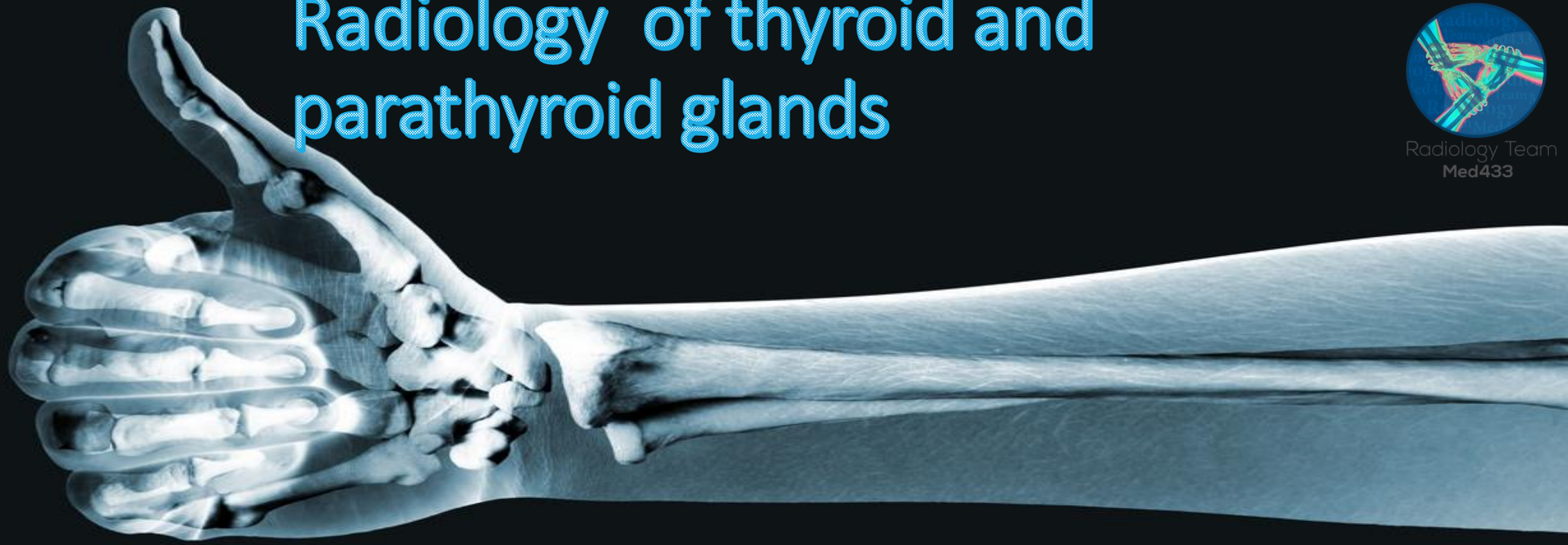
Lecture 4

Radiology of thyroid and parathyroid glands

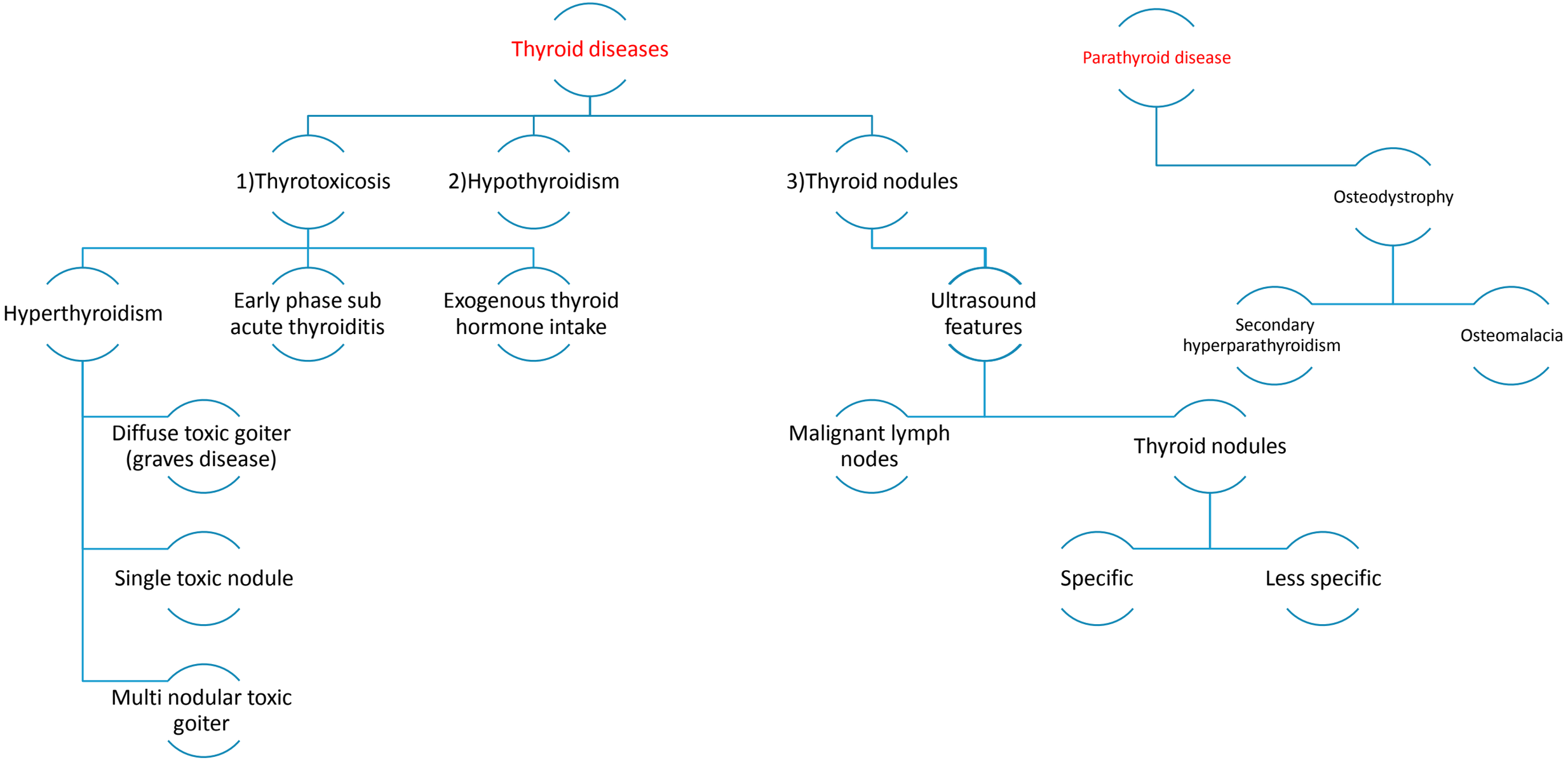


Radiology Team
Med433

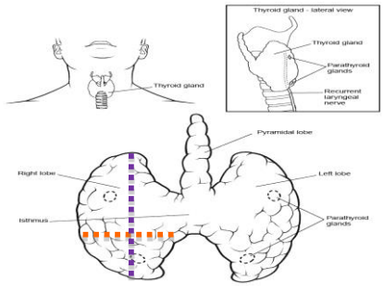
● Slides ● Explanation ● Notes ● Additions ● Important

Objectives

Not given


Thyroid diseases
1)Thyrotoxicosis
2)Hypothyroidism
3)Thyroid nodules
Hyperthyroidism
Early phase sub acute thyroiditis
Exogenous thyroid hormone intake
Diffuse toxic goiter (graves disease)
Single toxic nodule
Multi nodular toxic goiter
Ultrasound features
Malignant lymph nodes
Thyroid nodules
Specific
Less specific
Parathyroid disease
Osteodystrophy
Secondary hyperparathyroidism
Osteomalacia

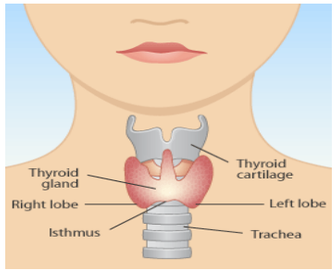
Anatomy of thyroid gland



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

Thyroid diseases

1) Thyrotoxicosis
2) Hypothyroidism
3) Thyroid nodules



Thyrotoxicosis VS Hyperthyroidism

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

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

Causes of Thyrotoxicosis

1)Hyperthyroidism : Diffuse toxic goiter (Graves' disease)(symmetric bilateral enlargement of the thyroid gland)
Single toxic nodule .
Multi-nodular toxic goiter.
2)Early phase sub-acute thyroiditis.
3)Exogenous thyroid hormone intake.

