



431

Radiology Team

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Lecture 7: Imaging of Thyroid and Parathyroid Diseases



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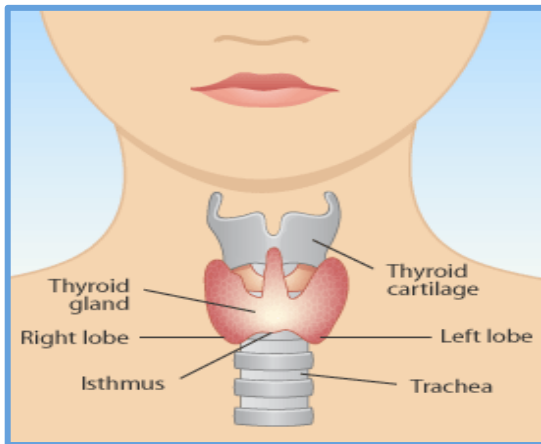
◆ Important

◆ Doctor's notes

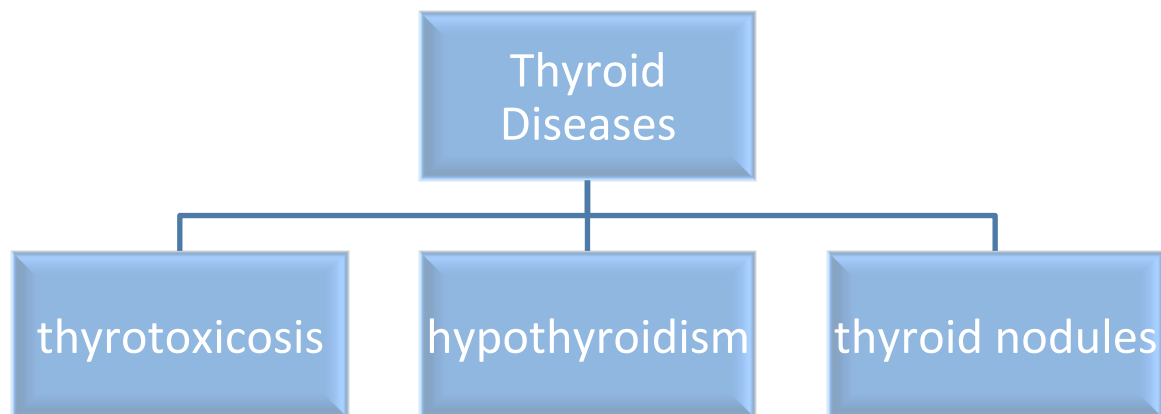
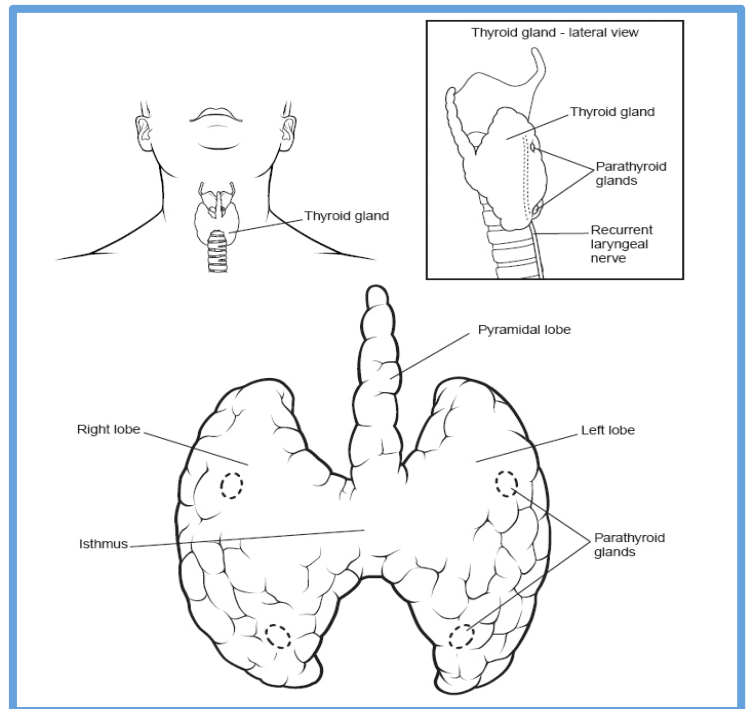
◆ Team's notes

Imaging of Thyroid & Parathyroid Disease

Anatomy of the Thyroid Gland



- Anterior neck
- Extending from the level of **C5 - T1**
- Overlays **2nd - 4th** tracheal rings
- Average height: **50-60 mm** long
- Average width: **12-15 mm (each lobe)**



Thyrotoxicosis versus Hyperthyroidism

- Hyperthyroidism:

A group of symptoms and signs due to increased production of thyroid hormones by hyper functioning thyroid gland.

- Thyrotoxicosis:

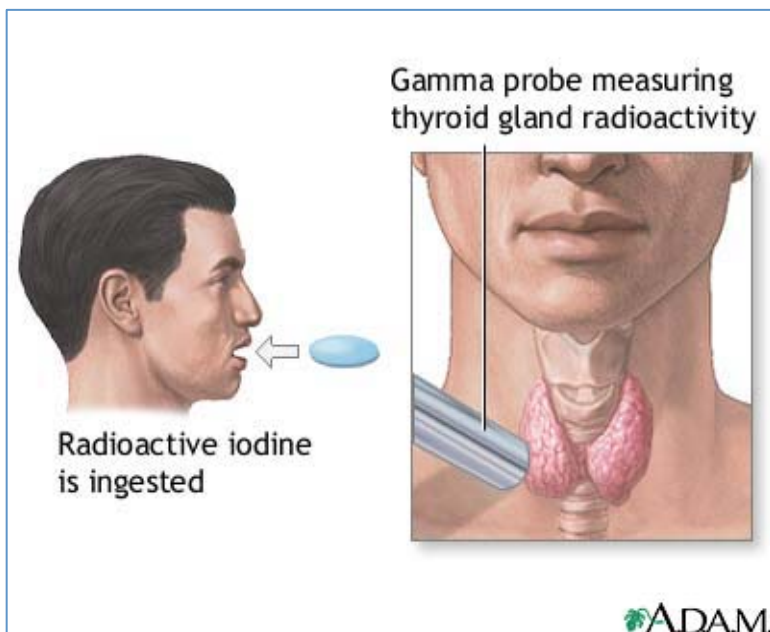
A group of symptoms and signs due to elevated thyroid hormones in the body of any cause.

Causes of Thyrotoxicosis

- Hyperthyroidism
 - 1- Diffuse toxic goiter (Graves' disease).
 - 2- Single toxic nodule.
 - 3- Multi-nodular toxic goiter.
- Early phase sub-acute thyroiditis.
- Exogenous thyroid hormone intake.

TFT and Thyroid scan

- Thyrotoxicosis = suppressed TSH and elevated T3/T4.
- Based on TFT, the exact cause of thyrotoxicosis cannot be determined.
- **Thyroid scan** is a very helpful tool in **differentiating between various causes of thyrotoxicosis.**

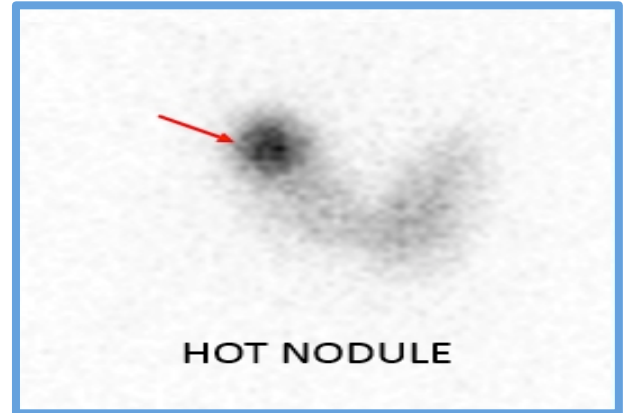
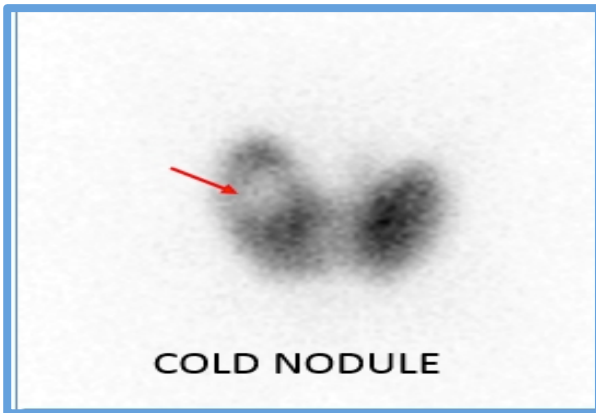


Thyroid scan and uptake

- **Radioactive Iodine (RAI)** is used for thyroid scan and uptake.
- RAI is given **orally**.
- Image and uptake are obtained after **24 hours**
- This test determines how much of orally ingested iodine accumulated in the thyroid at 24 hours

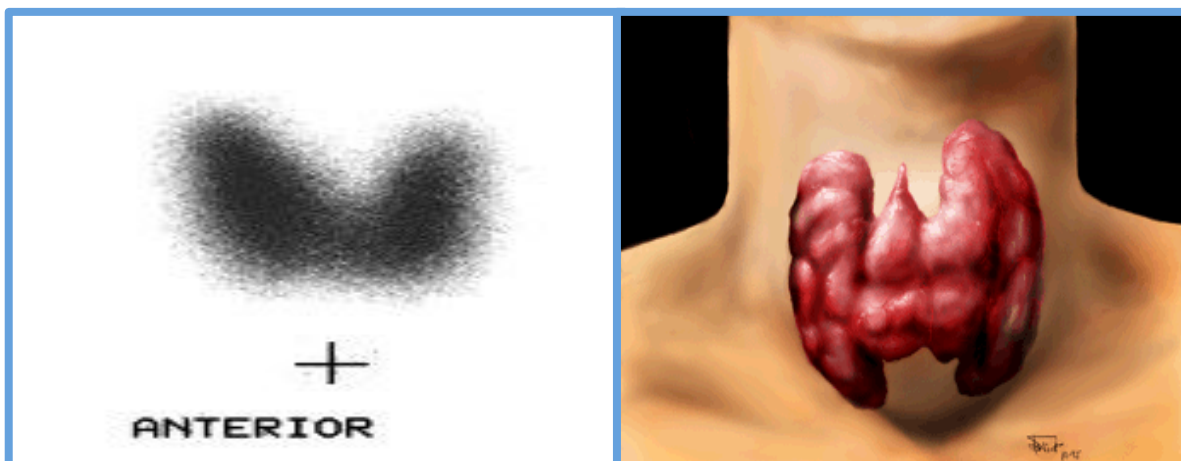
Imaging Findings

- Symmetric or asymmetric uptake.
- Homogeneous or inhomogeneous uptake.
- Nodules: Cold or Hot



