

432
Radiology
Team



(3): Thyroid And Parathyroid Glands



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COLOR GUIDE: • Females' Notes • Males' Notes • Important • Additional

Objectives

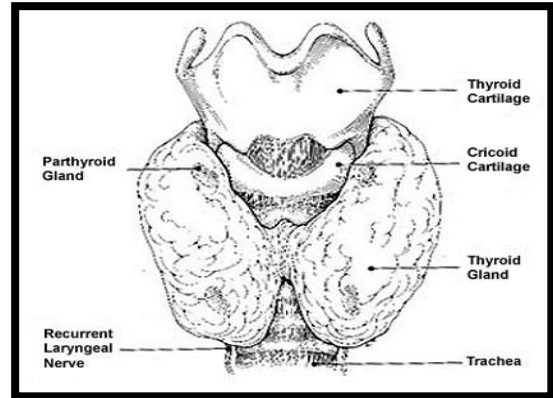
-Not mentioned

Anatomy of the Thyroid gland

- **Location:** at neck at C5-T1, overlays 2nd – 4th tracheal rings (most important)
- Average width: 12-15 mm (each lobe)
- Average height: 50-60 mm long

Thyroid Diseases

- Thyrotoxicosis
- Hypothyroidism
- 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**.

Note(s):

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-Hyperthyroidism causes thyrotoxicosis but not every thyrotoxicosis is due to hyperthyroidism.
- in thyrotoxicosis the elevated thyroid hormones are specifically T4 (free thyroxine) and T3 (triiodothyronine).

Causes of Thyrotoxicosis:

- Hyperthyroidism:
 - 1- Diffuse toxic goiter (Graves' disease).
 - 2- Single toxic nodule.
 - 3- Toxic multi-nodular 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.**

Note(s):

Hyperthyroidism and thyrotoxicosis are not synonyms.

It's very important to differentiate between thyrotoxicosis caused by hyperthyroidism (accelerate the biosynthesis of the hormone and its secretion from the gland) or other causes of thyrotoxicosis like inflammation which causes release of the hormones without accelerating its synthesis, or when taking exogenous thyroid hormone it can cause thyrotoxicosis as well.

-Why is it important? For the management and treatment

-In addition to TFT, you need to do thyroid scan to determine the cause 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**
- Follicular cell traps iodine and organifys it to be incorporated with thyroid hormone.

Imaging findings:

- Symmetric or asymmetric lobes.
- Homogeneous or inhomogeneous uptake
- Nodules; cold or hot

Note(s):

-By the iodine uptake we comment on 3 things if the lobes are:

1-symmetrical or asymmetrical

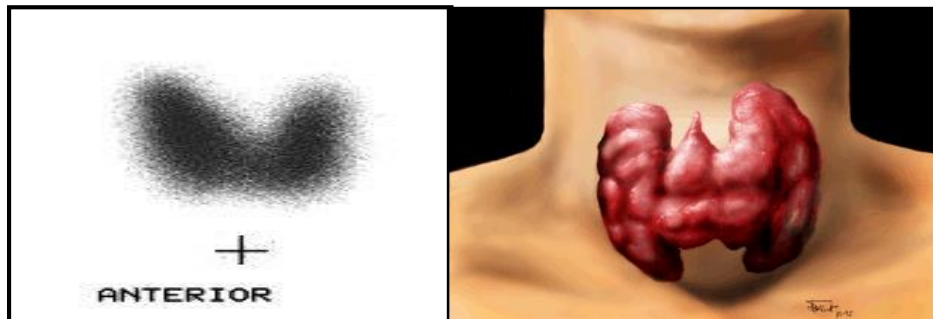
2-homogenous (all colored no gaps) or not

3-cold (no iodine uptake appears like an empty spot) or hot nodule (active nodule uptakes the iodine -dark colored spot-)

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%** (mean of 40%).