Hyperthyroidism is a subtype of Thyrotoxicosis

TFT and Thyroid scan

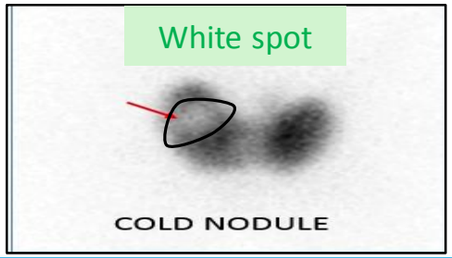
- Thyrotoxicosis = suppressed TSH and elevated T3/T4.
- Based on TFT (Thyroid function test) the exact cause of Thyrotoxicosis can not be determined.
- Thyroid scan is a very helpful tool in differentiating between various causes of Thyrotoxicosis.

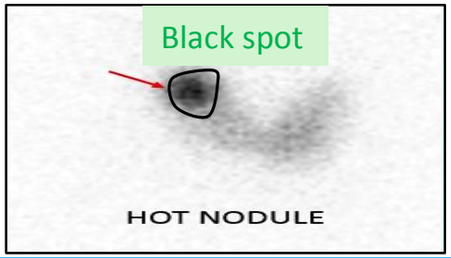
Thyroid scan and uptake

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

Thyroid scan and uptake Imaging findings

1)Symmetric or asymmetric lobes.
2)Homogeneous or inhomogeneous uptake.
3)Nodules; cold (malignant)or hot (Benign) .

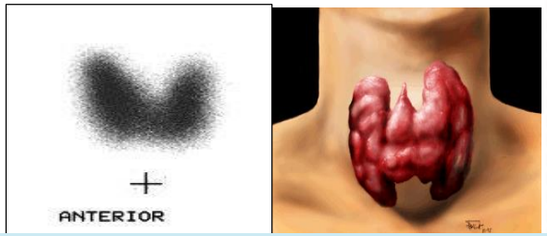




1)Hyperthyroidism

1) Diffuse Toxic goiter (Graves' Disease)

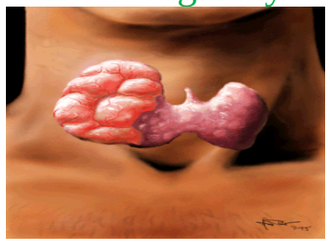
- Diffuse enlargement of thyroid gland.
- Homogeneous uptake.
- No significant focal abnormalities (nodules).
- 24-hour RAI uptake is elevated, usually > 35%



- Graves disease is an autoimmune disorder.
- presence of circulating antibodies directed at TSH receptors; stimulate the receptors
excessive thyroid hormone leads to hyperthyroidism.
- symptoms:
Nervousness;Irritability;Difficulty sleeping ;Rapid heartbeat ;Fine tremor of the hands or fingers ; Increased sweating ;Sensitivity to heat ;Sudden weight loss ;Bulging eyes ;Unblinking stare ;Goiter ;light menstrual periods ;Frequent bowel movements .
- unrelated tissue manifestations such as exophthalmos .
- In Graves' ophthalmopathy, the eyeball protrudes beyond its protective orbit because tissues behind the eye attract and hold water. When this happens, the tissues and muscles swell, causing the eyeball to move forward in the orbit. The front surface of the eye can dry out. Eye symptoms and hyperthyroidism symptoms usually appear within 18 months of each other. sometimes referred to as diffuse toxic goiter.

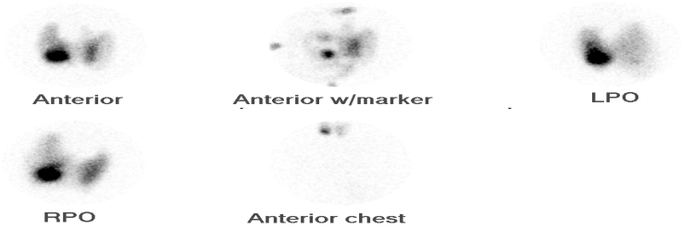
2) Single Toxic Nodule

- 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%.
- Treat surgically .



Toxic HOT nodule

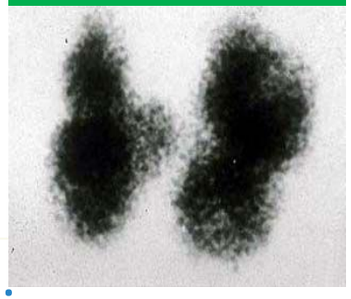
Hyper functioning



3) Toxic Multi-Nodular Goiter

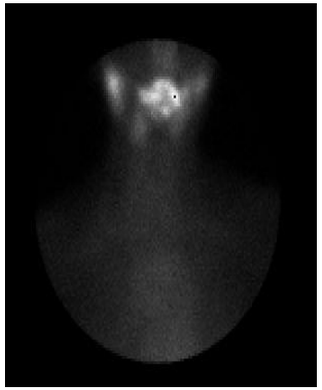
- Mild inhomogeneous uptake in thyroid gland.
- Multiple cold and hot nodules in both thyroid lobes.
- 24-hour uptake is mildly elevated, usually between 20%-30%.

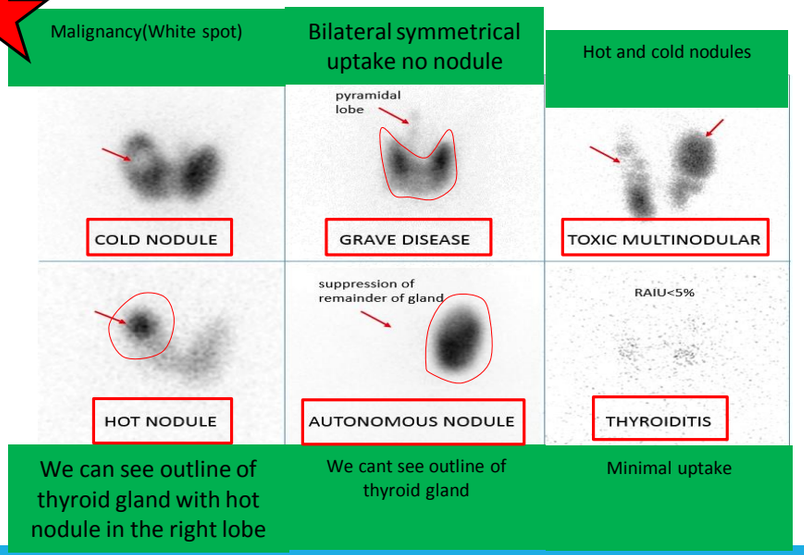
Asymmetrical multi nodular goiter



2)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% (Minimal or no uptake at all).