1) Diffuse Toxic goiter (Graves' Disease)

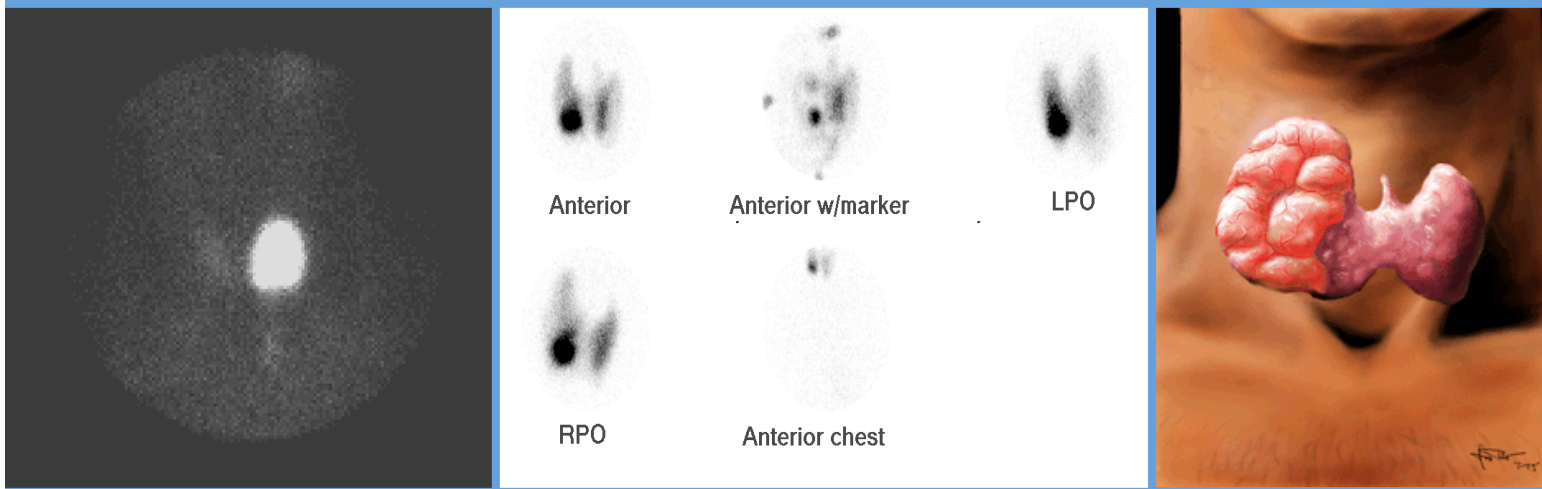
- **Diffuse enlargement** of thyroid gland.
- **Homogeneous** uptake.
- No significant focal abnormalities (nodules).
- 24-hour RAI uptake is **elevated**, usually > 35% (mean of 40%).



2) Single Toxic Nodule

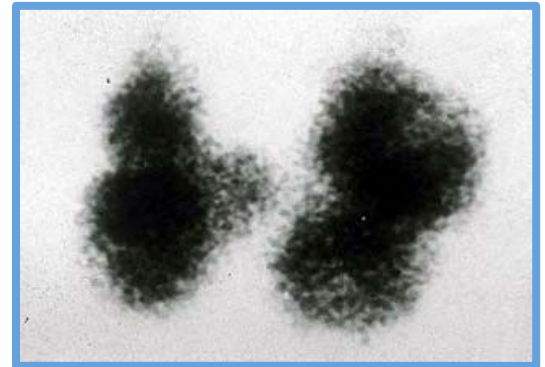
- Single hot nodule (independent of TSH or autonomous).
- Rest of thyroid gland is **poorly visualized** due to low TSH level (TSH dependent).
- 24-hour RAI uptake is **slightly elevated**, usually around 20%.

Toxic (Hot) Nodule



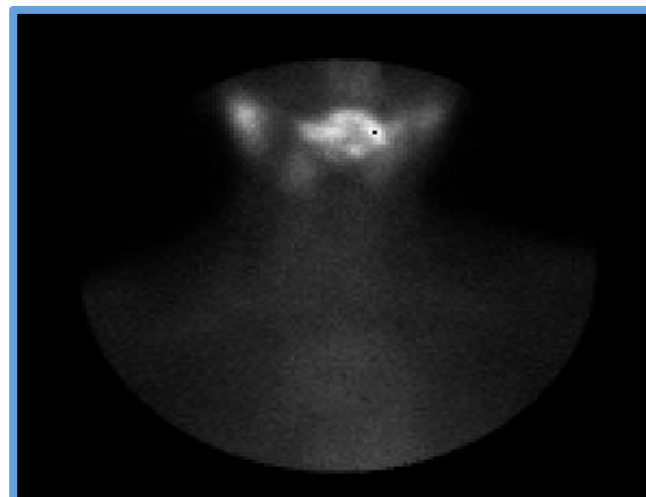
3) Toxic Multi-Nodular Goiter

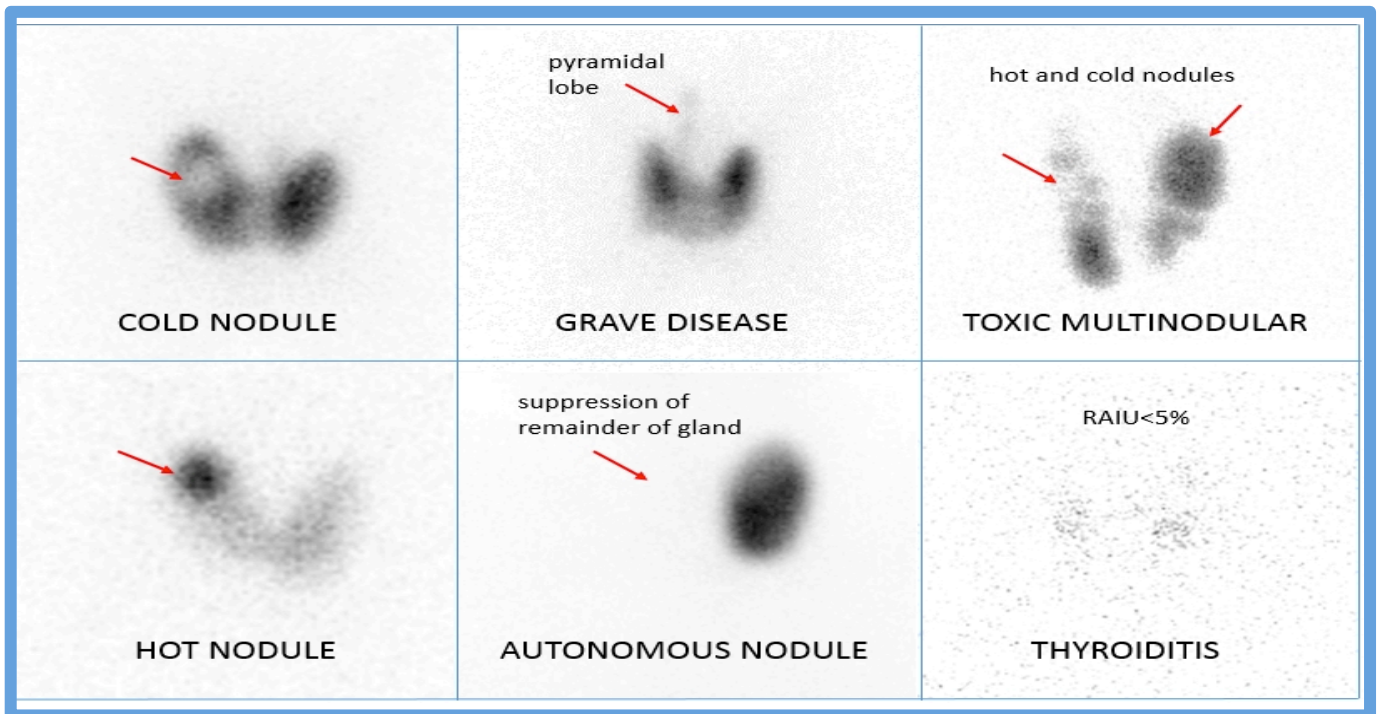
- **Mild inhomogeneous** uptake in thyroid gland.
- **Multiple cold and hot nodules** in **both** thyroid lobes.
- 24-hour uptake is **mildly elevated**, usually between 20%-30%.



Early Phase Sub-acute Thyroiditis

- **Inhomogeneous** uptake could be mild or severe. In some cases thyroid gland is not visualized.
- No significant focal abnormalities (nodules).
- 24-hour RAI uptake is **low**, usually < 5%.





Hypothyroidism

- The main cause is **chronic thyroiditis** (Hashimoto's thyroiditis).
- TSH is elevated.
- **Thyroid scan does not have significant diagnostic value** in this entity. Unless, there is nodule, thyroid scan may be helpful.

