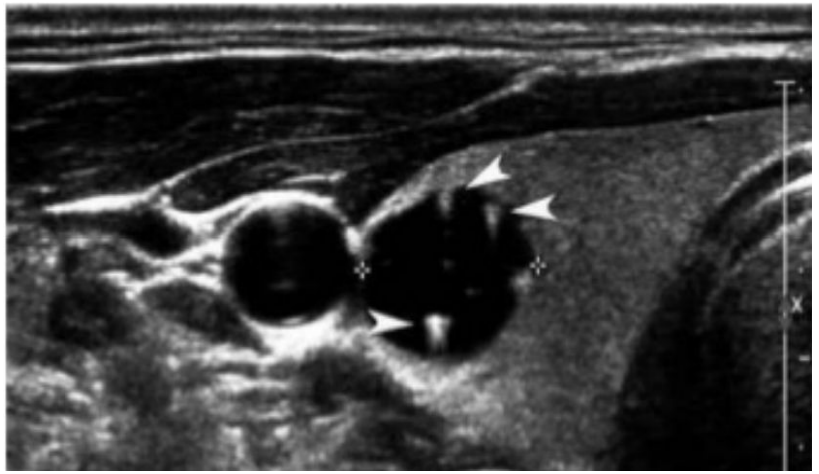
US patterns	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Microcalcifications	6.1–59.1	85.8–95.0	24.3–70.7	41.8–94.2
Hypoechogenicity	26.5–87.1	43.4–94.3	11.4–68.4	73.5–93.8
Irregular margins or no halo sign	17.4–77.5	38.9–85.0	15.6–27.0	88.0–92.1
Solid	26.5–87.1	43.4–94.3	11.4–68.4	73–93.8
Intranodular vascularity	54.3–74.2	78.6–80.8	24.0–41.9	85.7–97.4
Taller than wide	32.7	92.5	66.7	74.8