Causes of Thyrotoxicosis

Hypothyroidism

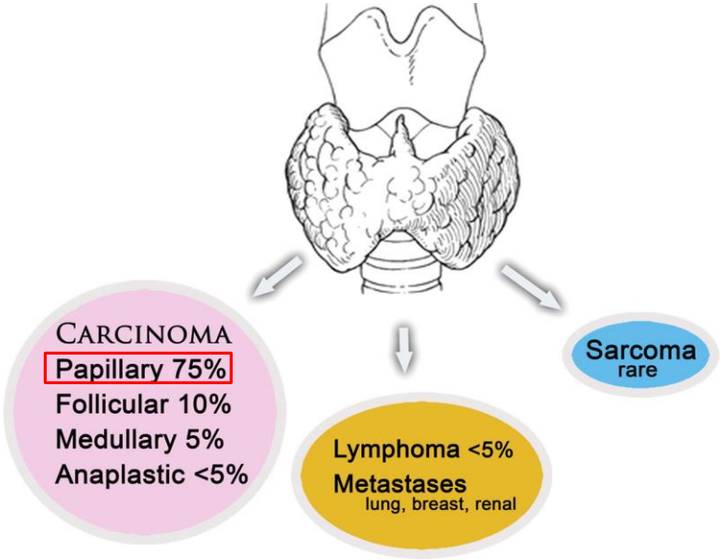
- The main cause is chronic thyroiditis (Hashimoto's thyroiditis).
- TFT: Elevated TSH , Suppressed T3/T4.
- Thyroid scan does not have significant diagnostic value in this entity. Unless, there is nodule, thyroid scan may be helpful.

Thyroid Nodules

- Common, almost existing in half of the population.
- 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.
- 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%**

There is some overlap between the US appearance of benign and malignant nodules.

Frequency of Occurrence of Thyroid Malignancies



Notes

- If you have patient with multi nodular goiter and lab shows euthyroid what is the next step ? US then FNA
- If you have patient with multi nodular goiter and lab shows hyperthyroidism what is the next step ? US then thyroid scan then +/- FNA if need it

So always after lab results (TFT) do US

Risk Factors for Thyroid Cancer

1) Family history of thyroid cancer.
2) History of head and neck radiation.
3) Female Gender.
4) Age of less than 30 years or more than 60 years.
5) Previous diagnosis of type 2 Multiple Endocrine Neoplasia (**MEN2 syndrome**).

US features of thyroid nodules

Certain US features are helpful in differentiating between the two. The **malignant** Specific features are includes:

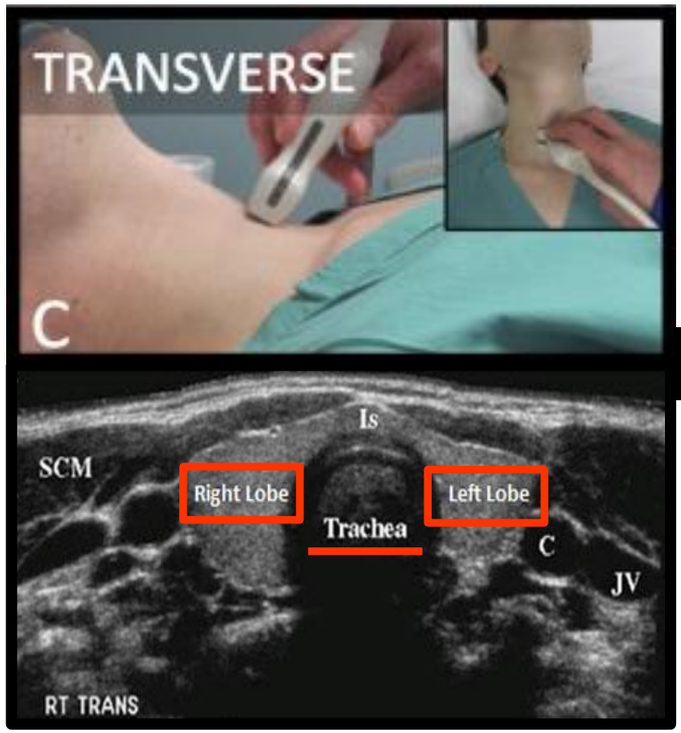
1. Micro-calcifications.
2. Local invasion.
3. A nodule that is taller than wider.
4. Markedly reduced echogenicity (Hypo-echoic= Black more with malignant)
5. Lymph node metastases.

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
Hypoechogenicity (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 wider (2)	32.7	92.5	66.7	74.8



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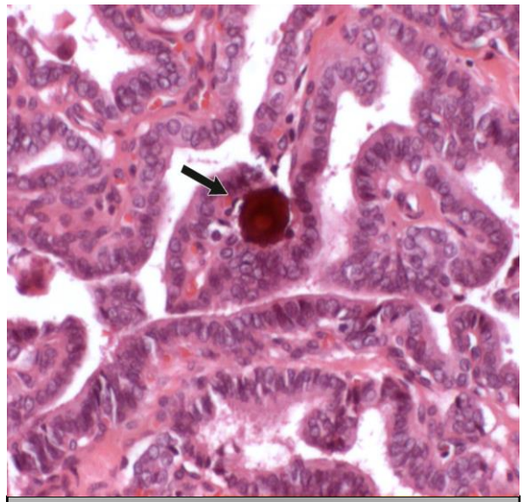
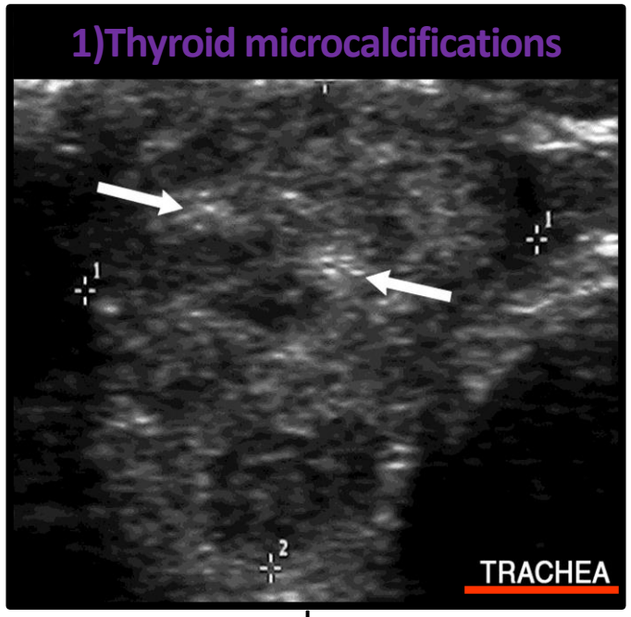


They are psammoma bodies, which are 10–100-µm

a

1)Thyroid microcalcifications



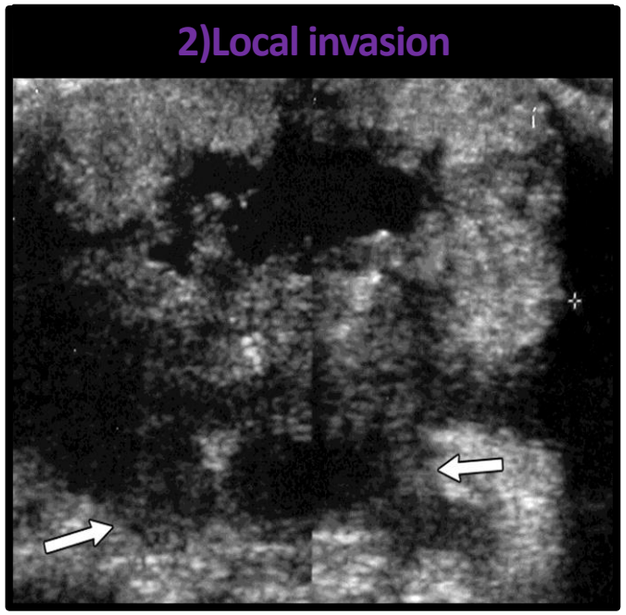
b

Papillary thyroid carcinoma in a 42-year-old man.

a) Photomicrograph (original magnification, × 400; hematoxylineosin stain) shows a psammoma body (arrow), a round laminar crystalline calcification.
b) Transverse sonogram of the right lobe of the thyroid demonstrates punctate echogenic foci without posterior acoustic shadowing, findings indicative of **microcalcifications** (arrows).