Thyroid Nodules

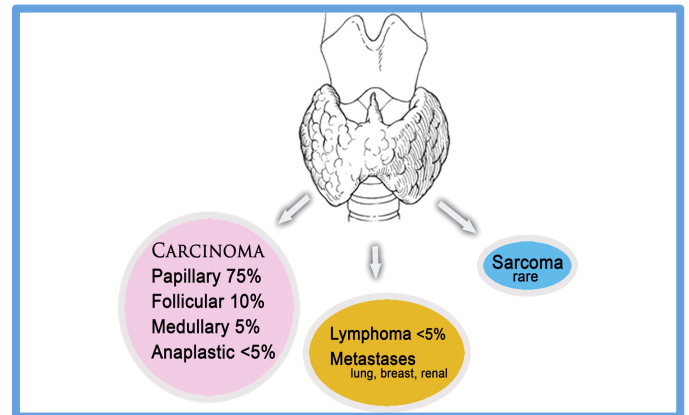
- Thyroid nodules are common, almost existing in half of the population.
- Nodules are usually found by physical examination or by ultrasound.
- **US is the first modality** used to investigate a palpable thyroid nodule.
- Scintigraphy is reserved for **characterizing functioning nodules** and for **staging follicular and papillary carcinomas**.
- The patient is usually **euthyroid (normal thyroid function)**
- If the patient is **hyperthyroid** do nuclear scan otherwise do FNA.
- **FNA is the most accurate and cost-effective method for diagnostic evaluation of thyroid nodules.**
- FNA have **a sensitivity of 76%–98%, specificity of 71%–100%**

Thyroid Malignancies

Risk Factors for Thyroid Cancer

- Family history of thyroid cancer.
- History of head and neck irradiation.
- Male Gender.
- Age of less than 30 years or more than 60 years.
- Previous diagnosis of type 2 Multiple Endocrine Neoplasia

Frequency of Occurrence of Thyroid Malignancies



US features of thyroid nodules

- There is some overlap between the US appearance of benign and malignant nodules.
- Certain US features are helpful in differentiating between the two.

The malignant features include:

1. Micro-calcifications.
2. Local invasion.
3. Lymph node metastases.
4. A nodule that is taller than it is wider.
5. Markedly reduced echogenicity (hypo-echoic=black).

The most important topic of this lecture

Other less specific features of malignant nodules which may be useful, such as:

1. Absence of a halo.
2. Ill-defined irregular margins.
3. Solid composition.
4. Vascularity

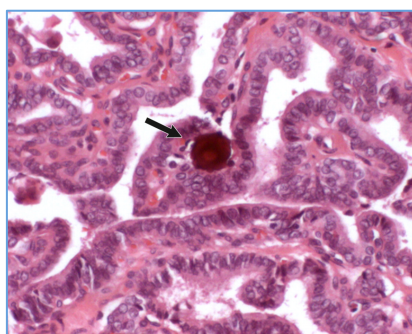
US Features Associated with Thyroid Cancer

US Feature*	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)
Microcalcifications (1–5)	26.1–59.1	85.8–95.0	24.3–70.7	41.8–94.2
Hypoechoogenicity (2–5)	26.5–87.1	43.4–94.3	11.4–68.4	73.5–93.8
Irregular margins or no halo (2–5)	17.4–77.5	38.9–85.0	9.3–60.0	38.9–97.8
Solid (4–6)	69.0–75.0	52.5–55.9	15.6–27.0	88.0–92.1
Intranodule vascularity (3, 6)	54.3–74.2	78.6–80.8	24.0–41.9	85.7–97.4
More tall than wide (2)	32.7	92.5	66.7	74.8

←————— Not important —————→

Thyroid microcalcifications

- They are psammoma bodies, which are 10–100- μm round laminar crystalline calcific deposits.
- They are **one of the most specific** features of thyroid malignancy, with a specificity of 85.8%–95% and a positive predictive value of 24.3%–70.7%

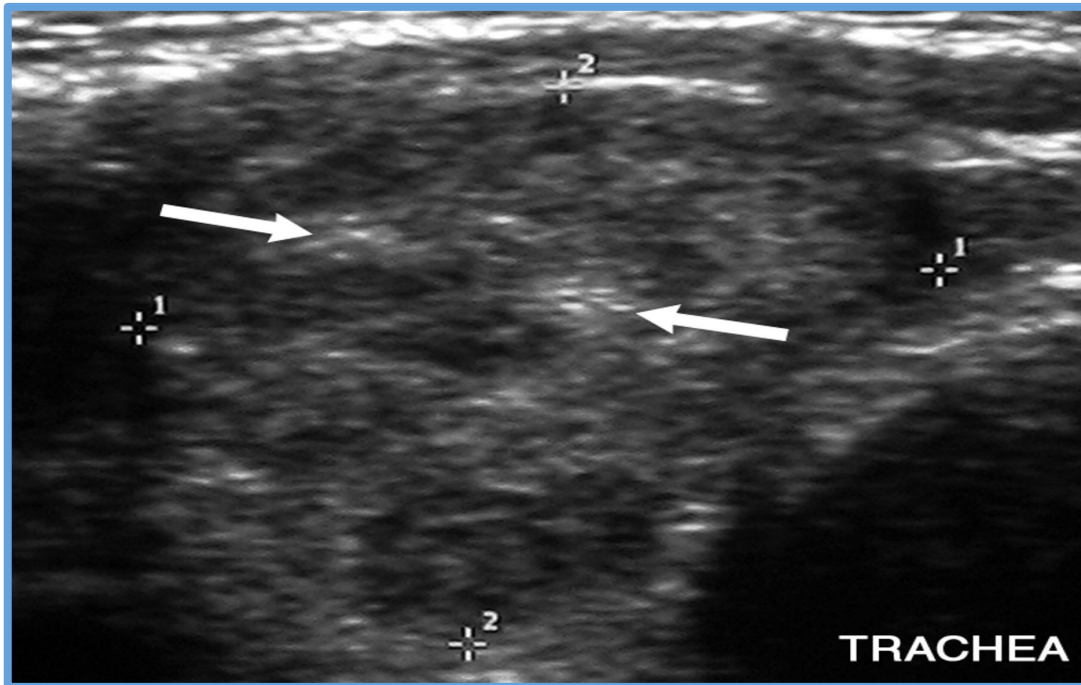


Pathology slide shows a psammoma body (arrow), a round laminar crystalline calcification.

An ultrasound of a normal thyroid

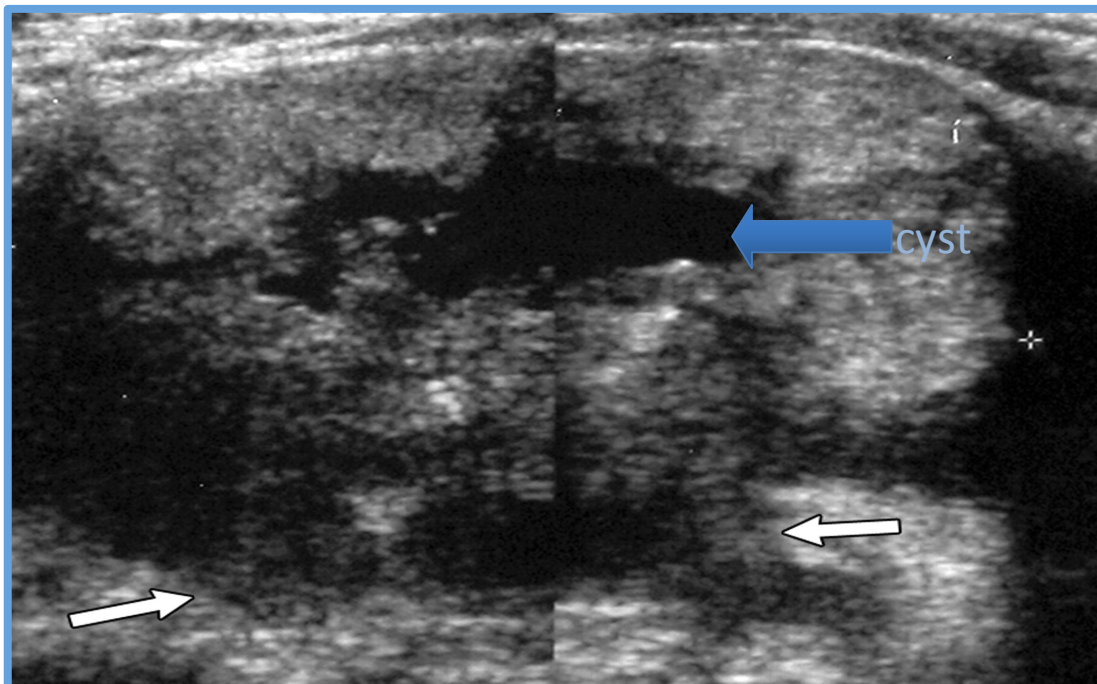


Papillary thyroid carcinoma in a 42-year-old man



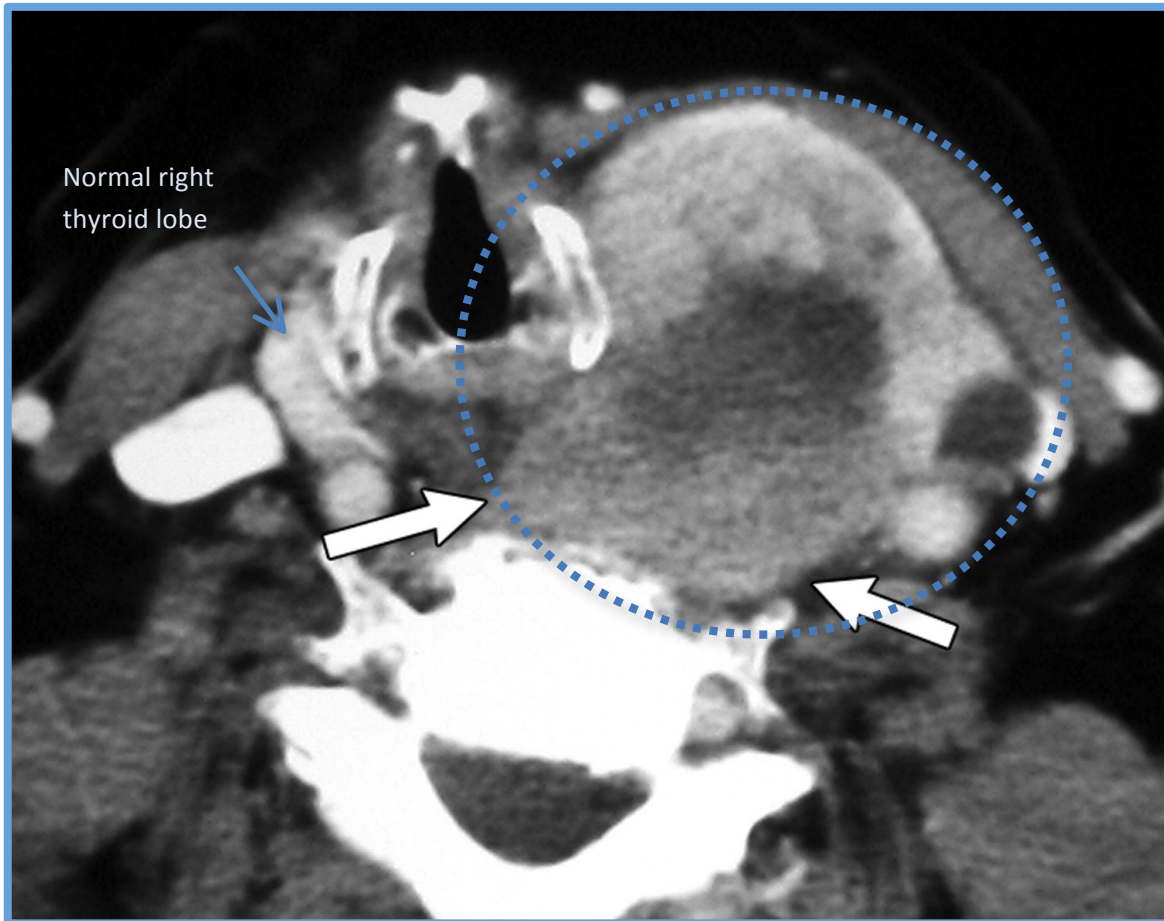
Transverse sonogram of the **right lobe** of the thyroid replaced by large heterogeneous mass with **multiple echogenic foci = microcalcifications** (arrows). without posterior acoustic shadowing.