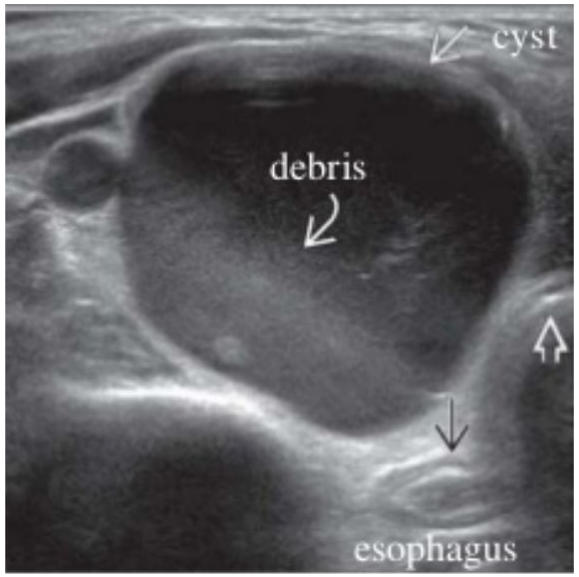
Follicular Carcinoma



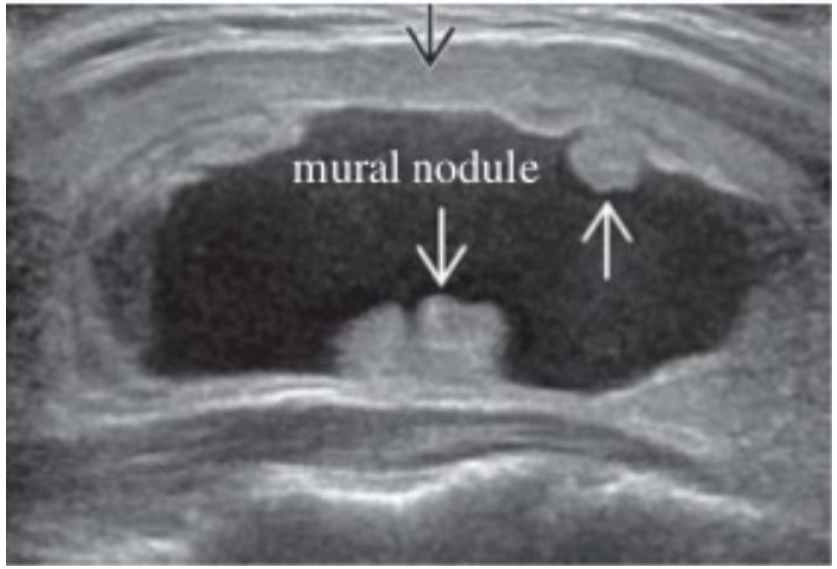
Completely Cystic



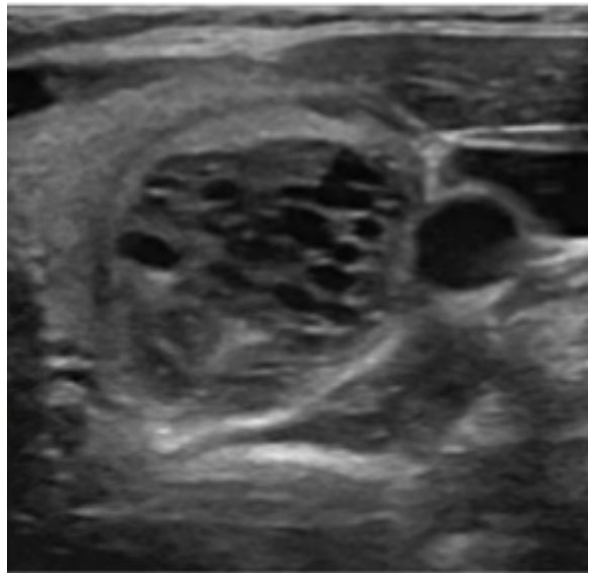
Colloid Cyst



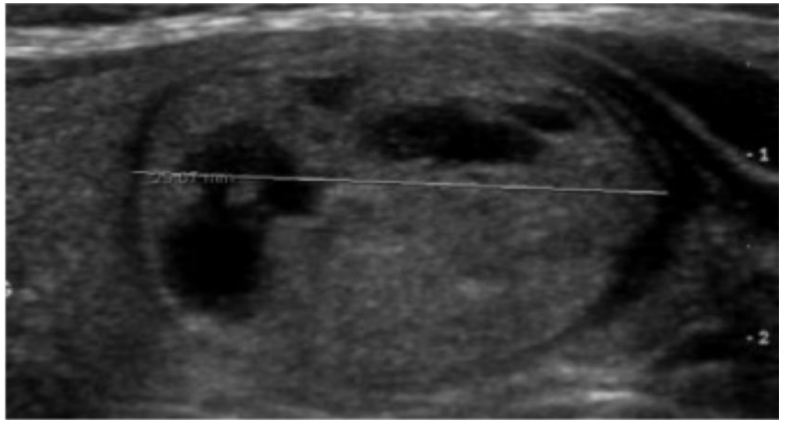
Hemorrhagic Cyst



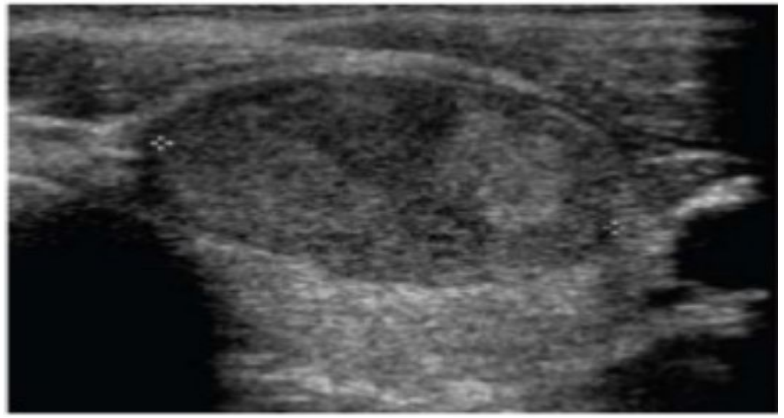
Hemorrhagic Cyst

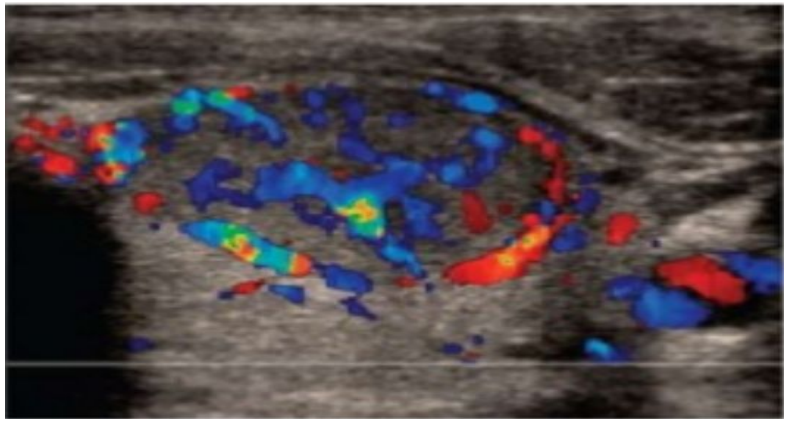


Spongiform / Honeycomb



Predominantly Solid





Papillary Thyroid Carcinoma

ADVANTAGES AND DISADVANTAGES OF ACR TI-RADS

Advantages

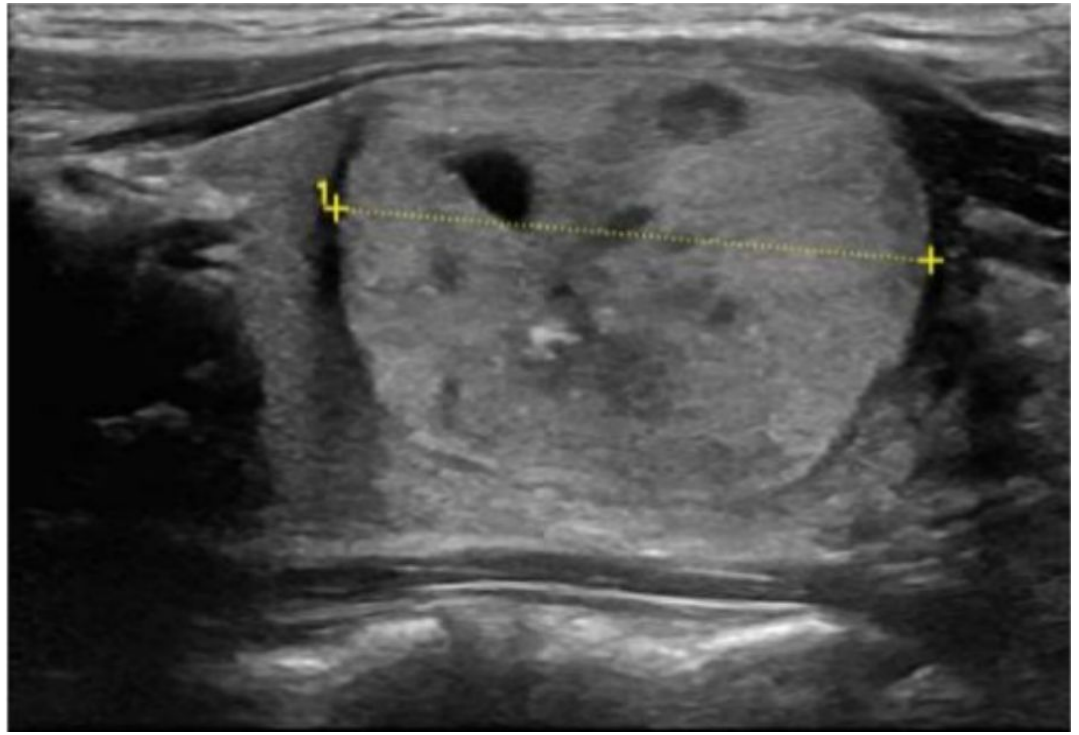
- Standard terms for ultrasound reporting.
- Able to classify almost all thyroid nodules.
- Evidence based to the greatest extent possible.

Disadvantages

- High size threshold for FNA in mild and moderate suspicious lesions,
- Doesn't take into consideration - thyroid nodule vascularity
- Doesn't take into consideration - Elastography

EXAMPLE CASE - 1

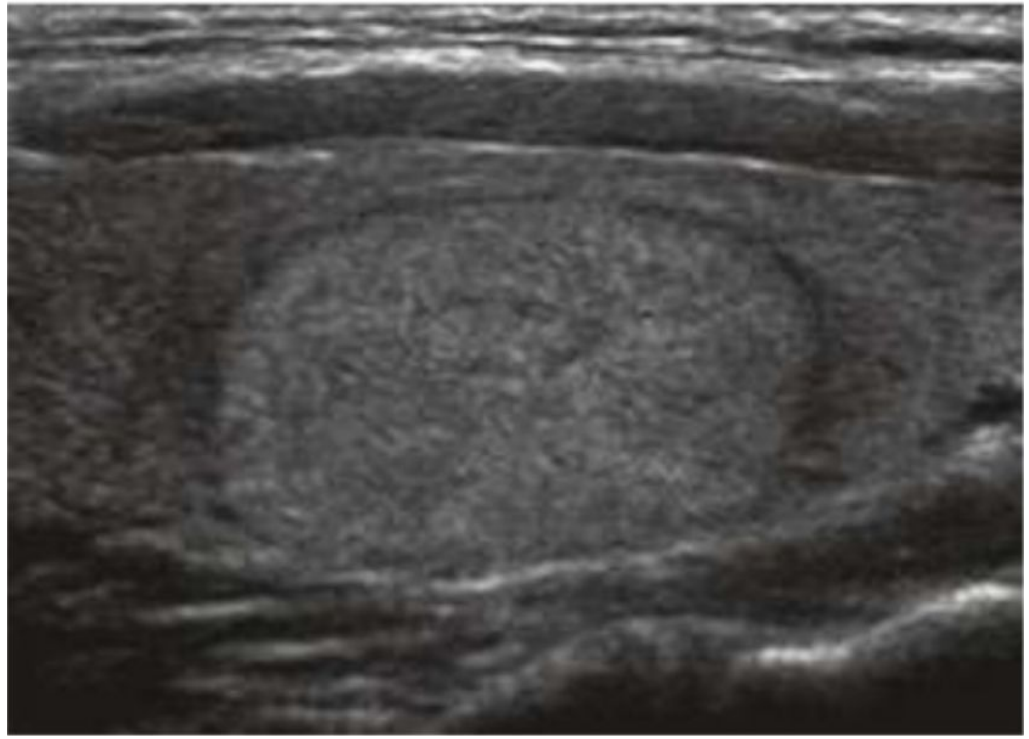
- Almost completely solid (2 points)
- Hyperechoic nodule (1 point)
- Wider than tall (0 point)
- Smooth margin (0 Point)
- No calcification (0 point)
- Total : 3 points
- ACR TR3
- Mildly suspicious – FNA if more or equal to 2.5cm



CHART

EXAMPLE CASE - 2

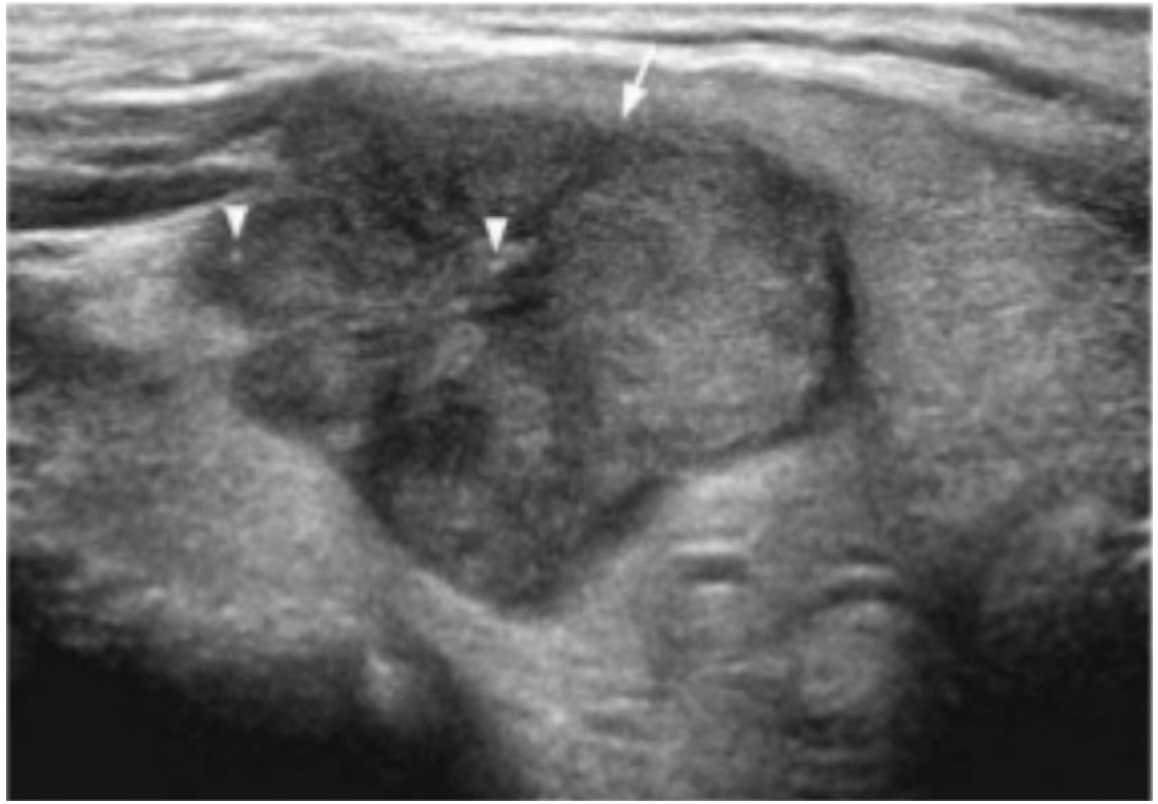
- Completely solid (2 points)
- Hyperechoic (1 point)
- Smooth margin (0 point)
- Wider than tall (0 point)
- No echogenic foci/micro-calcification. (0 point)
- Total - 3 points
- ACR TR3
- Mildly suspicious – FNA if more or equal to 2.5cm



CHART

EXAMPLE CASE - 3

- Completely solid (2 points)
- Hyperechoic (1 points)
- Lobulated margin (2 points)
- Taller than wide (3 points)
- Micro-calcifications/echogenic foci (3 points)
- Total - 11 points
- ACR TR5
- Highly suspicious – FNA if more or equal to 1.0 cm
- Papillary Carcinoma on FNA