How to know which lobe is it in this US? Look at trachea location so most likely it is right lobe

2)Local invasion



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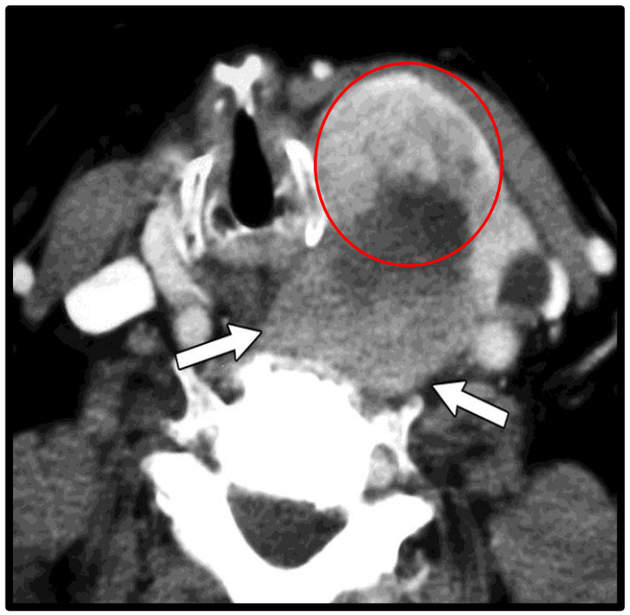


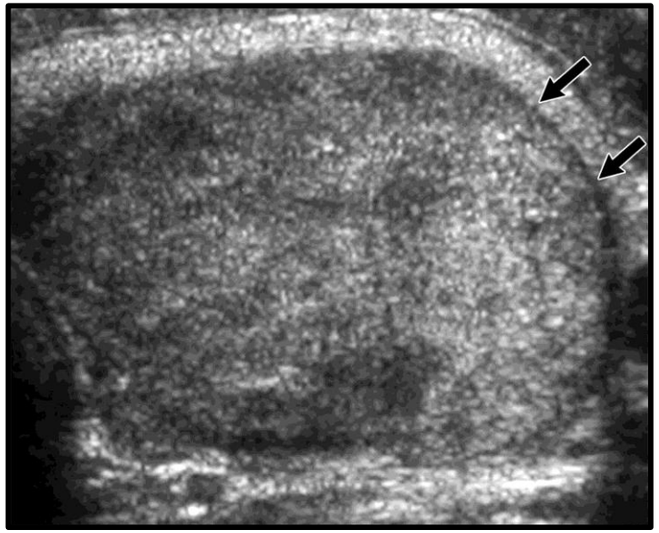
b

Anaplastic thyroid carcinoma in an 84-year-old woman.

a) Transverse sonogram of the left lobe of the thyroid shows an advanced tumor with infiltrative posterior margins (arrows) and invasion of prevertebral muscle.
b) Axial contrast-enhanced CT image shows a large tumor that has invaded the prevertebral muscle (arrows).

3)Margins, Contour, and Shape

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

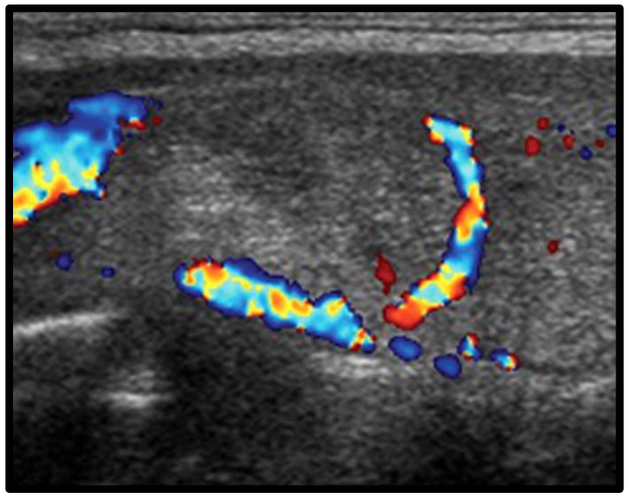


Follicular adenoma in a 30-year-old woman.

- Transverse sonogram of the left lobe of the thyroid shows a follicular adenoma with a **(sharp)hypoechoic halo** (arrows).
- Halo is the black line that separate the nodule .

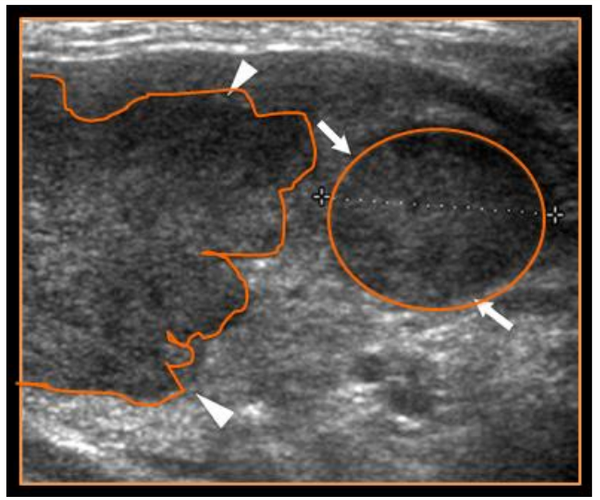
4)Vascularity

- Papillary thyroid carcinomas had some intrinsic blood flow
- Avascular nodule is very unlikely to be malignant.



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 (Benign).



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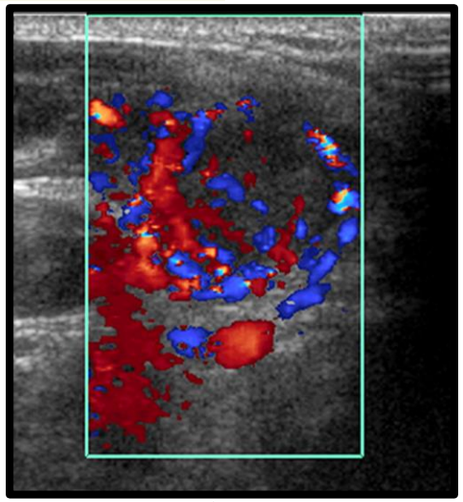


b

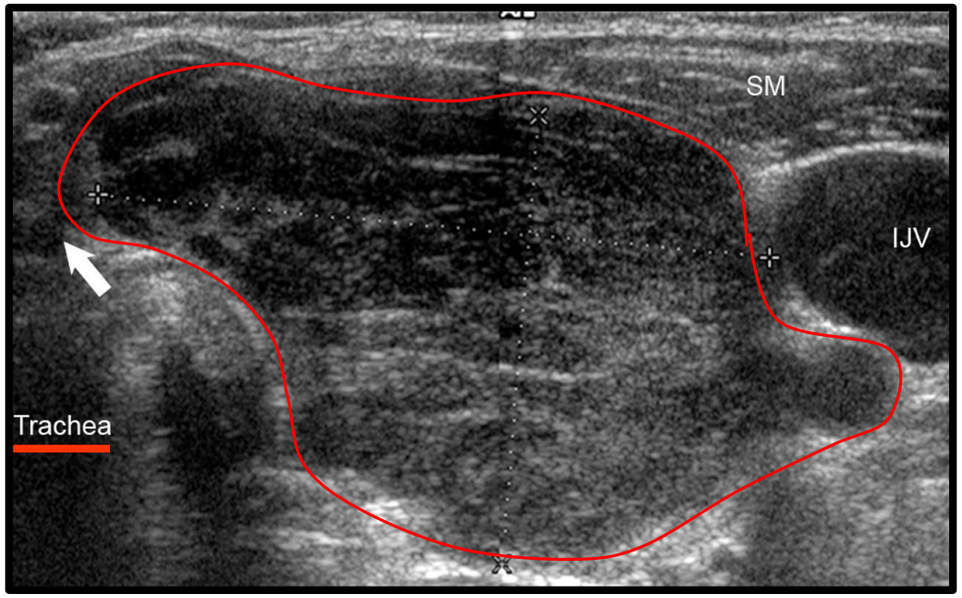
Renal cell carcinoma metastases to the thyroid in a 69-year-old woman.

a) Longitudinal sonogram of the right lobe of the thyroid shows a round hypoechoic nodule (arrows) and an irregular-shaped hypoechoic nodule (arrowheads).
b) Color Doppler sonogram of the round nodule shows increased internal vascularity (Malignant)

When vascularity of the nodule within center is considered malignant while if in the periphery is considered benign

5)Hypoechoic Solid Nodule

- Marked hypoechogenicity is very suggestive of malignancy.