Note(s):

~~~~~  
*-autoimmune disorder*

*-presence of circulating antibodies directed at TSH receptors; stimulate the receptors  
 excessive thyroid hormone leads to hyperthyroidism*

*-Symptoms of grave's disease: 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.*

**-in order to differentiate between grave's and multinodular goiter you check if there are nodules or not, plus loss of homogeneity and not symmetrical.**

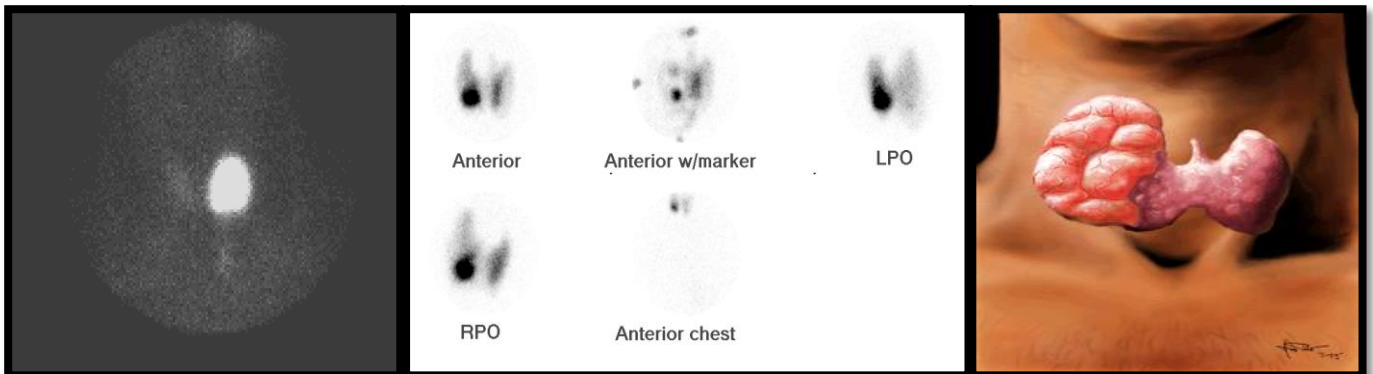
**-and to differentiate between grave's and normal thyroid since both are symmetrical and homogenous, is through the amount of the uptake whether iodine or technetium 99-m.**

**Normal uptake of Tech99-m : 0.5-4 (> 4 = Grave's disease) (<0.5 = hypothyroidism )**

**In Grave's: High intake of iodine, homogenous appearance of both lobes, bilateral enlargement ( symmetrical )**

## 2-Single Toxic Nodule

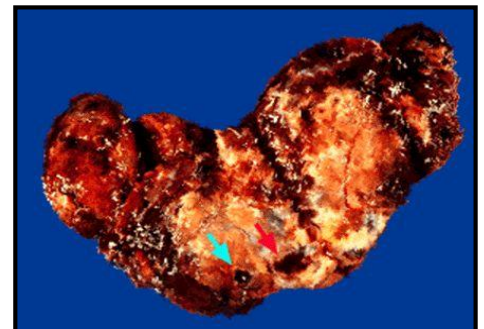
- Single hot nodule (independent of TSH or autonomous).
- Rest of thyroid gland is poorly visualized due to low TSH level (TSH dependant).
- 24-hour RAI uptake is slightly elevated, usually around 20%.



\*singular, high uptake of iodine and the rest of the thyroid is dark or vice versa according to imaging manipulation.

## 3-Toxic Multi-Nodular Goiter

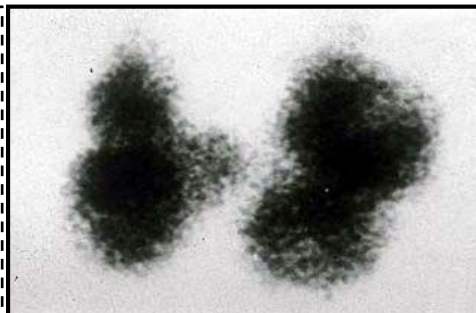
- Mild inhomogeneous uptake in thyroid gland.
- Multiple cold and hot nodules in both thyroid lobes.
- 24-hour uptake is mildly elevated, usually between 20%-30%.



Asymmetrical lobes with irregular edges

Multinodules , mixture of hot and cold ( dark and white spots)

Inhomogeneous



Cut surface of one lobe of thyroid gland showing ill defined nodules.

- Focus of cystic degeneration seen (blue arrow).