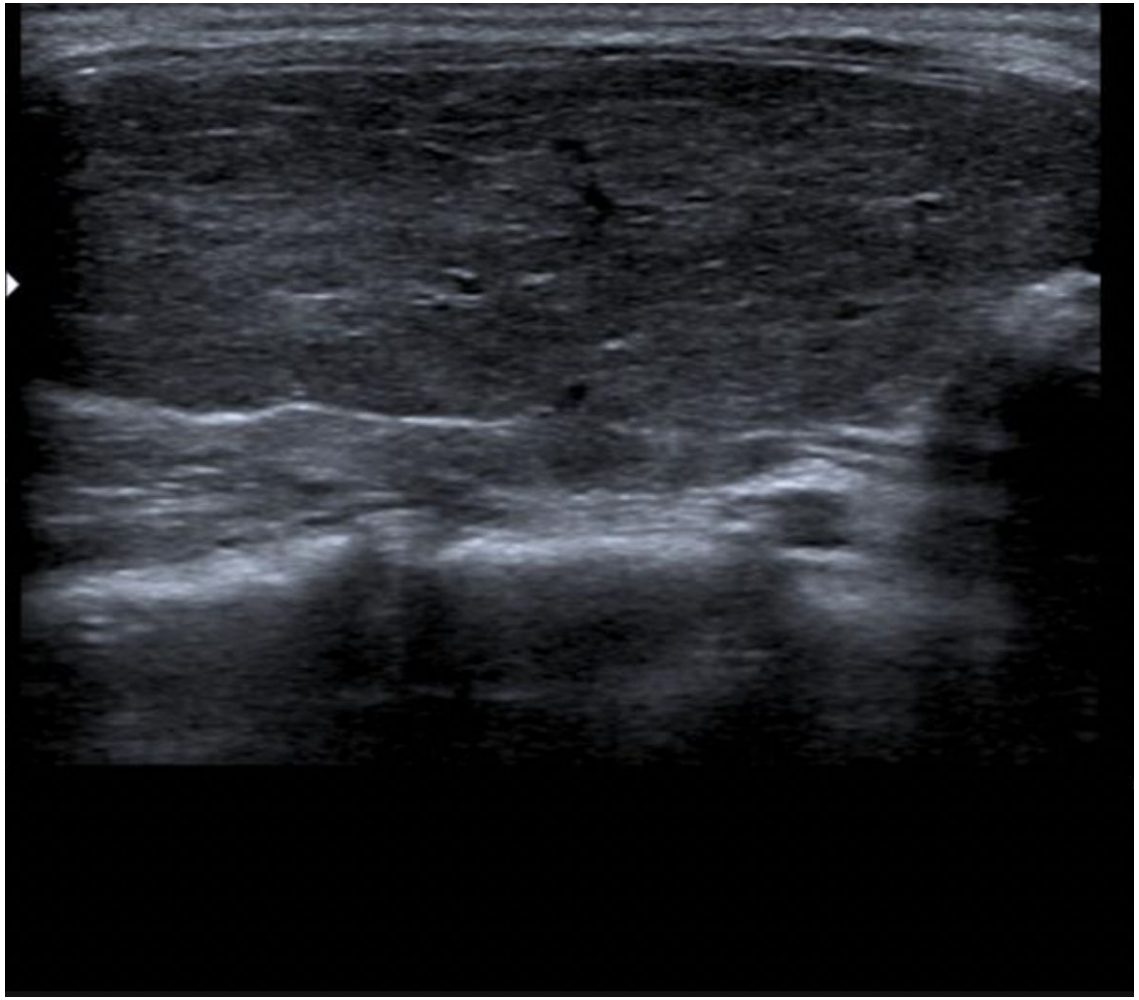


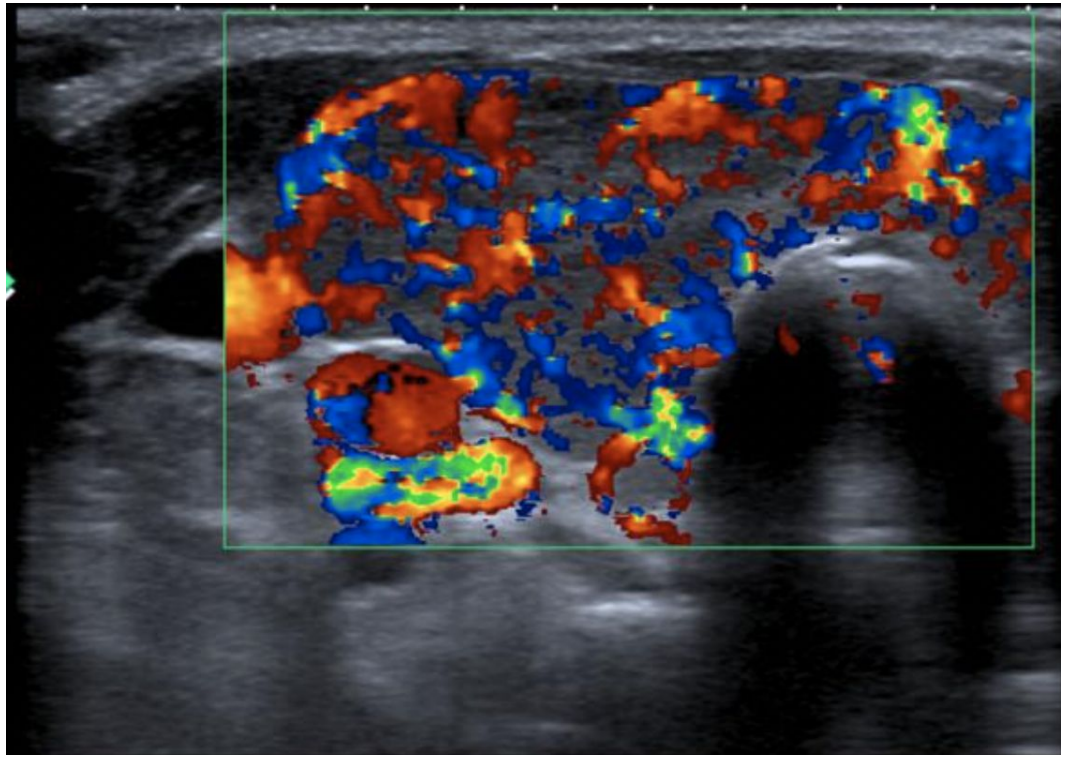
CHART

THYROID DISEASES: GRAVES DISEASE

- Is an autoimmune thyroid disease.
- It is the most common cause of hyperthyroidism.
- The gland is usually enlarged by x2 to x3 of its normal size, and is usually homogenously hypoechoic.
- Doppler US will show diffuse increased vascularity with multiple areas of intense intrathyroid flow, called “Thyroid inferno”.