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 hypoechogenicity when compared with the strap muscles (SM). A normal isthmus (arrow) also is visible. IJV = internal jugular vein.

Nonspecific US Features

- 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.

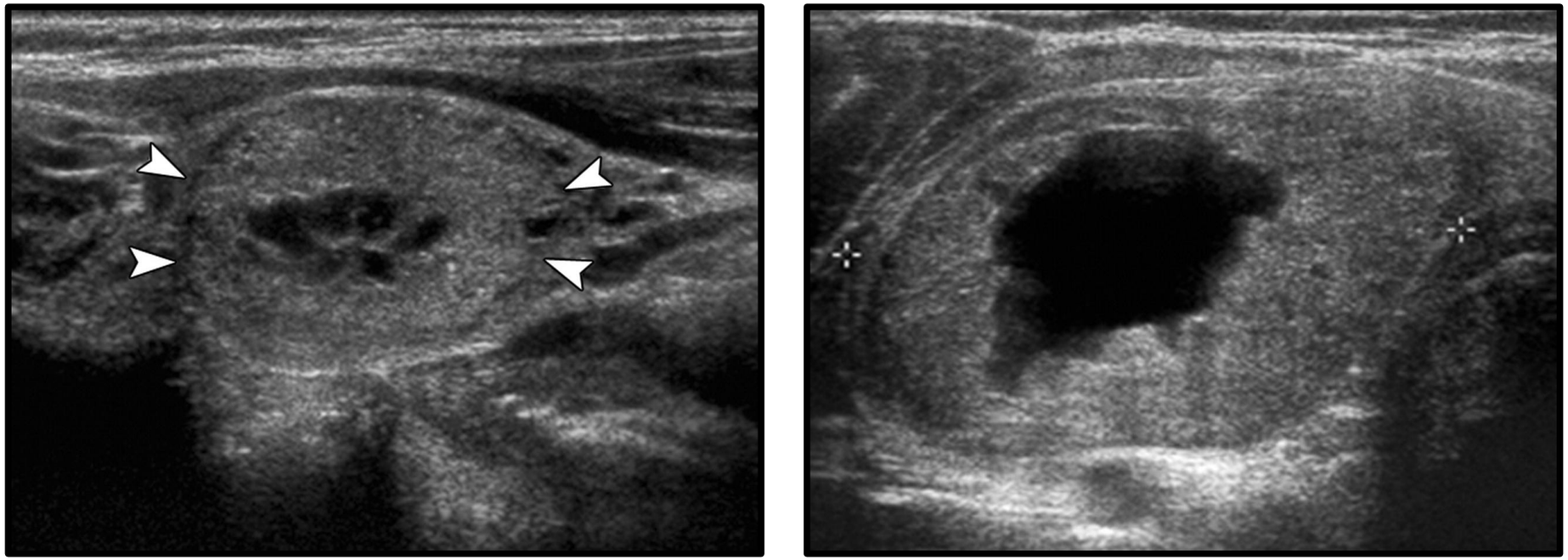
Interval Growth of a Nodule

- In general, interval growth of a thyroid nodule is a poor indicator of malignancy (more with benign) . 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

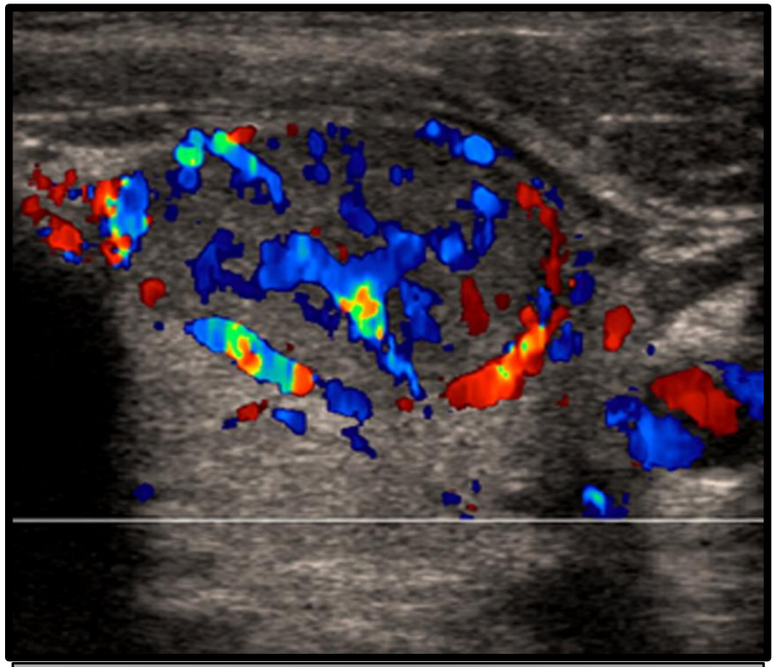
US Feature	Recommendation
Solitary nodule	
Microcalcifications	Strongly consider US-guided FNA if ≥1 cm
Solid (or almost entirely solid) or coarse calcifications	Strongly consider US-guided FNA if ≥1.5 cm
Mixed solid and cystic or almost entirely cystic with solid mural component	Consider US-guided FNA 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*

Mixed = Solid and cyst



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

a) Sagittal image of solid nodule (arrowheads), which proved to be papillary carcinoma.
b) Sagittal image of predominantly solid nodule (arrowheads), which proved to be benign at cytologic examination.
c) Transverse image of mixed solid and cystic nodule (calipers), which proved to be benign at cytologic examination.
d) Sagittal image of predominantly cystic nodule (calipers), which proved to be benign at cytologic examination.
e) Sagittal image of cystic nodule (arrowheads). FNA of this presumed benign lesion was not performed because the nodule appears entirely cystic.

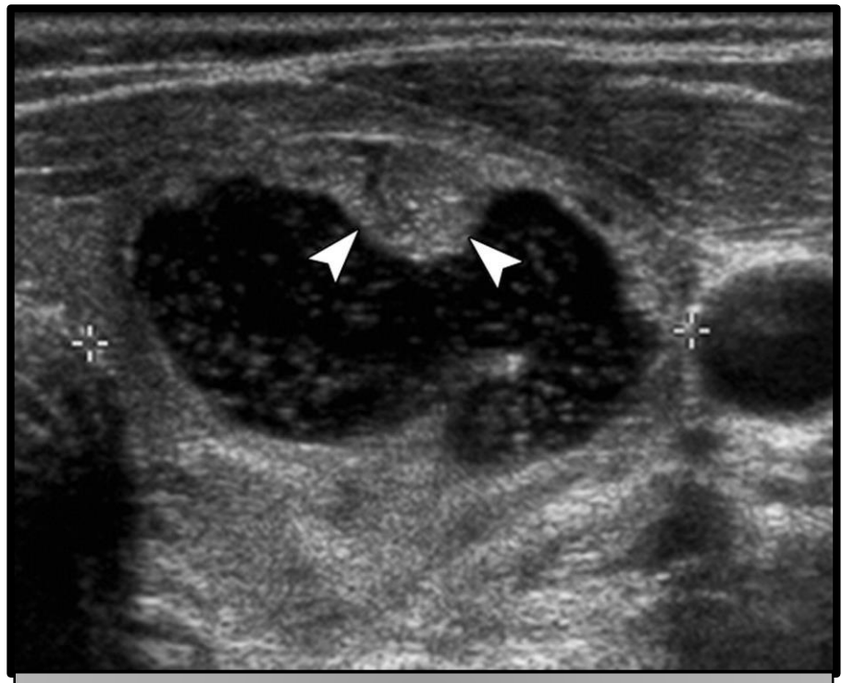


Papillary carcinoma

Predominantly solid thyroid nodule

Role of color Doppler US.

a) Transverse gray-scale image of predominantly solid thyroid nodule (calipers).
b) Addition of color Doppler mode shows marked internal vascularity, indicating increased likelihood that nodule is malignant. This was a papillary carcinoma.