Anaplastic thyroid carcinoma in an 84-year-old woman



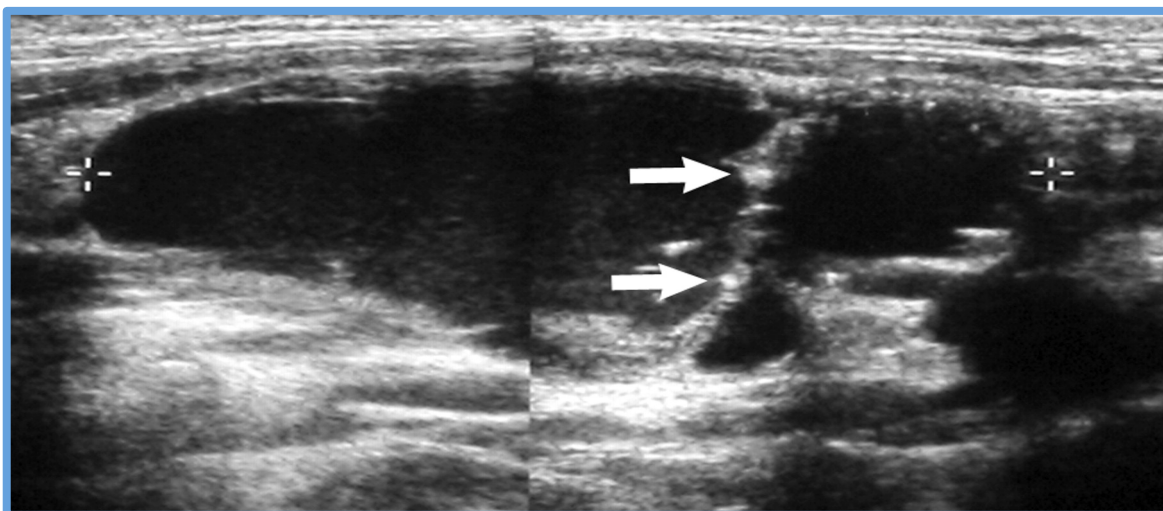
Transverse sonogram of the **left lobe** of the thyroid shows a large mass with **solid and cystic component with infiltrative posterior margins** (arrows) and **local invasion of prevertebral muscle** (an advanced tumor).

CT of the same patient above



Axial contrast-enhanced CT image shows a large enhancing tumor with central area of cystic necrotic component and with **invasion of the prevertebral muscle** (white arrows). Proven to be Anaplastic thyroid carcinoma.

Papillary carcinoma and cystic lymph node metastasis in a 28-year-old woman

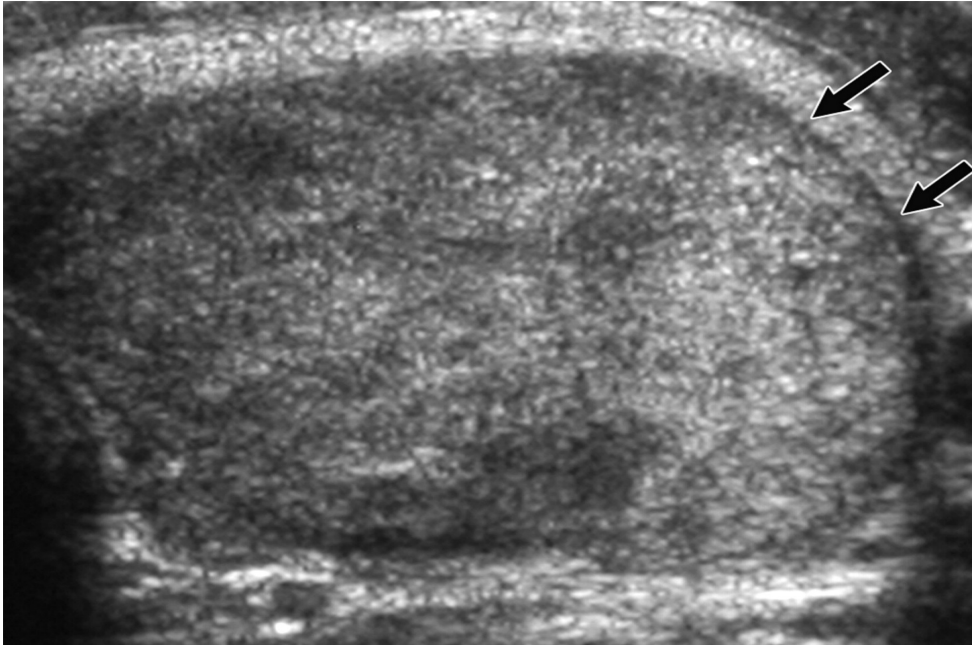


Longitudinal sonogram of the right neck showing a **large lymph node** (not thyroid) with **irregular septation** (arrows) and **echogenic foci (microcalcifications)**. This is **papillary cancer with cystic lymph node metastases**.

Margins, Contour, and Shape

- A **completely uniform halo around a nodule** is highly suggestive of **benignity**, with a specificity of 95%

Follicular adenoma in a 30-year-old woman

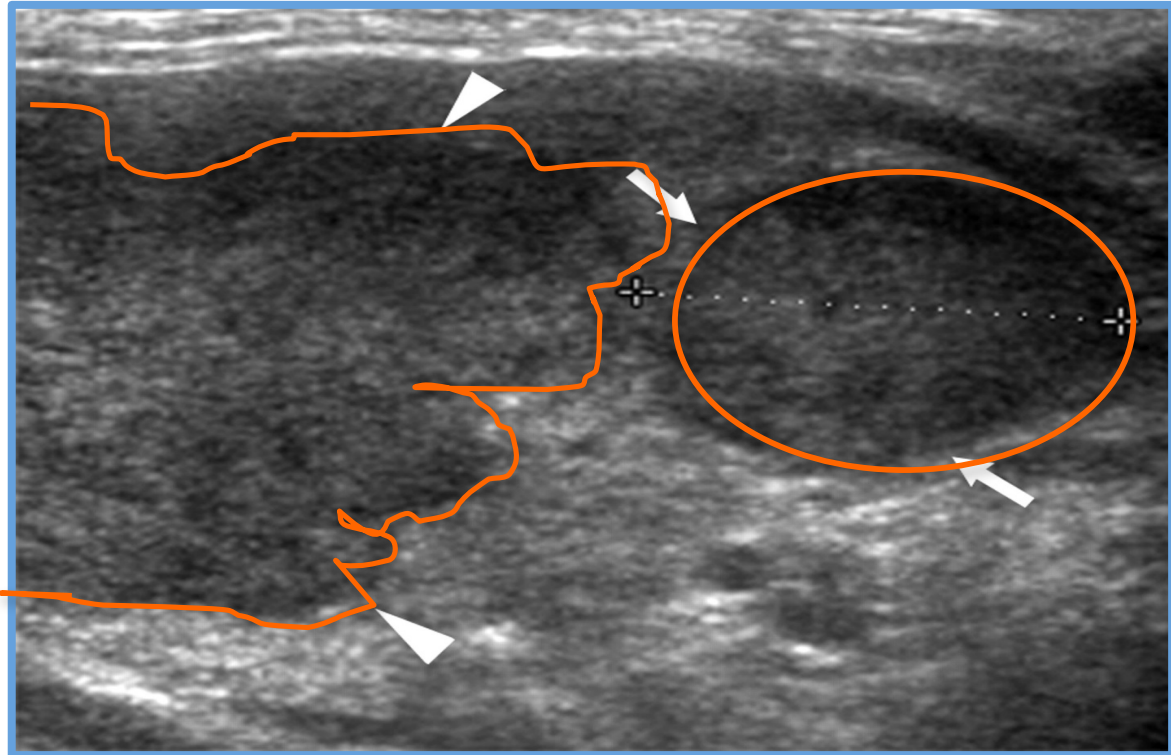


Transverse sonogram of the **left lobe** of the thyroid shows a thin hypoechoic (black) line =**halo** (arrows), suggests **benign lesion** that is proven to be adenoma

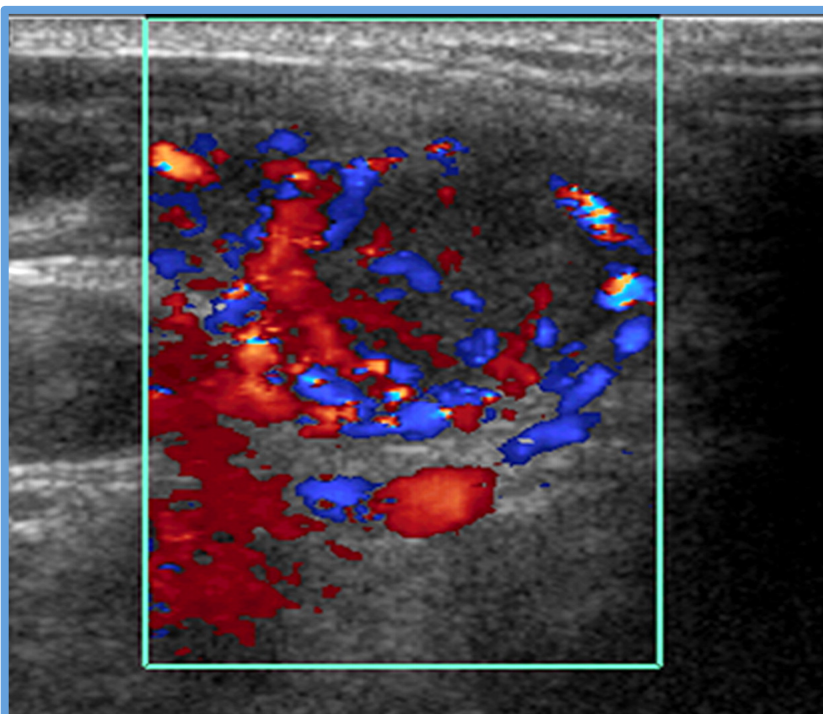
Vascularity

- Papillary thyroid carcinomas has some intrinsic blood flow (internal vascularity is more likely to be malignant)
- Avascular nodule or has peripheral vascularity this is very unlikely to be malignant.