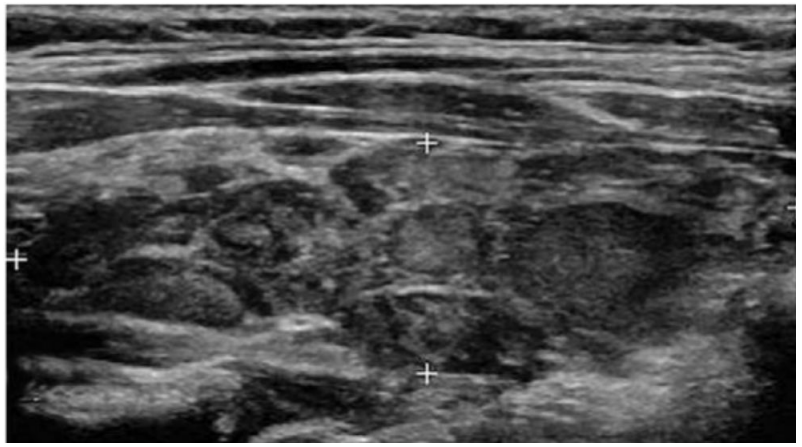
GRAVES DISEASE

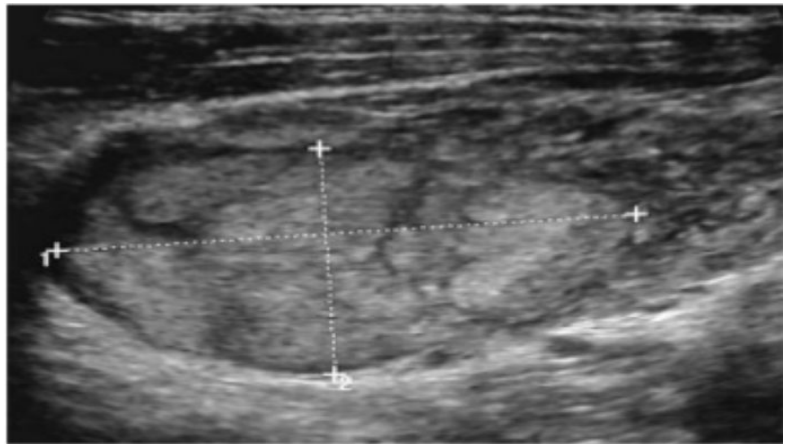


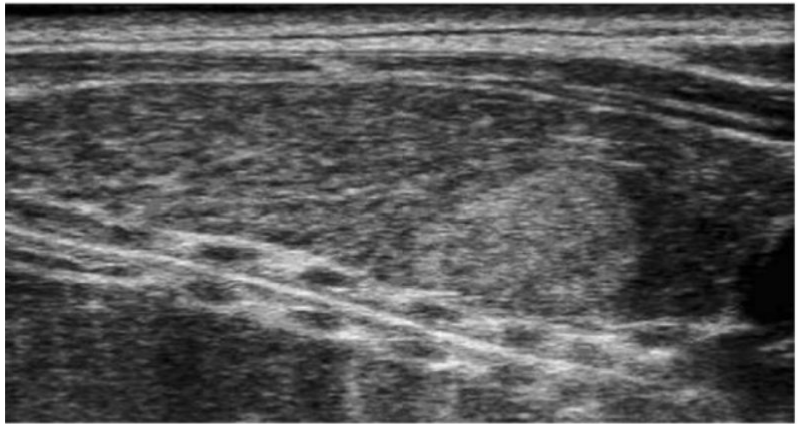


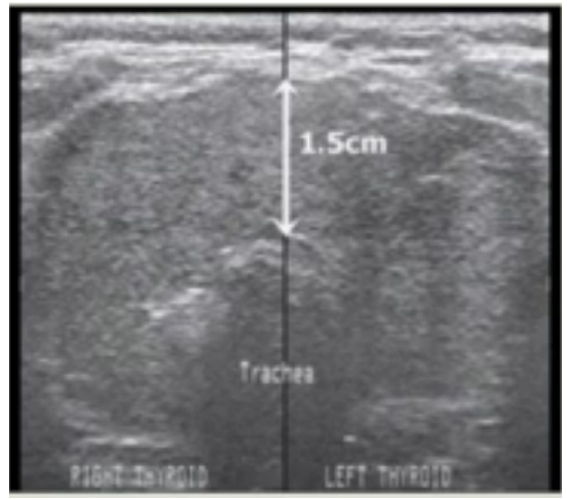
THYROID DISEASES : HASHIMOTO'S THYROIDITIS

- Causes hypo/hyper thyroidism
- Enlarged heterogenous gland.
- Presence of Pseudo-nodules
- Vascularity may be normal or decreased.
- Increased risk of (Hashimoto)
  - Papillary thyroid carcinoma
  - Thyroid lymphoma



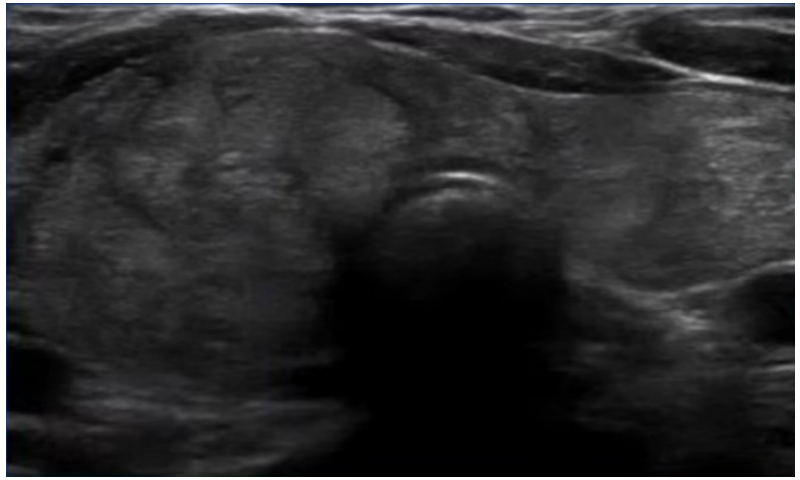


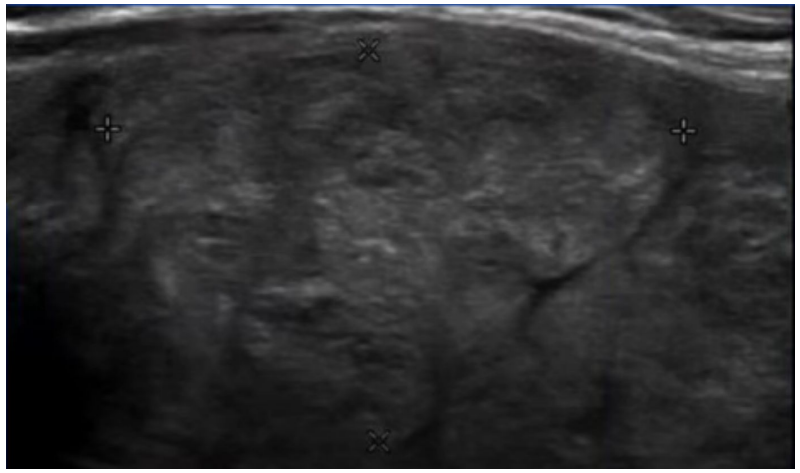




THYROID DISEASES : MULTINODULAR GOITER (MNG)

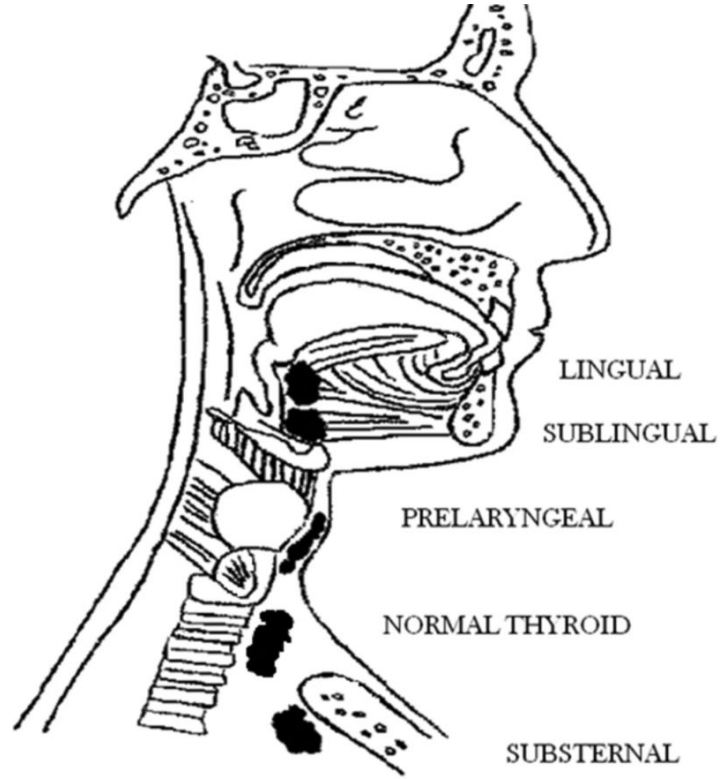
- MNG is an enlarged gland with multiple nodules that maybe hypo or hyper functioning (Toxic MNG)
- Iso-hyperechoic
- Surrounding hypoechoic halo
- Spongiform/honeycomb pattern
  - anechoic areas may contain colloid fluid which may show echogenic foci with comet tail artifacts
- Peripheral (eggshell) or coarse calcifications
- Doppler: peripheral vessels are usually noted, may show intranodular vascularity (mostly in hyperfunctioning nodules)





THYROID DISEASES : ECTOPIC THYROID

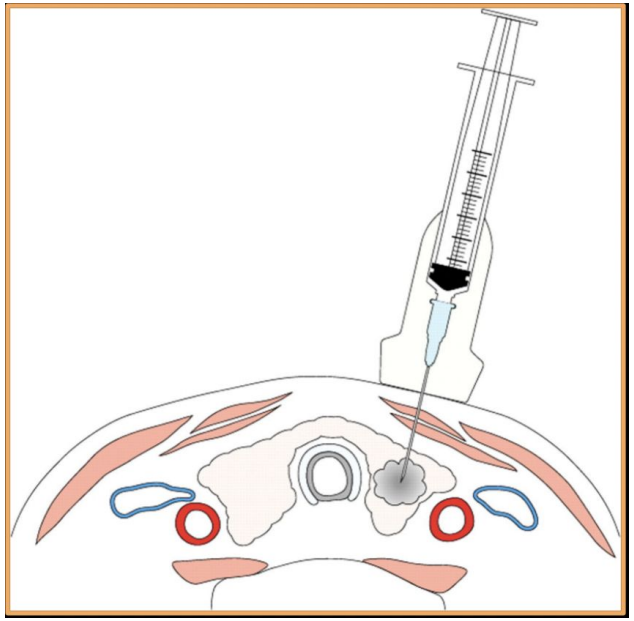
- Can be found anywhere in the central neck compartment, including esophagus, trachea and anterior mediastinum
- Lingual : Most common (90%)
- Imaging is performed to demonstrate absent thyroid tissue in the normal location.

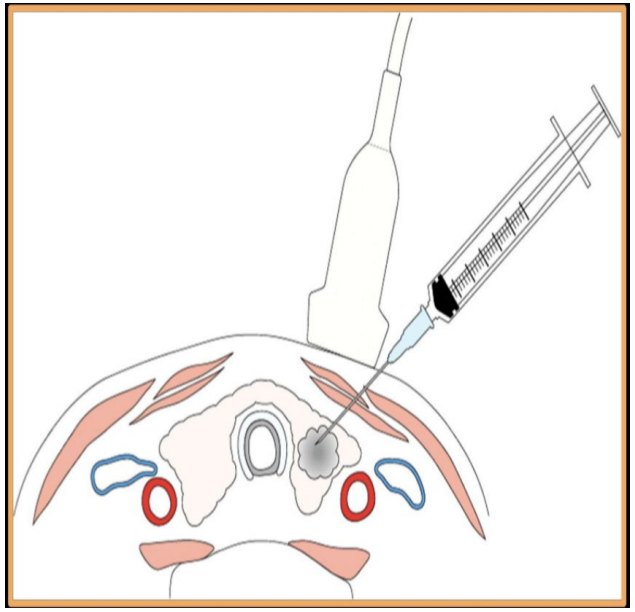


Distribution of heterotopic thyroid tissue.