The lesion was benign at cytologic examination

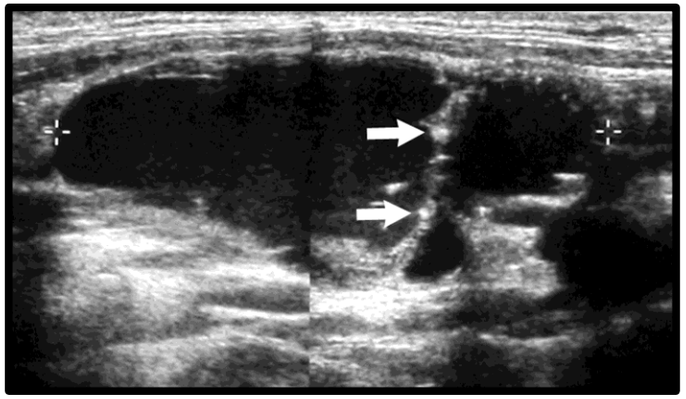
Predominantly cystic nodule with small solid-appearing mural component

Transverse US images of mostly cystic thyroid nodule with a mural component containing flow.

a) Gray-scale image shows predominantly cystic nodule (calipers) with small solid-appearing mural component (arrowheads).
b) Addition of color Doppler mode demonstrates flow within mural component (arrowheads), confirming that it is tissue and not debris. **US-guided FNA can be directed into this area**. The lesion was benign at cytologic examination.

US features of Malignant lymph nodes

- Rounded bulging shape.
- Increased size.
- Replaced fatty hilum (White) .
- Irregular margins.
- Heterogeneous echotexture.
- Calcifications.
- Cystic areas.
- Vascularity throughout the lymph node instead of normal central hilar vessels at Doppler imaging.



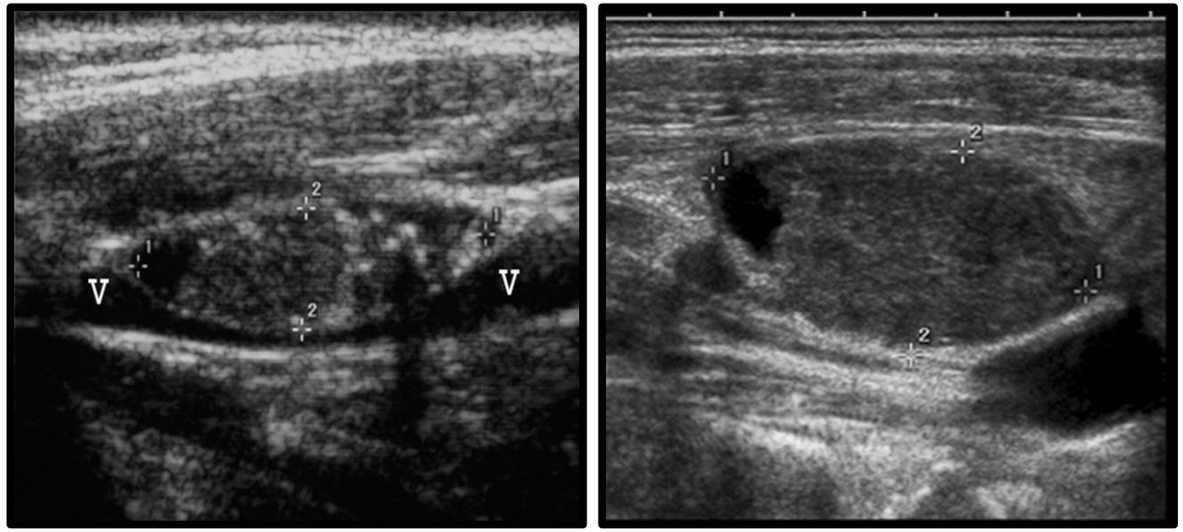
Papillary carcinoma and cystic lymph node metastasis in a 28-year-old woman.

(a) Longitudinal sonogram of the right lobe of the thyroid shows an irregular hypoechoic tumor with microcalcifications.

(b) Longitudinal sonogram of the right neck shows a cystic level 5 nodal metastasis with internal septation and foci of calcification (arrows).

(c) Axial contrast-enhanced CT image shows the metastasis (arrow).

Metastatic papillary carcinoma



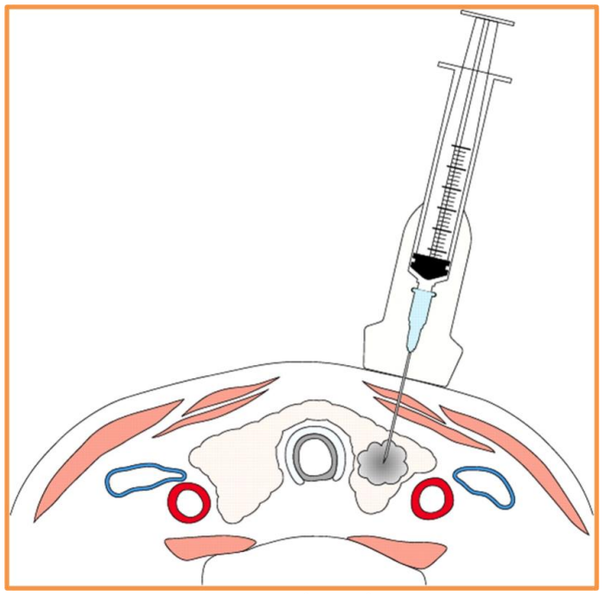
a b

Abnormal cervical lymph nodes.

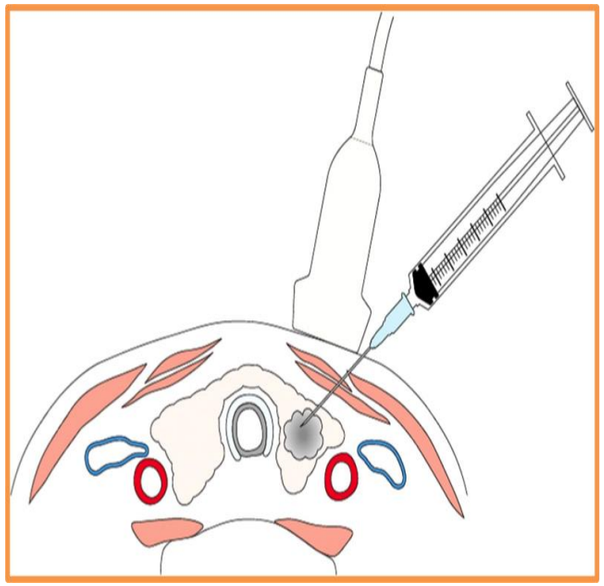
(a) Sagittal US image of enlarged node (calipers) with central punctate echogenicities, consistent with microcalcifications, shows mass effect on internal jugular vein (V). Node was proved to be metastatic papillary carcinoma.