- Some hemorrhage (red arrow) and some scarring.

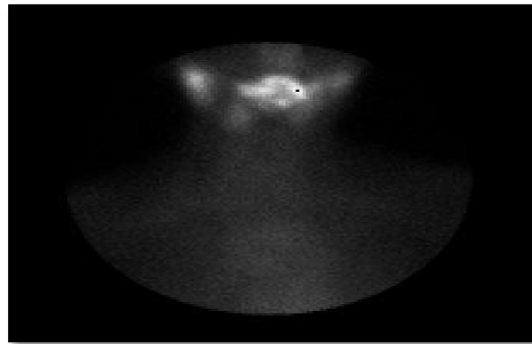
## 2-Early Phase Sub-acute Thyroiditis

- **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%**.

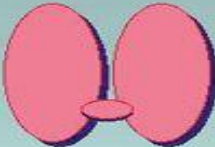





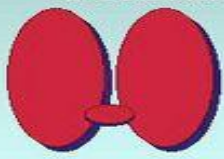

-Very low uptake of iodine, lobes are not showing in the picture

-The white structures are the mandibular glands

-Thyroiditis lead to hypothyroidism at the end



### Thyroid Scan in Thyrotoxicosis

|                                                                                     |                                                                                     |                                                                                      |                                                                                       |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|  |  |   |  |
| <b>Graves' Disease</b>                                                              |                                                                                     | <b>Follicular Adenoma</b>                                                            |                                                                                       |
|  |  |  |  |
| <b>Multinodular Goiter</b>                                                          |                                                                                     | <b>Subacute Thyroiditis</b>                                                          |                                                                                       |

### 3-Hypothyroidism

- The main cause is **chronic thyroiditis (Hashimoto's thyroiditis)**.
- **TSH is elevated.**
- **Thyroid scan does not have significant diagnostic value in this entity .**