FINE NEEDLE ASPIRATION

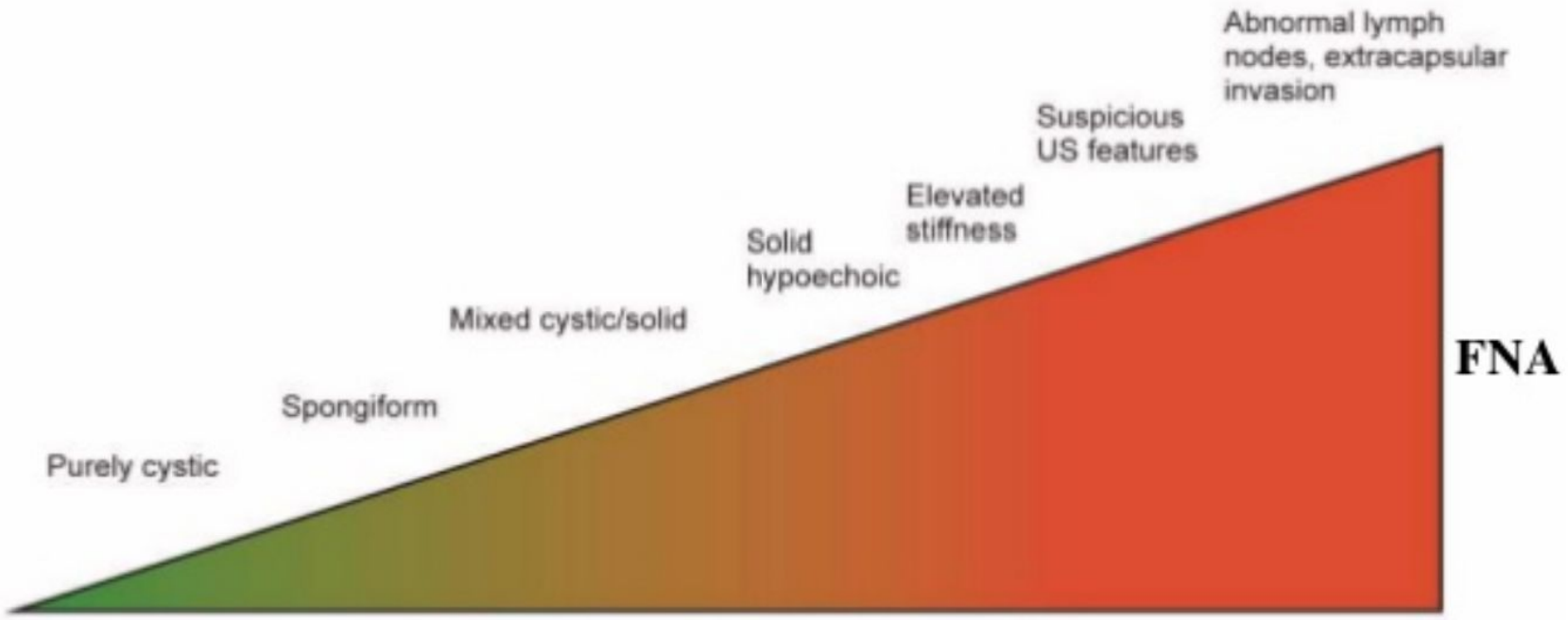
- FNA is a minimally invasive tissue sampling procedure, usually done under ultrasound guidance.
- It can be done under Fluoroscopy, CT , or MRI.
- Technique: The needle may be introduced parallel or perpendicular to the transducer, and the needle tip should be carefully monitored during the procedure.





FNA – FINE NEEDLE ASPIRATION

Indications for FNA according to US findings



Diagram

FNA – FINE NEEDLE ASPIRATION

Indications of FNA in ACR TI-RADS

- TR3 (mildly suspicious nodules): if they are **≥ 2.5 cm**
- TR4 (moderately suspicious nodules): if they are **≥ 1.5 cm**
- TR5 (highly suspicious nodules): if they are **≥ 1 cm**
- No FNA of nodules **< 1 cm** even if they are highly suspicious

  This is in concordance with other guidelines

  FNA of **5-9 mm** nodules may be done in certain conditions:

  Shared decision making between referring physician and patient

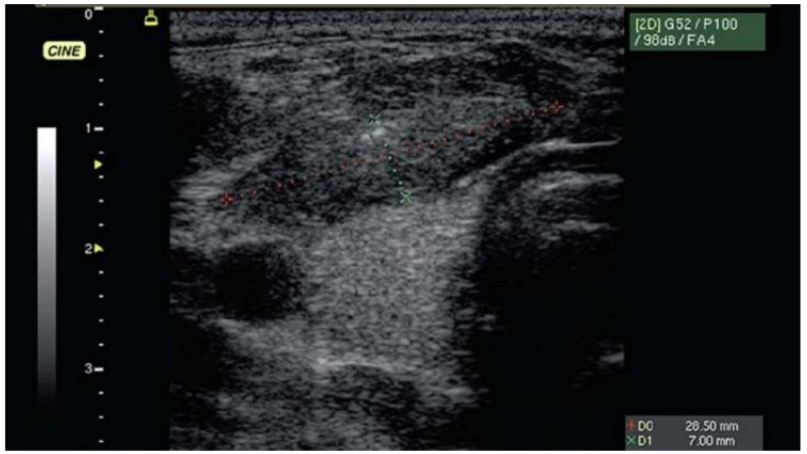
Advantages	Inexpensive, widely available, easy to perform, accurate (>90%) and cost-effective
Disadvantages	Depends on skill of operator & cytopathologist
Complications	Rare – no reported case of cutaneous implantation of malignancy following FNA
False negative rate	0.5 – 11.8% (pooled rate 2.4%)
False positive rate	0 – 7.1% (pooled rate of 1.2%)
Non-diagnostic rate	Vary among different centers 5% is the maximum acceptable limit

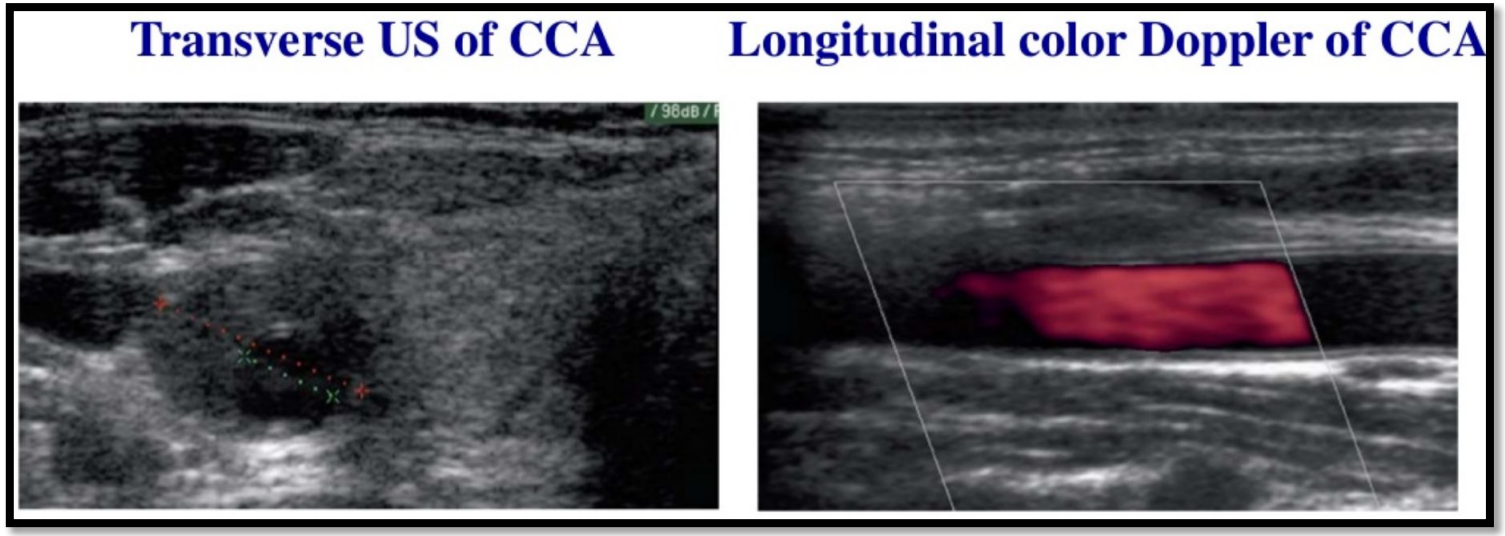

1.28 cm
1.29 cm
Trans Right Thyroid Mid


Trans Right Thyroid Mid FNA

COMPLICATIONS OF FNA

- Hematoma
- Injury of CCA
- Injury of IJV
- Nerve puncture
- Trachea puncture
- Esophageal puncture





RFA (RADIO FREQUENCY ABLATION)