Renal cell carcinoma metastases to the thyroid in a 69-year-old woman

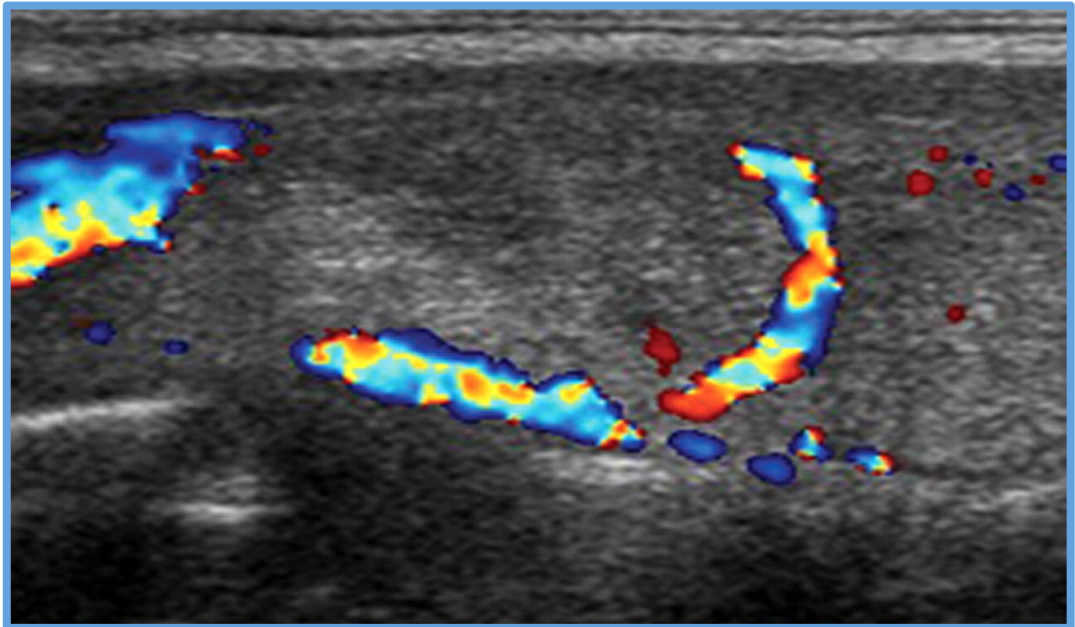


Longitudinal sonogram of the right lobe of the thyroid shows a **round hypoechoic nodule** (arrows) and an **irregular-shaped hypoechoic nodule** (arrowheads). So it is very important to know the margin of the mass whether it's irregular or lobulated and it's also important to assess the primary tumour if the patient is known to have lung, breast or renal metastasis to the thyroid.



Color Doppler sonogram of the round nodule shows increased **internal vascularity** (so it is going more to malignancy).

Follicular adenoma in a 36-year-old woman



Longitudinal color Doppler sonogram of the right lobe of the thyroid shows **perinodular flow around a follicular adenoma (peripheral vascularity)**, which is a **benign** feature, and pathologically proven to be adenoma.

Hypoechoic Solid Nodule

Marked **hypoechoogenicity** is very suggestive of **malignancy**. If echogenic it is more likely to be benign.

B cell lymphoma of the thyroid in a 73-year-old woman with Hashimoto thyroiditis



Transverse sonogram of the left lobe of the thyroid shows a large heterogeneous mass (between calipers) with marked hypoechoogenicity when compared with the strap muscles (SM). A normal isthmus (arrow) also is visible. IJV = internal jugular vein. B cell lymphoma is very rare.

Nonspecific US Features (do not depend on them)

The size of a nodule

- is **not helpful** for predicting or excluding malignancy.
- There is a common but **mistaken** practice of selecting the largest nodule in a multinodular thyroid for FNA.

Number of Nodules

- Although most patients with nodular hyperplasia have multiple thyroid nodules and some patients with thyroid carcinoma have solitary nodules, the presence of multiple nodules should never be dismissed as a sign of benignity.

Interval Growth of a Nodule

- In general, interval growth of a thyroid nodule is a **poor** indicator of malignancy. Benign thyroid nodules may change in size and appearance over time.
- The **exception** is **clinically** detectable **rapid interval growth**, which most commonly occurs in anaplastic thyroid carcinoma but also may occur in lymphoma, sarcoma, and, occasionally, high-grade carcinoma.

Recommendations for Thyroid Nodules 1 cm or Larger in Maximum Diameter

US Feature	Recommendation
Solitary nodule	
Microcalcifications	Strongly consider US-guided FNA if ≥ 1 cm
Solid (or almost entirely solid) or coarse calcifications	Strongly consider US-guided FNA if ≥ 1.5 cm
Mixed solid and cystic or almost entirely cystic with solid mural component	Consider US-guided FNA if ≥ 2 cm
None of the above but substantial growth since prior US examination	Consider US-guided FNA
Almost entirely cystic and none of the above and no substantial growth (or no prior US)	US-guided FNA probably unnecessary
Multiple nodules	Consider US-guided FNA of one or more nodules, with selection prioritized on basis of criteria (in order listed) for solitary nodule*

Easier explanation:

If there is Solitary nodule + Microcalcification & ≥ 1.5 cm \rightarrow do FNA

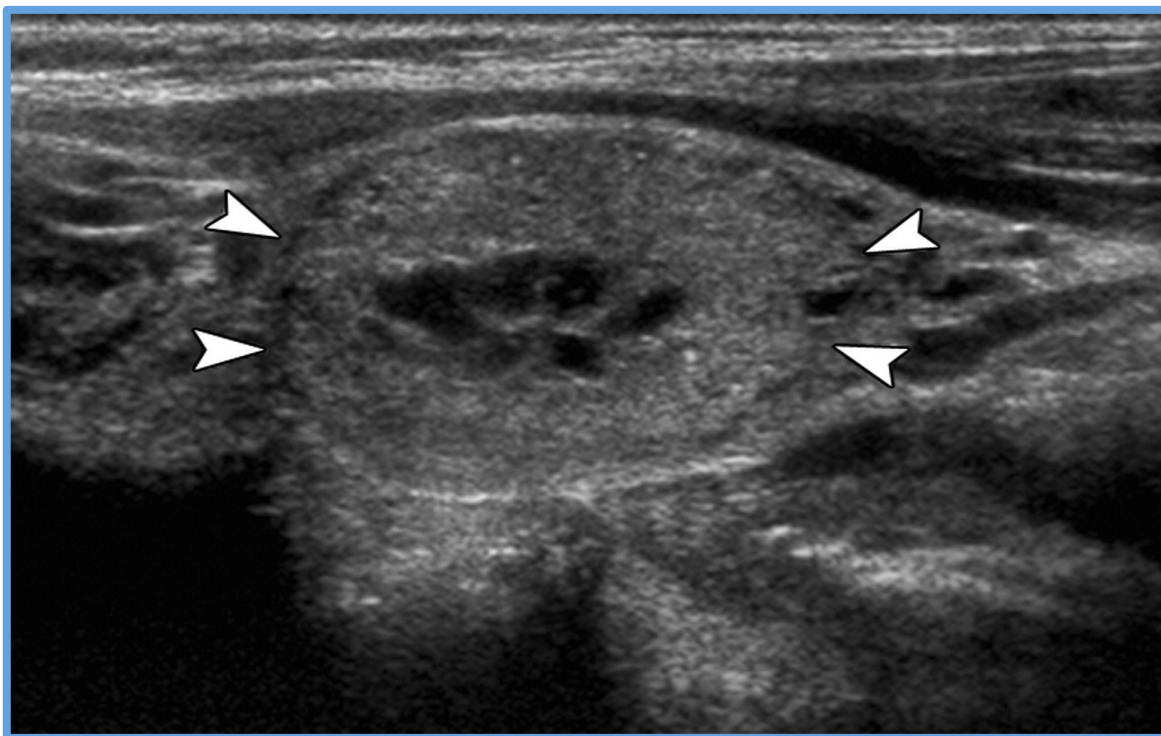
If there is Solitary nodule + Solid component & ≥ 1.5 cm \rightarrow do FNA

If there is Solitary nodule + Complex (solid & cystic) & ≥ 2 cm \rightarrow do FNA

If there is Multiple nodules \rightarrow choose the most suspicious one and do FNA