(b) Sagittal US image of enlarged node (calipers) with cystic component. Node was proved to be metastatic papillary carcinoma.

US-guided FNA Technique

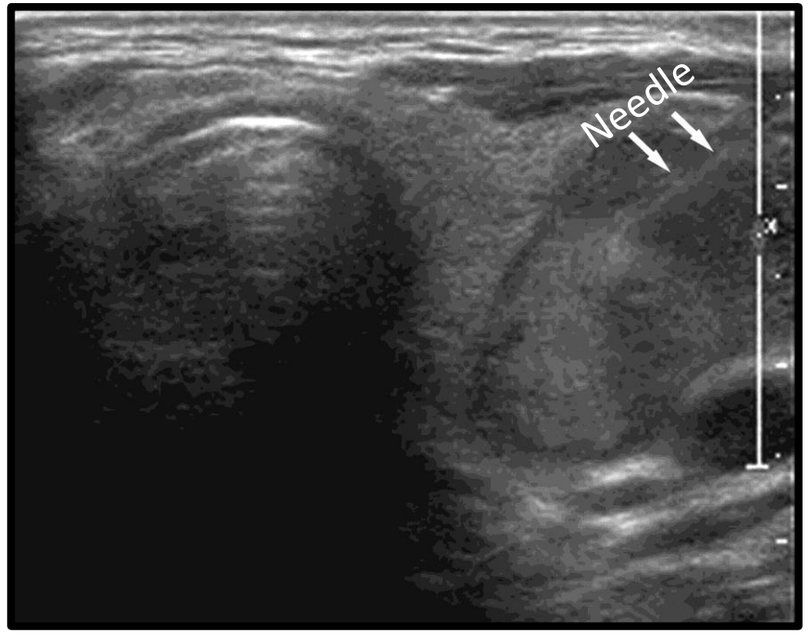


perpendicular



parallel

- 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.

(a) Diagram shows insertion of the needle in a plane parallel to that of scanning.

(b) US image, obtained with the transducer and needle positioned as in a, depicts the entire length of the needle (arrows) within the nodule.

Thyroid Ophthalmopathy (Graves' Disease)

Clinical history:

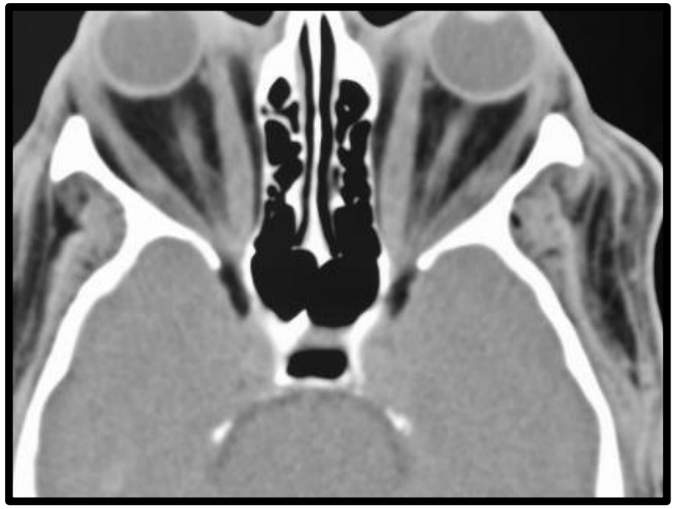
- Slow onset (months)
- painless exophthalmos

Patterns of muscle involvement in thyroid opthalmopathy:

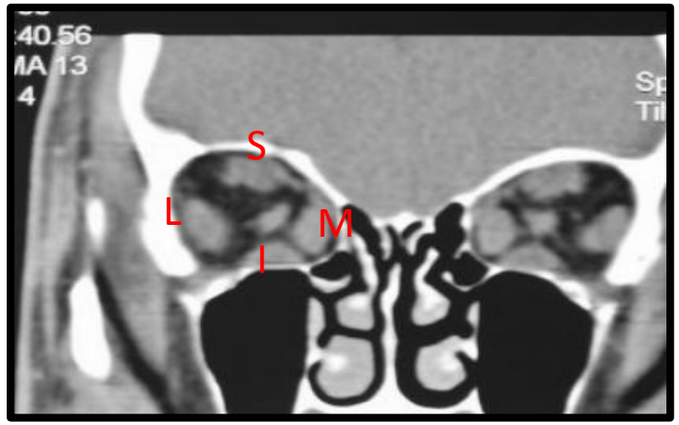
1. Bilateral (85%)
2. Unilateral (5%)
3. Normal muscles (10%)

- 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.
- There will be a retro palpable fat ⟶ enlargement of extraocular muscle ⟶ infiltration within extraocular muscle

⟶ the tendon will separated



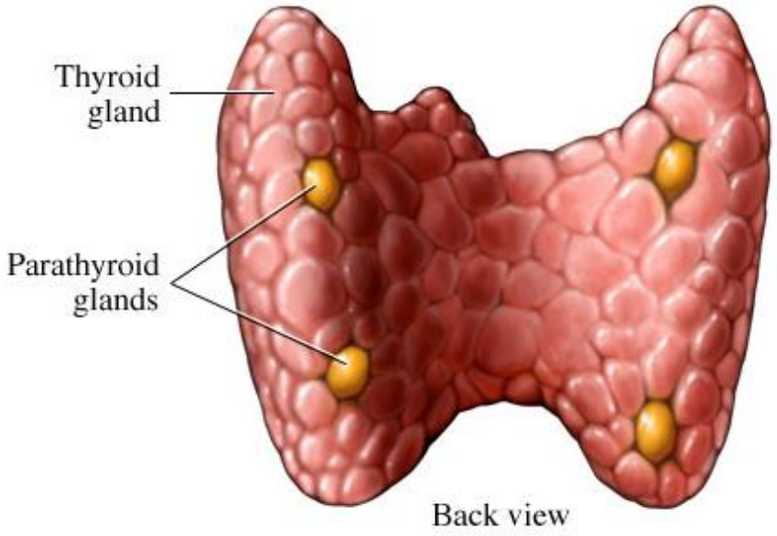
- The muscle is enlarged.
- the optic nerve is stretch.
- there is a retro palpable fat.
- and is symmetrical.



Coronal imaging is the method of choice for assessing muscle thickness

Anatomy of the Parathyroid Gland

- Two pairs of glands usually positioned behind the left and right lobes of the thyroid.
- Typically 4 parathyroid glands (Superior and Inferior) parathyroid glands.