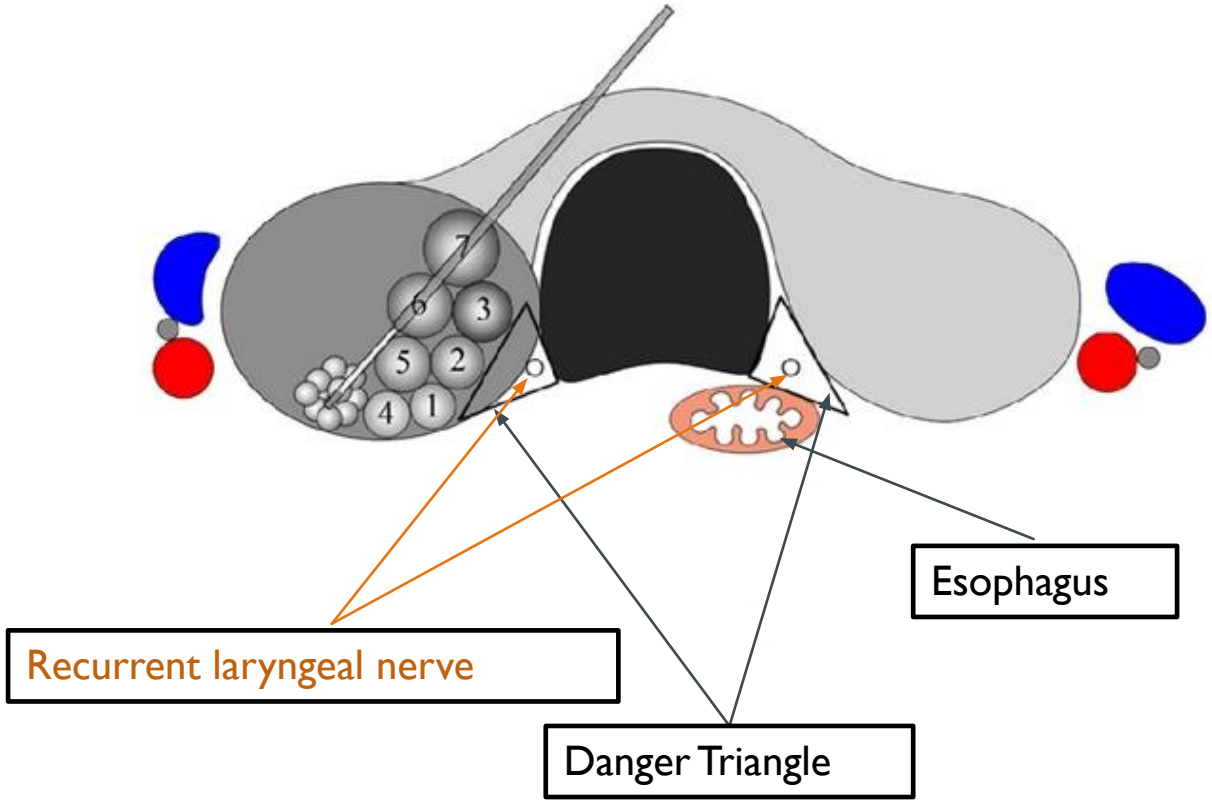
- **Radiofrequency ablation**, or RFA, is a minimally invasive technique that shrinks the size of tumors, nodules or other growths in the body.
- RFA is used to treat a range of conditions, including benign and malignant tumors, chronic venous insufficiency in the legs, as well as nerve ablation(chronic back and neck pain).
- The procedure is similar to a needle biopsy, and involves inserting a needle-like probe into the body.
- Radiofrequency waves are sent out from the probe into the surrounding tissue, which causes the nearby cells to heat up, thereby killing the cells. As these cells die, the immune system removes them, which causes an internal reaction and generally results in shrinkage of the nodule.

RFA (RADIO FREQUENCY ABLATION)

RFA (RADIO FREQUENCY ABLATION)

Procedure:

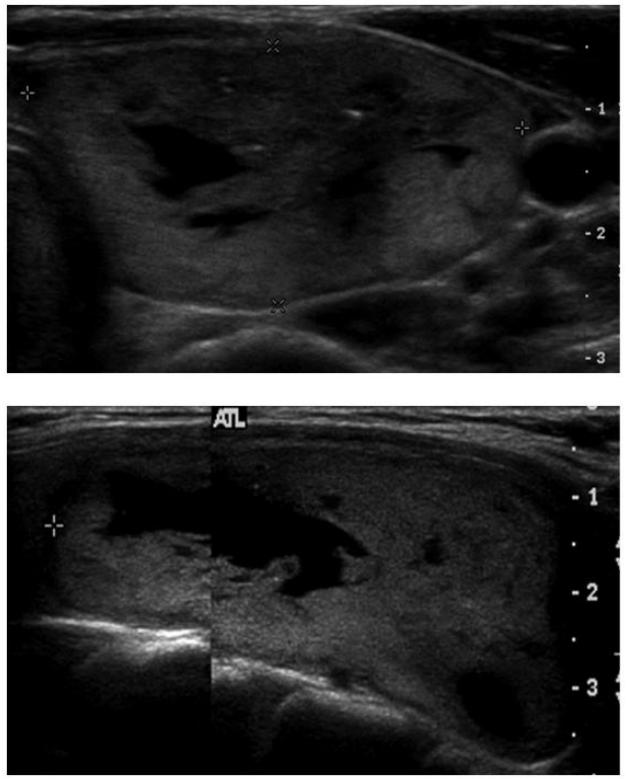
- Patient is placed in the supine position with mild neck extension.
- Trans-isthmic approach: the electrode is inserted from the isthmus to the lateral aspect of the targeted nodule.
- Minimal heat exposure to the danger triangle (which includes the recurrent laryngeal nerve and/or the esophagus).



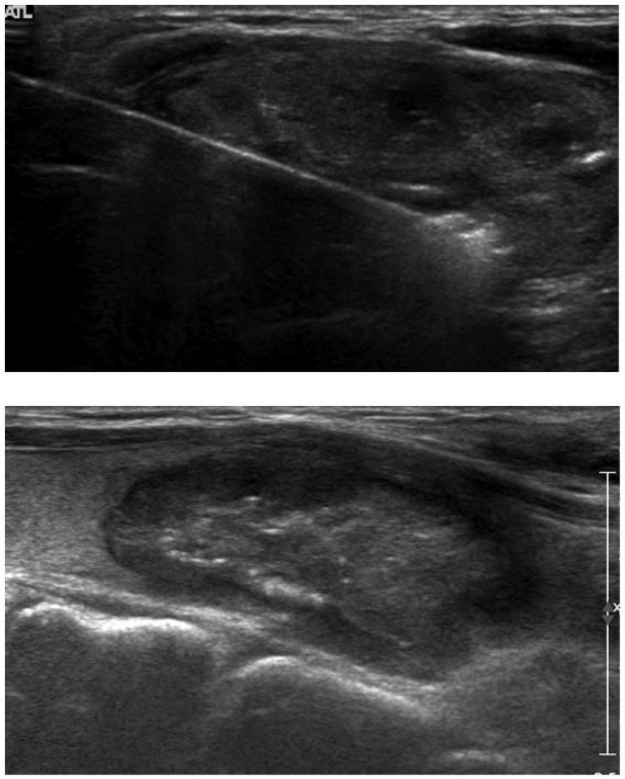
RFA (RADIO FREQUENCY ABLATION)

Before

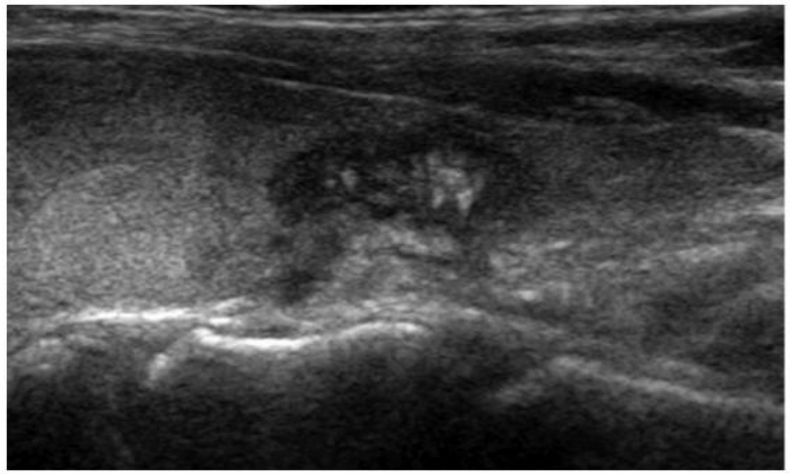
After (Shrinkage)



Predominantly solid nodule



Ablation of the periphery (Top) and center (Below)



SUMMARY

- US imaging plays a vital role in the diagnosis and management of thyroid and parathyroid diseases, especially in triage of thyroid nodule
- US elastography, US-guided FNA are actively under research to improve the diagnostic ability of the imaging modality in differentiating benign from malignant nodules, which can eventually reduce unnecessary biopsy and surgery.
- Thyroid RFA is an amazing minimally invasive, non-surgical treatment for undesirable thyroid nodules that can make surgery and radioactive iodine (RAI) obsolete for many patients with benign thyroid nodules. This procedure is a quick, safe option that enables patients to resume normal daily activity almost immediately with a minimal recovery period.

THYROID OPHTHALMOPATHY (GRAVES DISEASE)

- Clinical history:
- Slow onset (months), painless exophthalmos.