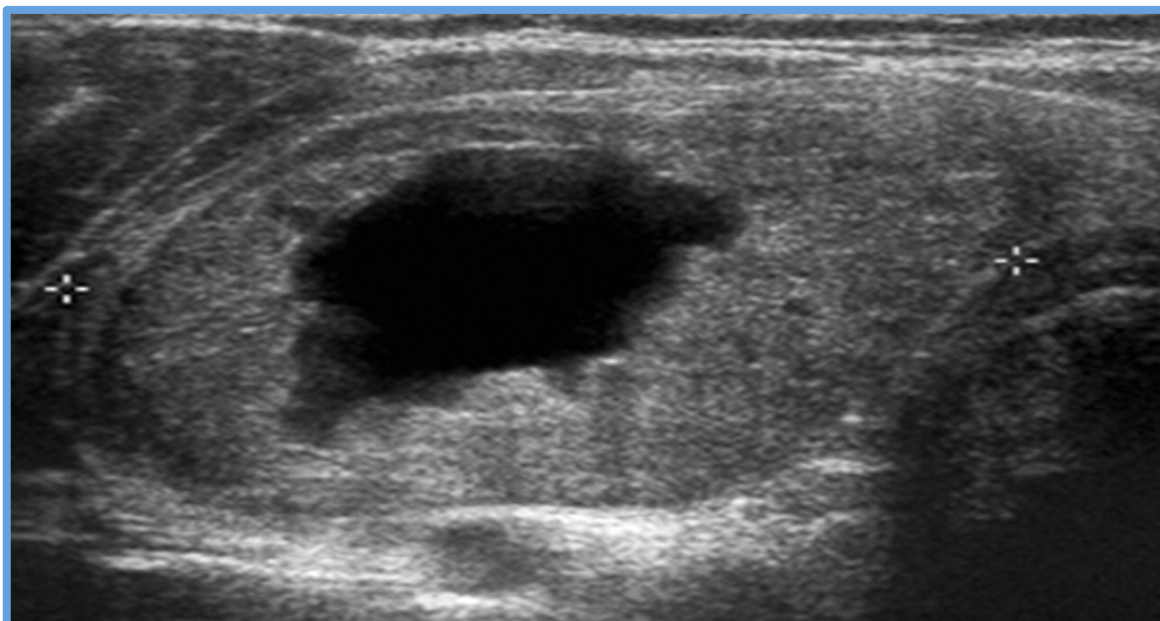
If there is Cystic lesion, no interval growth in size, no Solid component \rightarrow **do not do** FNA only follow up because mostly it is benign.

US images of thyroid nodules of varying parenchymal composition (solid+cystic=complex)



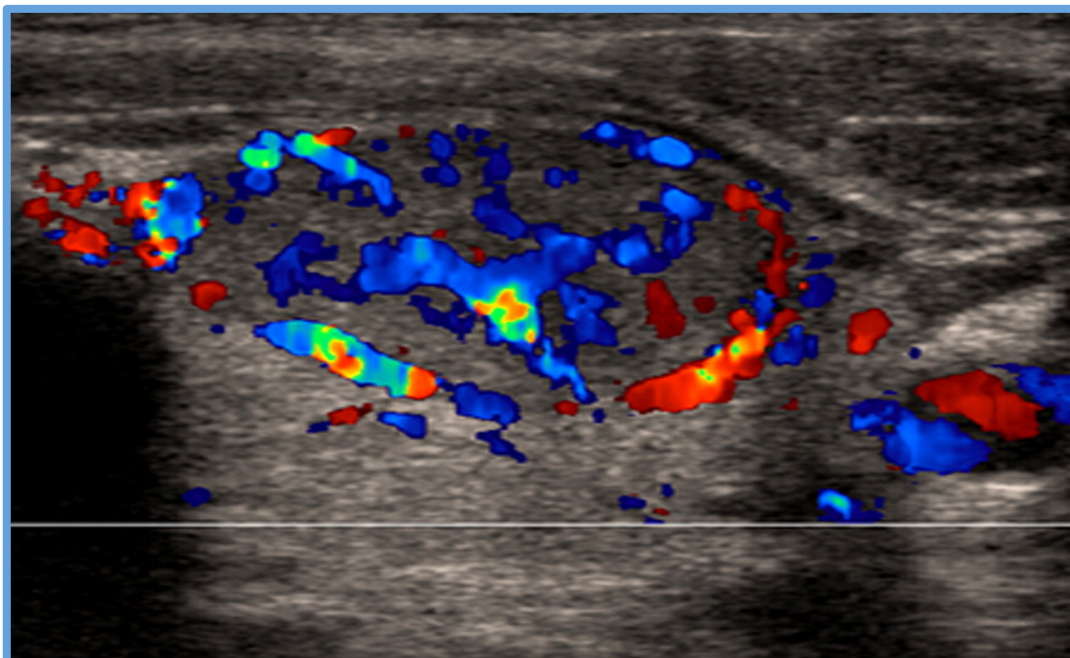
Benign

US images of thyroid nodules of varying parenchymal composition (solid+cystic)



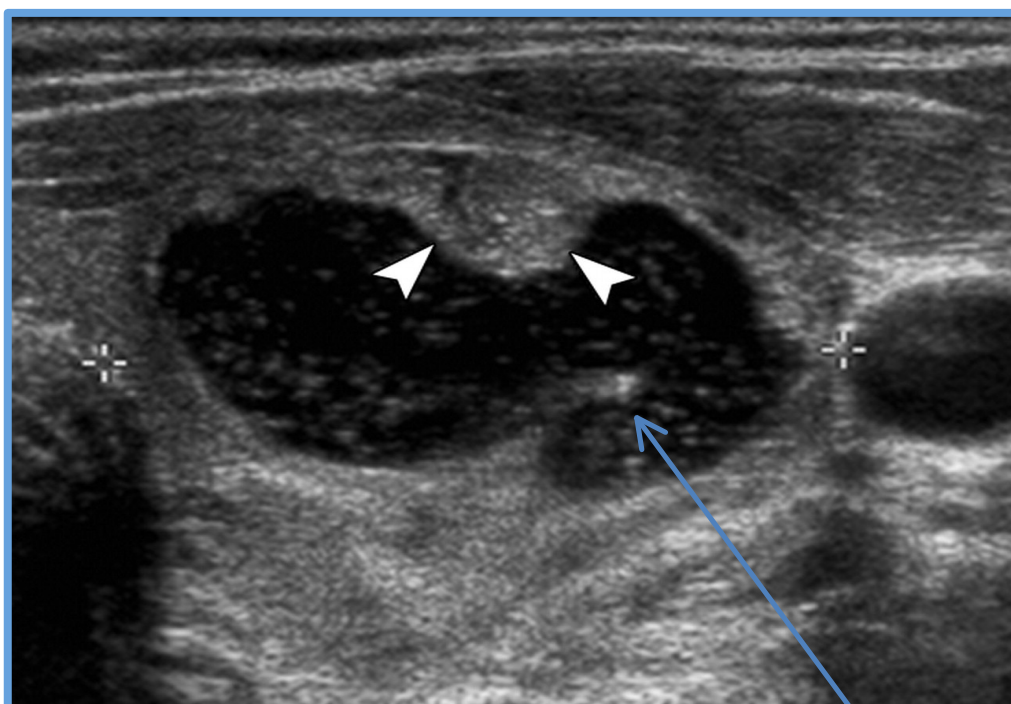
Also Benign

Predominantly solid thyroid nodule



Internal vascularity, indicating increased likelihood that nodule is malignant. This was a papillary carcinoma.

Predominantly cystic nodule with small solid-appearing mural component

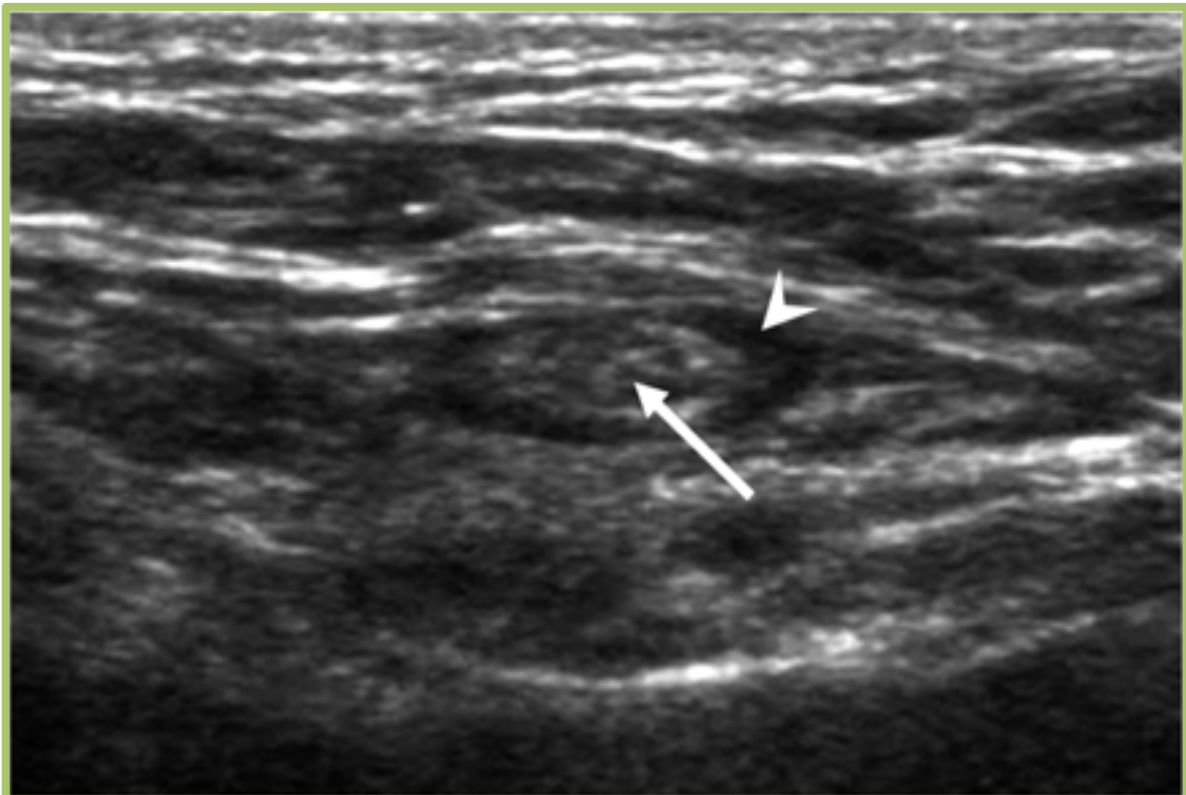


Cyst with peripheral solid component with multiple echogenic spots (which means that it is a complicated cyst), and the posterior enhancement indicates that the lesion is cystic not solid. (benign)