- However, if there is **nodule/nodules confirmed by physical examination and ultrasound, thyroid scan may be helpful.**

### 4-Thyroid Nodules

- thyroid nodules are common, perhaps existing in almost half 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**
- 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% **(both are high)**

#### **Note(s):**

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-If nodules were found, **US is the initial test. Best diagnostic method is fine needle aspiration.** You do **nuclear scan** to check the **nodules function (hot or cold) and staging of carcinomas**

-If there were **signs of hyperthyroidism** you do **nuclear scan** otherwise you just do **FNA**

-**nuclear scan was never a diagnostic method in a nodular thyroid**
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# Frequency of Occurrence of Thyroid Malignancies

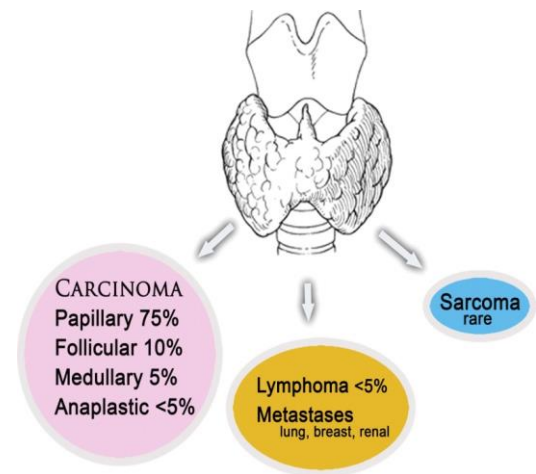
## Risk factors for thyroid cancer

- family history of **thyroid** cancer
- a history of head and neck irradiation
- male sex

-we always worry when a man presents with a nodule in his thyroid unlike females.

-Thyroid diseases are more common in females

- age of less than 30 years or more than 60 years,
- previous diagnosis of type 2 multiple endocrine neoplasia



## US features of thyroid nodules

- there is some overlap between the US appearance of benign nodules and that of malignant nodules
- certain US features are helpful in differentiating between the two. These features include

1. **micro-calcifications**
2. **local invasion**
3. **lymph node metastases**
4. **a nodule that is taller than it is wide**
5. **markedly reduced echogenicity.**

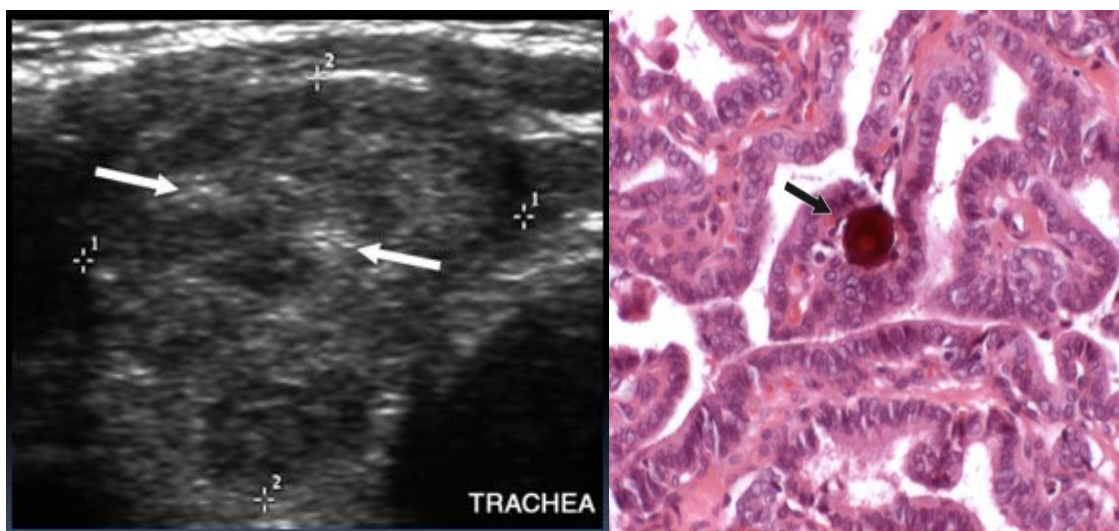