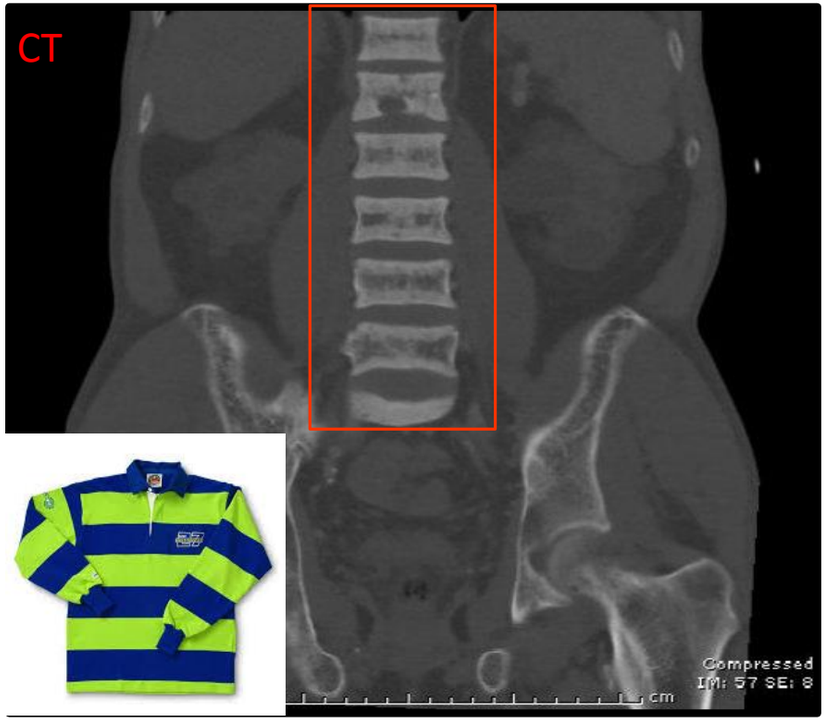


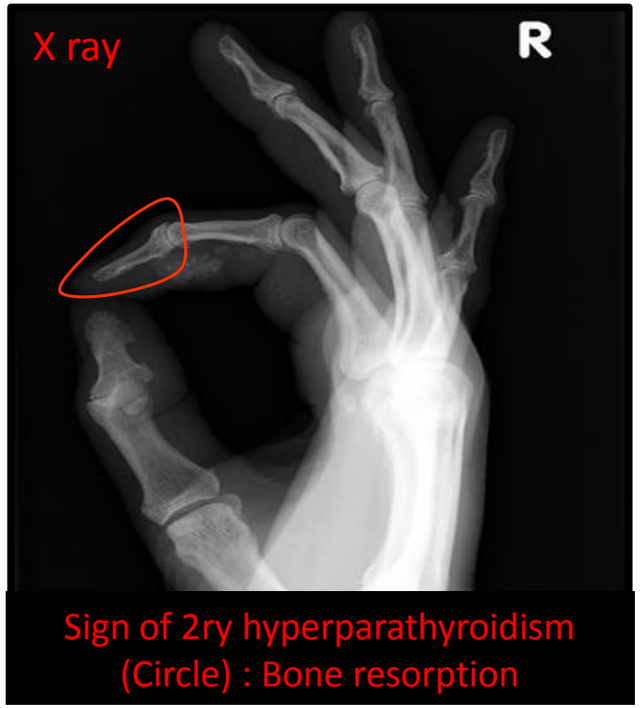
Renal Osteodystrophy

- Seen in setting of chronic, end-stage renal disease.
- Related to combination of :
  1. Osteomalacia.
  2. Secondary hyperparathyroidism

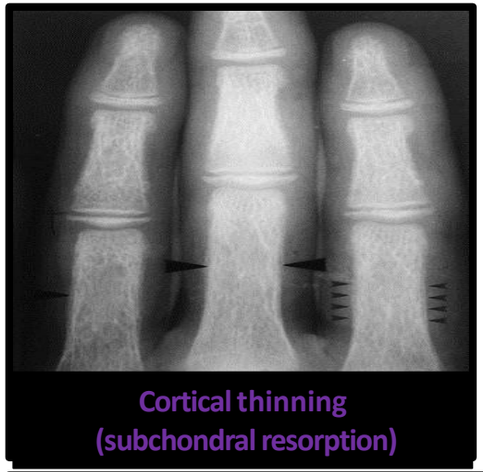
Clinical features

- Bone resorption mainly (Sub-periosteal)
- Cortical thinning.
- Soft tissue and vascular calcifications
- Osteosclerosis
- Brown tumors (it slightly greater in primary(3%) than in secondary(2%) hyperparathyroidism) .

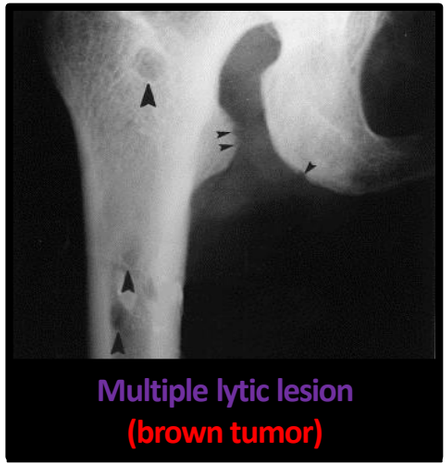




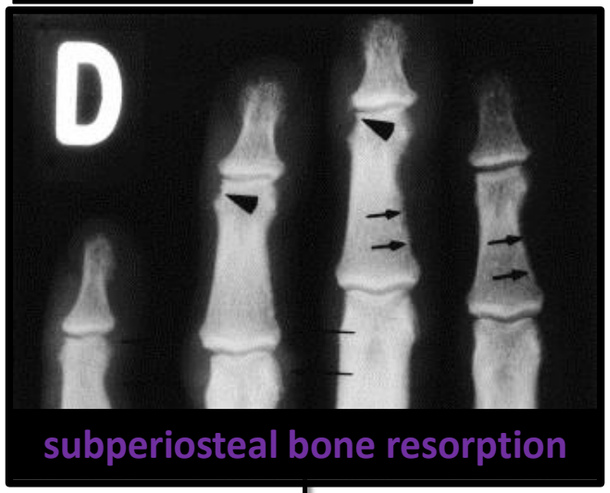
Sign of 2ry hyperparathyroidism (Circle) : Bone resorption



Cortical thinning (subchondral resorption)



Multiple lytic lesion (brown tumor)



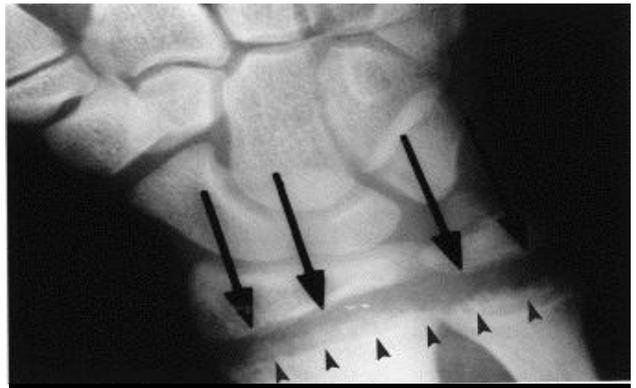
subperiosteal bone resorption

Rugger jersey spine

- Osteopenia(black) is most common finding; however, 10-20% of patients also exhibit osteosclerosis(white).
- Characteristic finding of <u>osteosclerosis</u> 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.



Subligamental resorption (at the site of attachement to the ligament)

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

Doctor's questions on thyroid lecture:

Q1: What is the difference between thyrotoxicosis & hyperthyroidism?

Ans: Both of them is characterized by elevated thyroid hormones except that:

Thyrotoxicosis is due to any cause.

Hyperthyroidism is due to thyroid hyper function.

Q2: What is the difference between Graves' disease & Toxic multi-nodular goiter on imaging finding?

Ans:

Graves' disease: Symmetrical enlargement of both lobes.

Toxic multi-nodular goiter: Asymmetrical enlargement of the lobes.

Q3: What is the difference between hot nodule and autonomous nodule in thyroid scan images ?

Ans:

Hot nodule : Present of thyroid outline.

Autonomous nodule : Absent of thyroid outline.

Q4: What is the first modality used to investigate a palpable thyroid nodule?

Ans: US.

Q5: What is the most accurate and cost-effective method for diagnostic evaluation of thyroid nodules.

Ans: FNA.

Q6: What is scintigraphy?

Ans: Diagnostic test used in nuclear medicine.

Notes:

1) Micro-calcifications & reduced echogenicity are signs of malignancy.
2) Presence of halo & well-defined regular margins are signs of benign lesion.
3) Ophthalmopathy in Graves' Disease is mostly bilateral (85%) sparing the tendon.
4) Renal osteo-dystrophy: in ESRD there is:

↓Vit. D → ↓ Ca → ↑ PTH → ↑ Bone resorption → Fractures. (Brown tumors are often present).

Thank You!

We hope you found this helpful and informative.

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