US features of Malignant lymph nodes

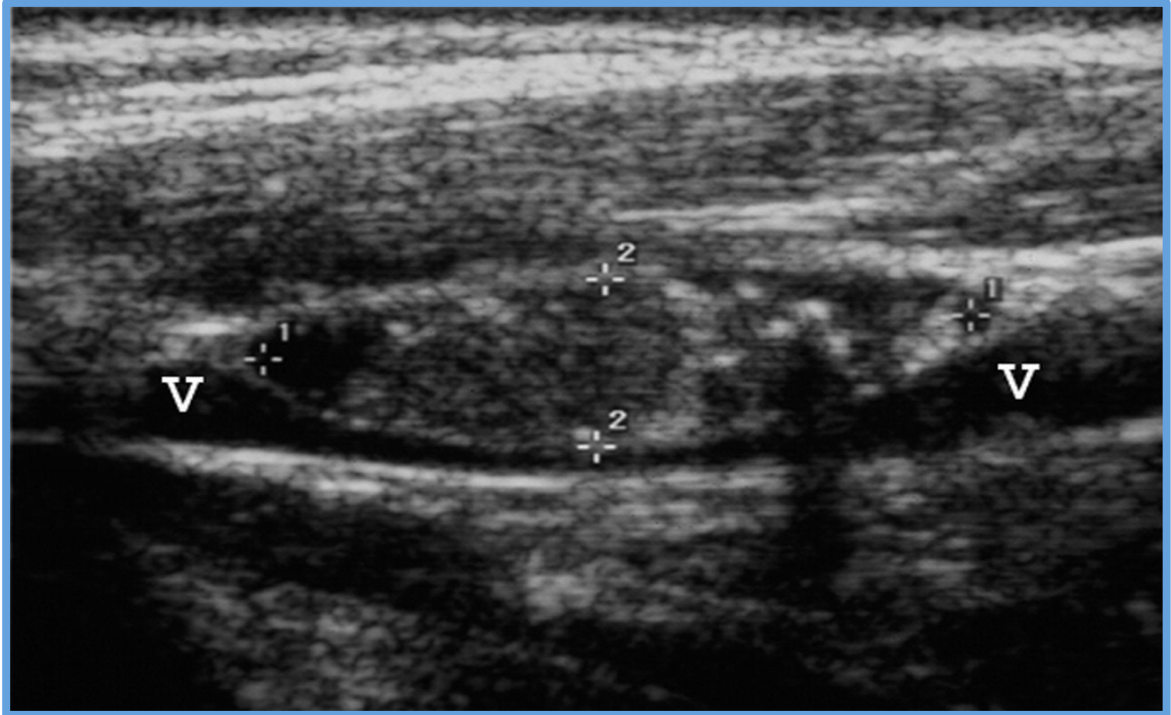
- Rounded bulging shape.
- Increased size.
- Replaced fatty hilum .
- Irregular margins.
- Heterogeneous echotexture.
- Calcifications.
- **Cystic areas.** (Here it indicates malignancy unlike in thyroid nodule)
- Vascularity throughout the lymph node instead of normal central hilar vessels at Doppler imaging.

Normal cervical lymph node



Normal lymph node. On sonography, features include an ovoid shape and thin cortex (arrowhead), well-defined margins, and a preserved fatty hilum (arrow)

Abnormal cervical lymph nodes



Sagittal US image of **enlarged** node (calipers) with central punctate echogenicities, consistent with **microcalcifications**, shows mass effect on internal jugular vein (V), and **no fatty hilum** (deeply hypoechoic). Node was proved to be metastatic papillary carcinoma.

Abnormal cervical lymph nodes

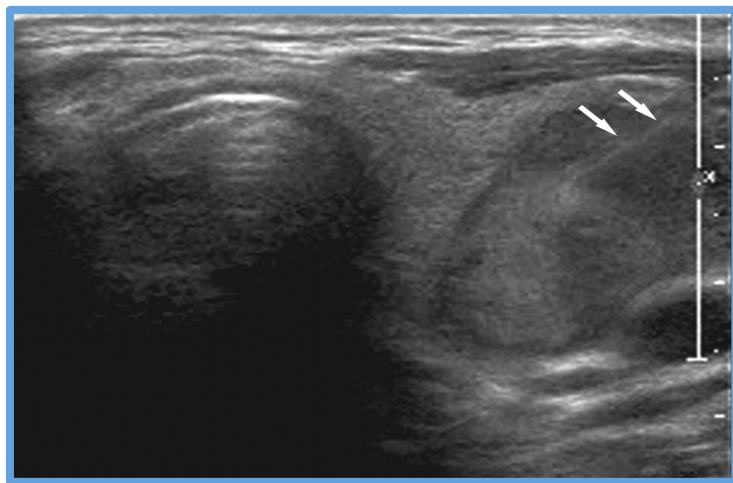
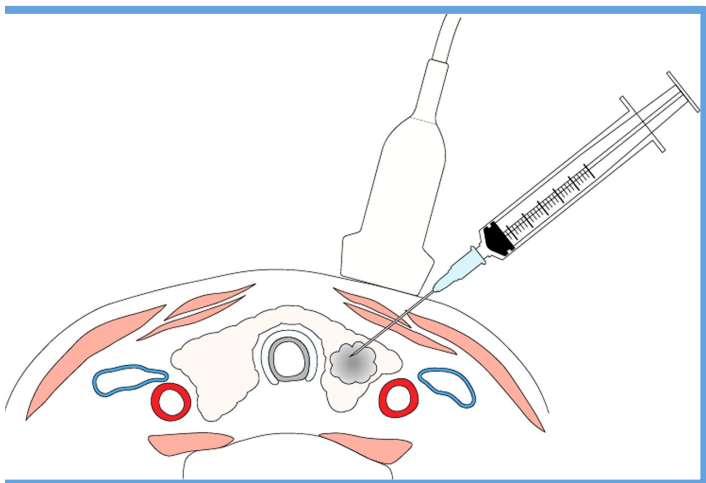


Sagittal US image of **enlarged** oval shaped node (calipers) with **cystic component**, and **loss of fatty hilum**. Node was proved to be metastatic papillary carcinoma.

US-guided FNA Technique

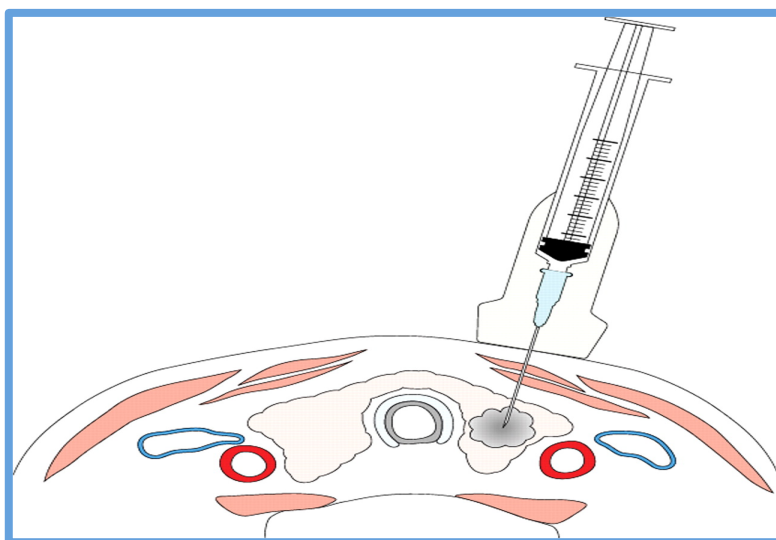
- The needle may be introduced parallel or perpendicular to the transducer, and the needle tip should be carefully monitored during the procedure.

Parallel positioning of the fine-gauge needle for thyroid nodule biopsy



- This positioning helps maximize the number of needle-generated reflected echoes perpendicular to the sound wave and is preferred by many operators
- depicts the entire length of the needle (arrows) within the nodule

Perpendicular positioning of the fine-gauge needle for thyroid nodule biopsy



- A shorter needle may be used with this option, and it is less likely that the carotid artery or jugular vein may be punctured. **In an ultrasound only the tip of the needle will appear.**

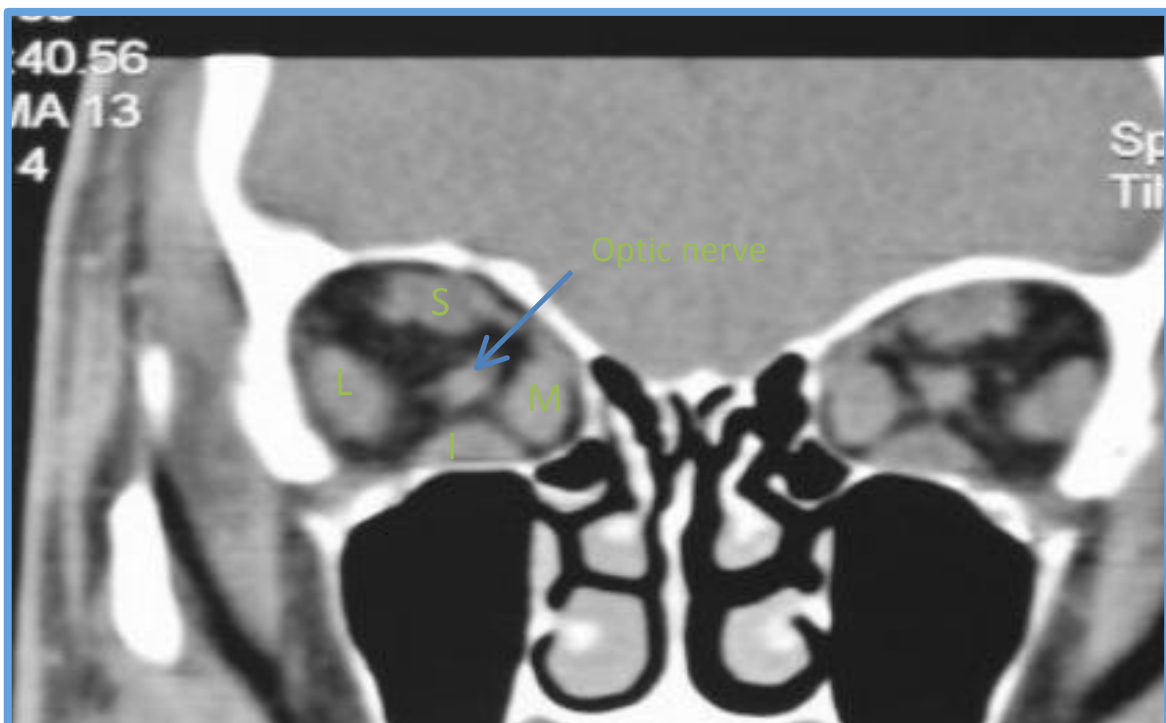
Thyroid Ophthalmopathy (Graves' Disease)