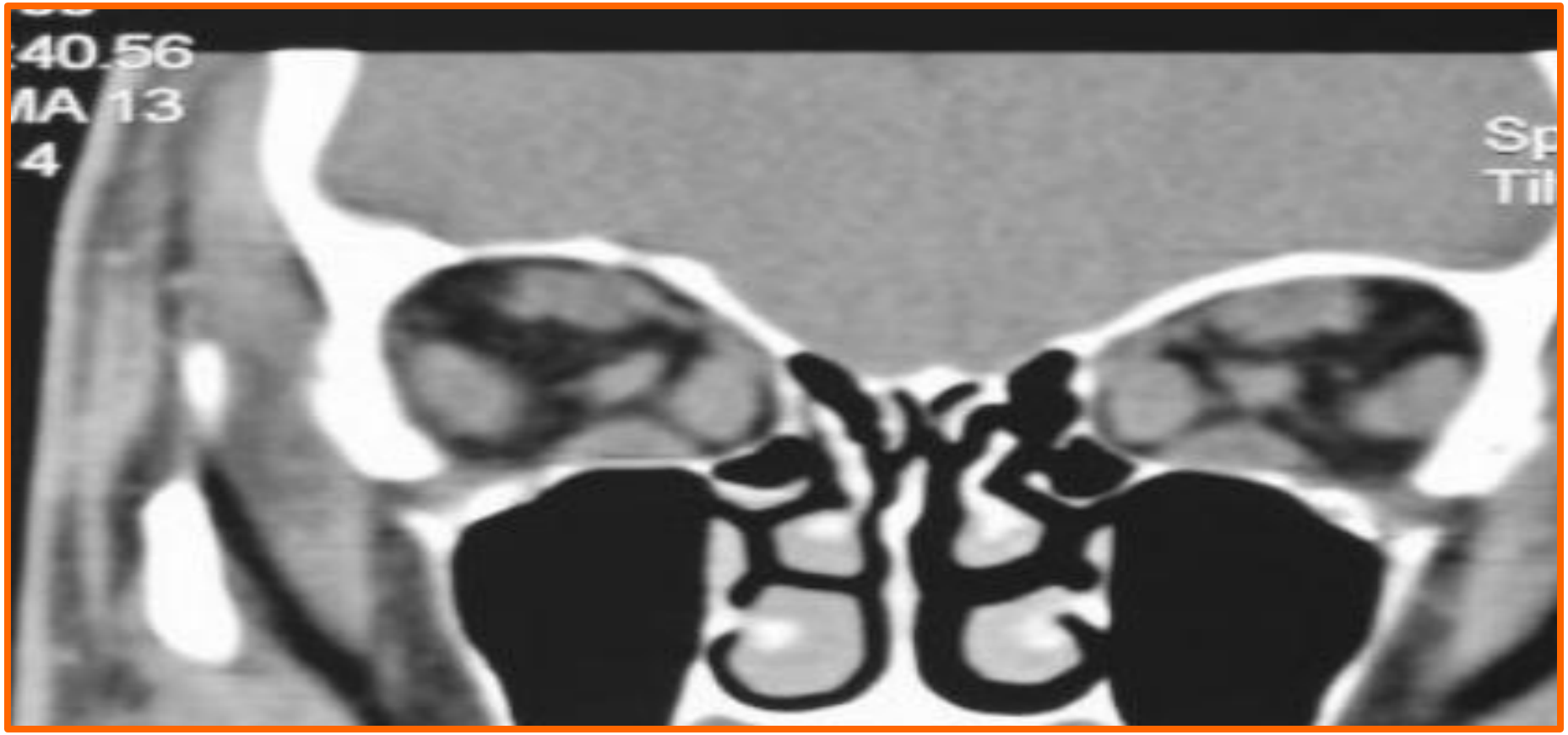
- Patterns of muscle involvement in thyroid opthalmopathy:
  1. Bilateral (85%)
  2. Unilateral (5%)
  3. Normal muscles (10%)

- ALL muscles involved is most common scenario of extraocular muscle enlargement.

- If only individual muscles involved, ~~commonly~~ Inferior then Medial recti muscles

- Lateral rectus muscle: last to become involved; rarely/never the only muscle involved
- I'M SLOW (Inferior, Medial, Superior , Lateral)
- Muscle enlargement characteristically involves the body of the muscle, sparing the tendinous attachment to the globe.

- Patients need not be hyperthyroid (some are euthyroid).
- Coronal imaging is the method of choice for assessing muscle thickness

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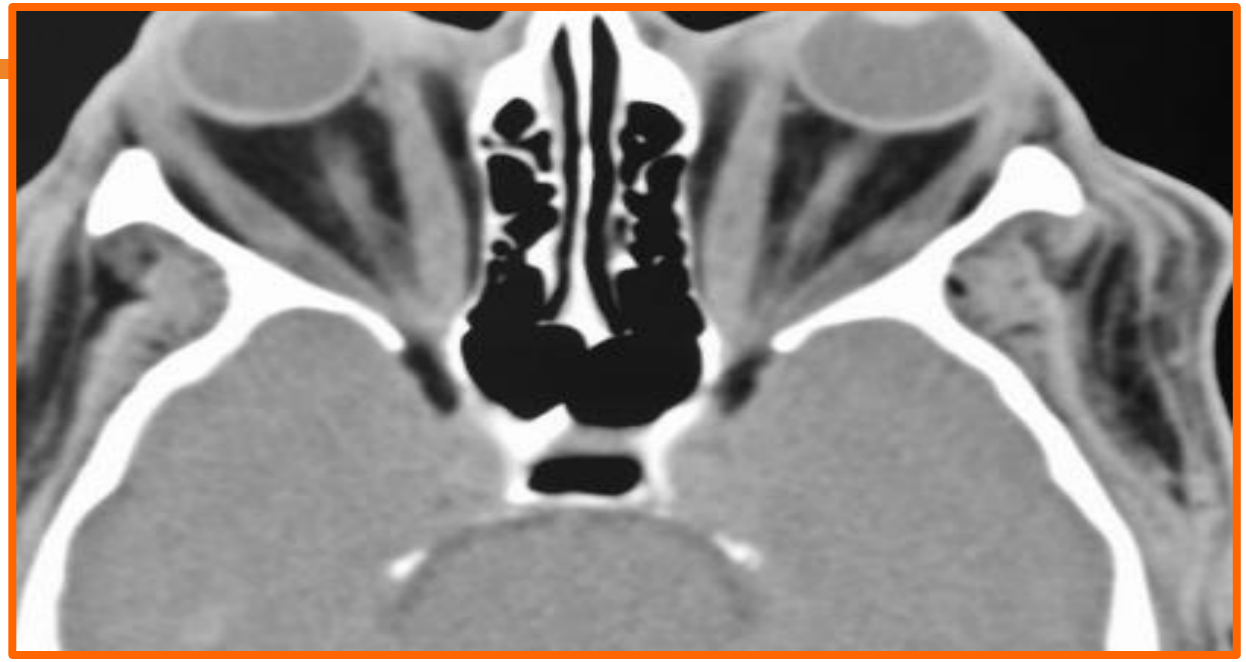

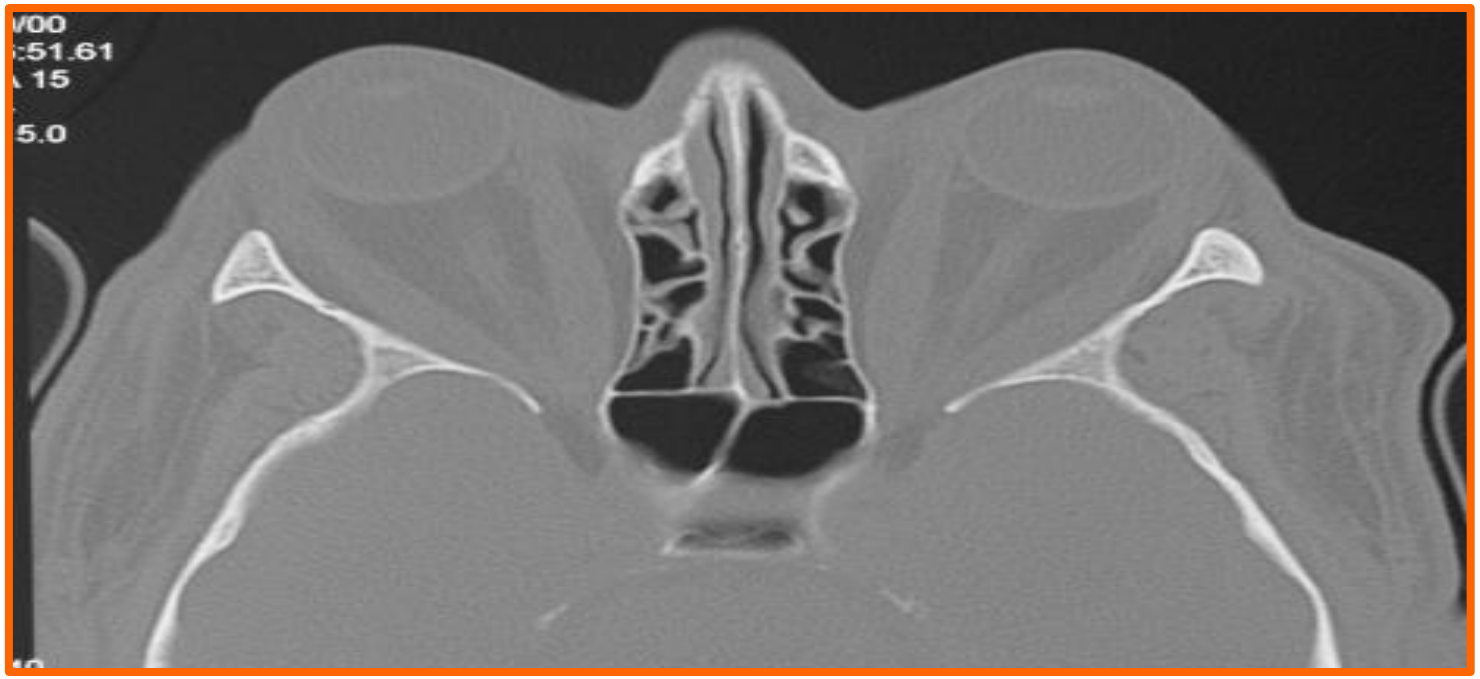
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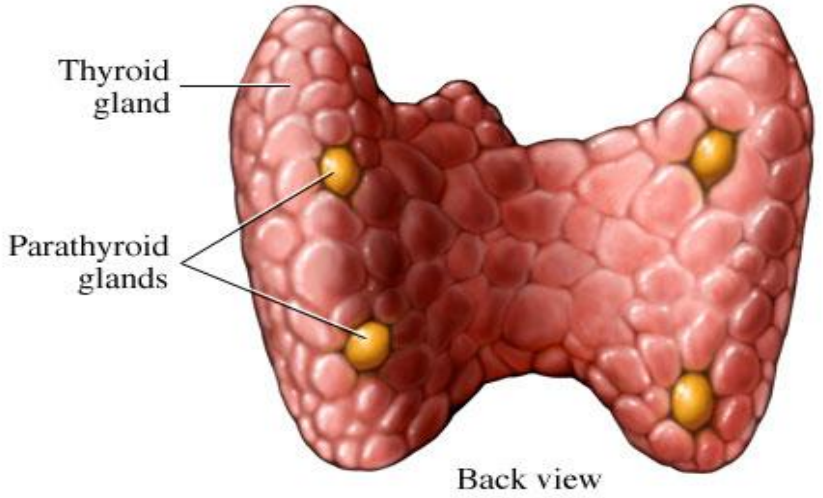
PARATHYROID GLAND