Clinical history:

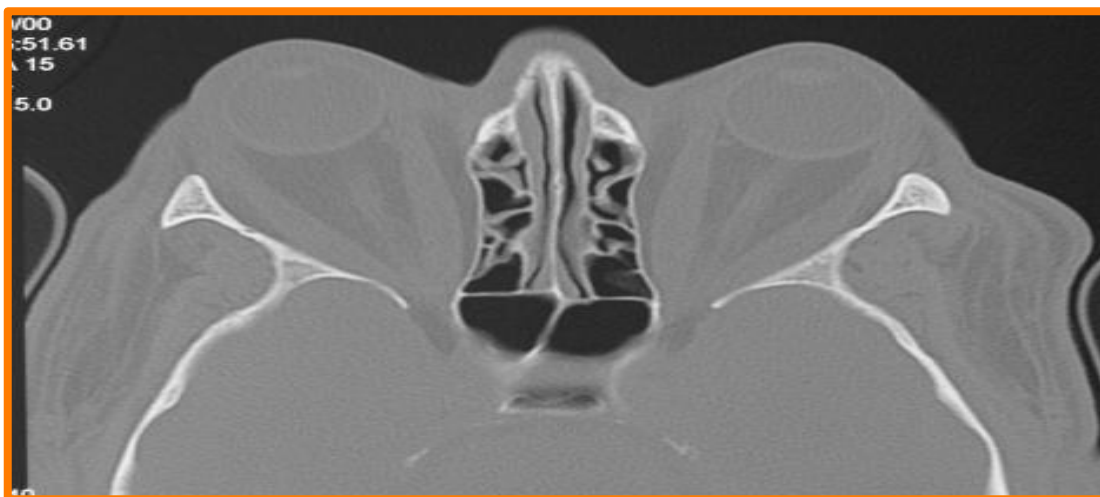
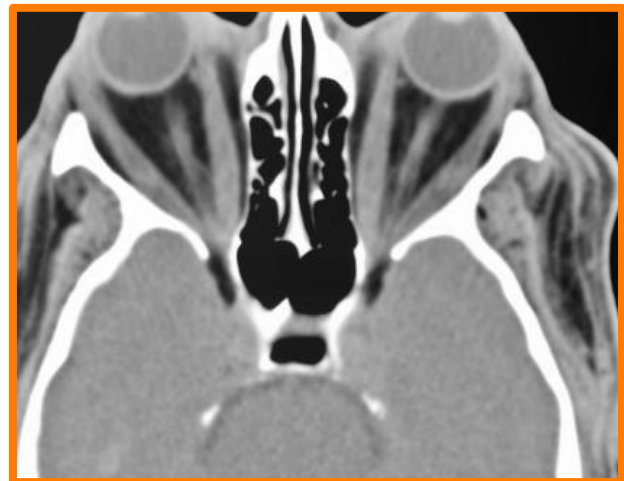
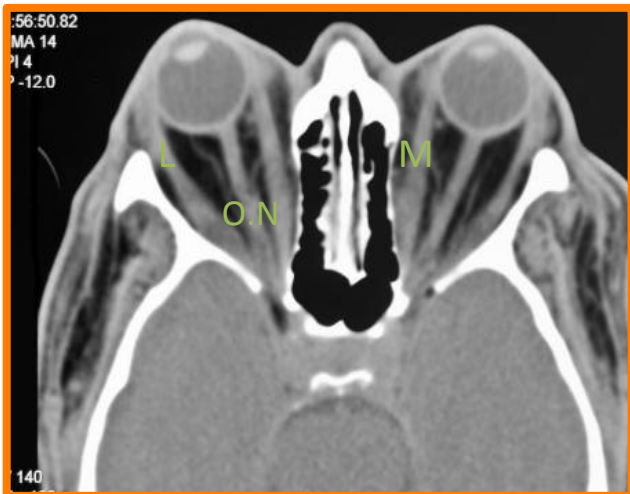
Slow onset (months), painless exophthalmos.

Patterns of muscle involvement in thyroid ophthalmopathy:

- Bilateral (85%)
- Unilateral (5%)
- 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)** →(the order of involvement)
- 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**



Axial CT of the brain



Parathyroid disease

Renal osteodystrophy

- Seen in setting of chronic, end-stage renal disease.
- Related to combination of **secondary hyperparathyroidism + osteomalacia**.
- **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



- Coronal CT of the lumbar vertebrae with multiple sclerotic bands at their ends.
- =Rugger Jersey Spine
- typical for renal osteodystrophy

• Additional signs of hyperparathyroidism such as:

1. Resorption of secondary trabeculae.
2. Cortical thinning.
3. Subperiosteal bone resorption.(in radial aspect) of the middle phalanges of the 2nd and 3rd fingers
4. Brown tumors are often present.

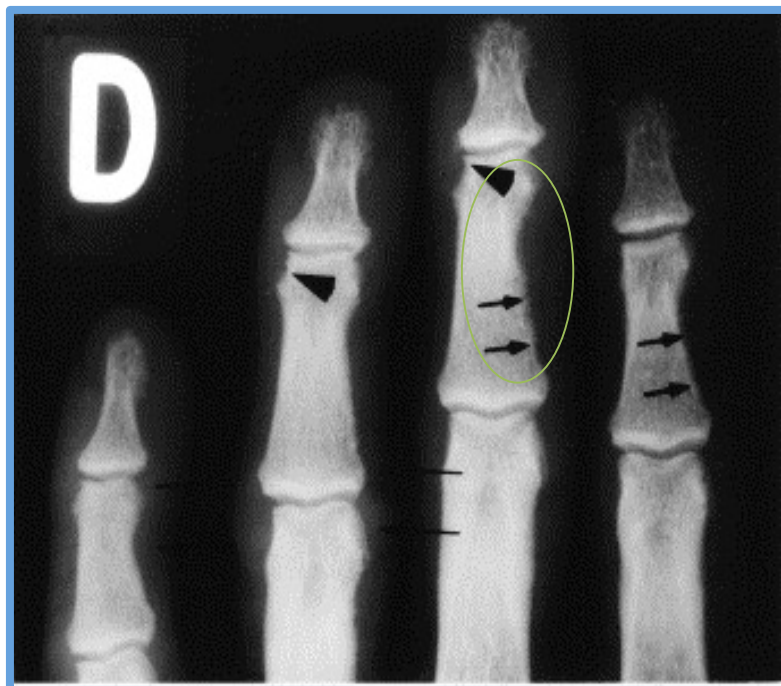


- Both axial and appendicular skeleton involved.
- Increased risk for pathologic fracture. (b/c it is a lytic lesion)

❖ Calcification of the soft tissue (presentation of secondary hyperparathyroidism)



- ❖ Subperiosteal bone resorption in the radial aspect of the distal interphalangeal joints



Rugger Jersey Spine



hyperparathyroidism

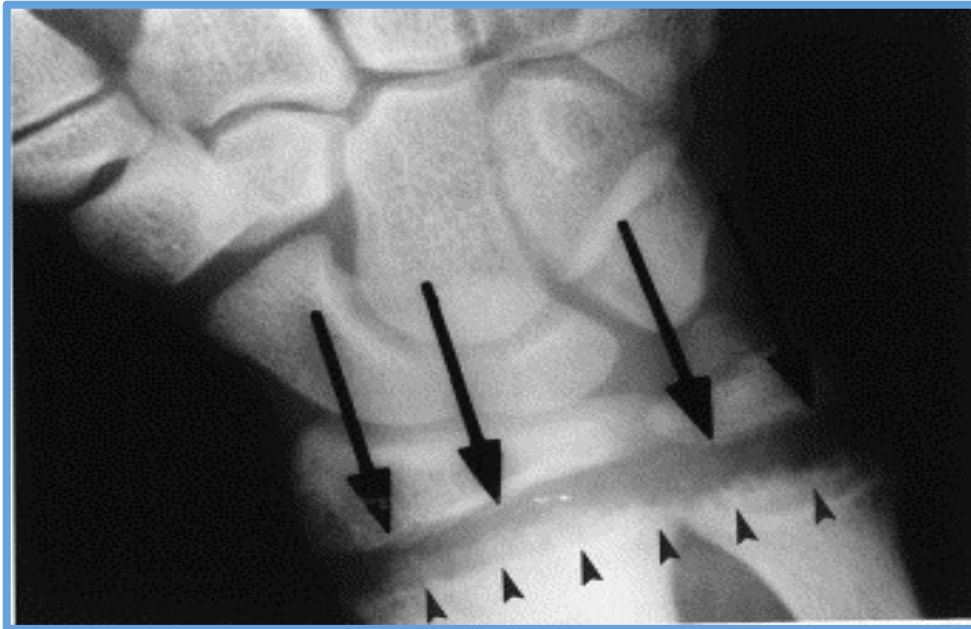
subperiosteal resorption

subchondral resorption

subligamentous resorption

- Subperiosteal bone resorption (arrowheads)

- Subchondral resorption (green arrows)



Subligamentous resorption (at the site of attachment to the ligament)



Brown Tumors (lytic lesions within the bones)

Summary:

- Thyroid scan is a very helpful tool in differentiating between various causes of thyrotoxicosis.
- Radioactive Iodine (RAI) is used for thyroid scan and uptake.
- Early phase sub-acute thyroiditis has no nodules unlike toxic multinodular goiter which has cold and hot nodules in the scan.
- The malignant features of thyroid nodules are : Micro-calcifications, Local invasion, Lymph node metastases, A nodule that is taller than it is wider and Markedly reduced echogenicity

MCQs

A 35 year old female presents with advanced SLE. The following x-ray represents:

- A) Renal Osteodystrophy
- B) Multiple Myeloma
- C) Vertebral body collapse due to metastasis
- D) The most likely diagnosis is TB of the spine because the patient is immunocompromised



Answer: A