- Anatomy:
- Typically 4 parathyroid glands (Superior and Inferior) parathyroid glands.
- Two pairs of glands usually positioned behind the left and right lobes of the thyroid.
- The 2 Superior parathyroid are slightly more medial than the 2 inferior one.
- Typically they are symmetric.



RENAL OSTEODYSTROPHY

- Seen in setting of chronic, end-stage renal disease.
- Related to combination of :

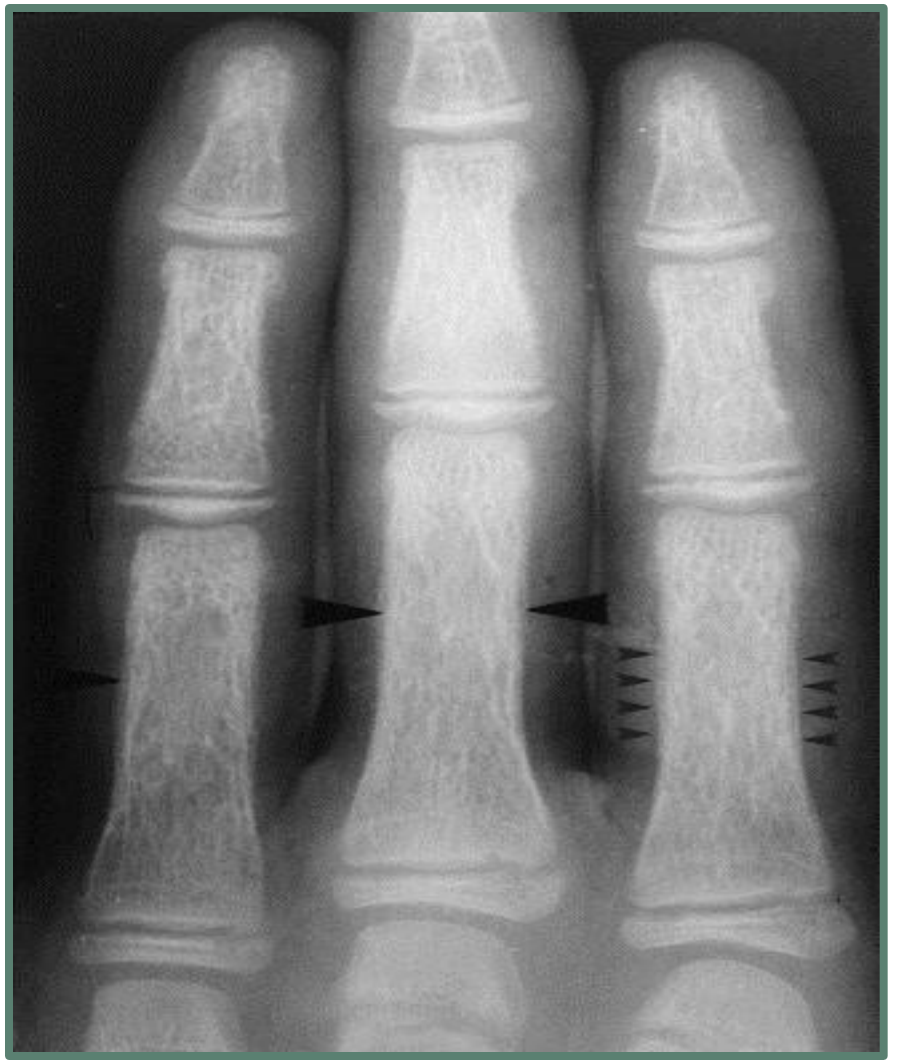
1. Osteomalacia.
2. Secondary hyperparathyroidism
   - Bone resorption mainly (Sub-periosteal)
   - Cortical thinning.
   - Soft tissue and vascular calcifications
   - Osteosclerosis
   - Brown tumors.

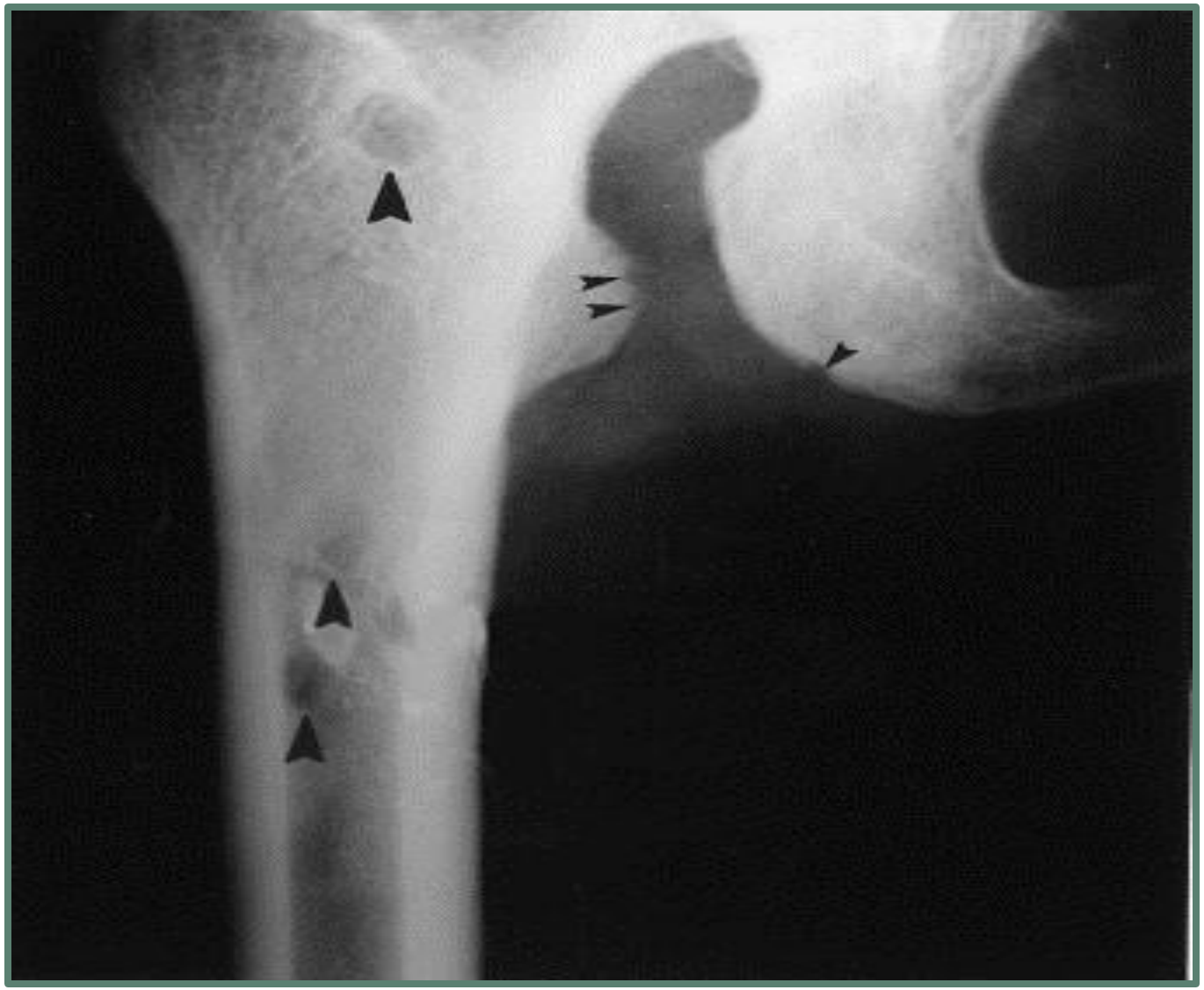
- Osteopenia is most common finding; however, 10-20% of patients also exhibit osteosclerosis.
- Characteristic finding of osteosclerosis is "Rugger jersey spine"

  Bands of hazy sclerosis that parallels the vertebral body endplates.
- Both axial and appendicular skeleton involved.
- Increased risk for pathologic fracture.


R

Typical subperiosteal bone resorption at the radial aspects of the middle phalanges with bone resorption at the margins of the distal interphalangeal joints.





Thank you!