- Other features, such as the **absence of a halo**, **ill-defined irregular margins**, **solid composition**, and **vascularity**, are less specific but may be useful.

| *Only this square is important<br>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                          |

## Thyroid microcalcifications

- They are psammoma bodies, which are 10–100- $\mu$ m 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 41.8%–94.2%



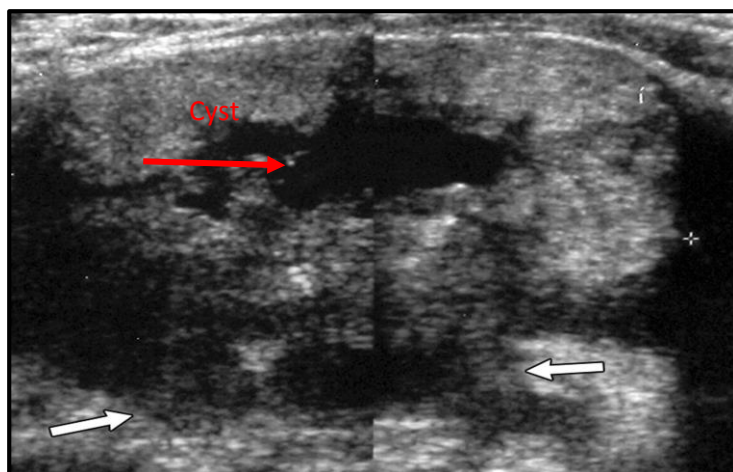
**Papillary thyroid carcinoma in a 42-year-old man.** (a) Photomicrograph (original magnification,  $\times 400$ ; hematoxylineosin stain) shows a psammoma body (arrow), a round laminar crystalline calcification. (b) Transverse sonogram of the right lobe of the thyroid demonstrates punctate echogenic foci=microcalcification without posterior acoustic shadowing. findings indicative of microcalcifications (arrows).

## Local Invasion and Lymph Node Metastases

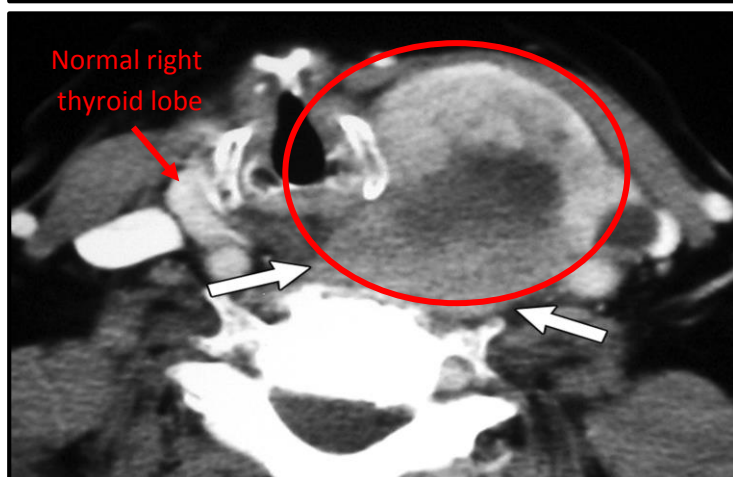
- US features that should arouse suspicion about lymph node metastases include a rounded bulging shape, increased size, replaced fatty hilum, irregular margins, heterogeneous echotexture, calcifications, cystic areas and vascularity throughout the lymph node instead of normal central hilar vessels at Doppler imaging

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

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



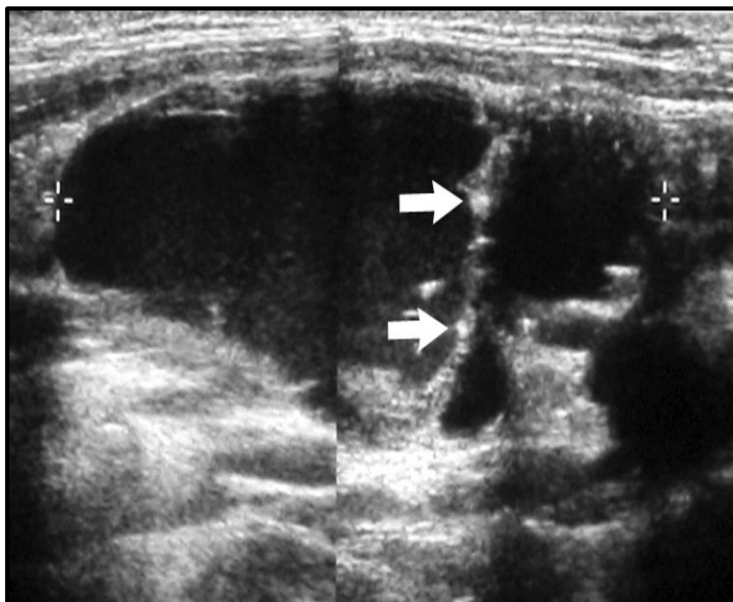
(Axial contrast-enhanced CT image shows a large enhancing tumor with central area of cystic necrotic component and with invasion of the prevertebral muscle (arrows). Proven to be anaplastic thyroid carcinoma.



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

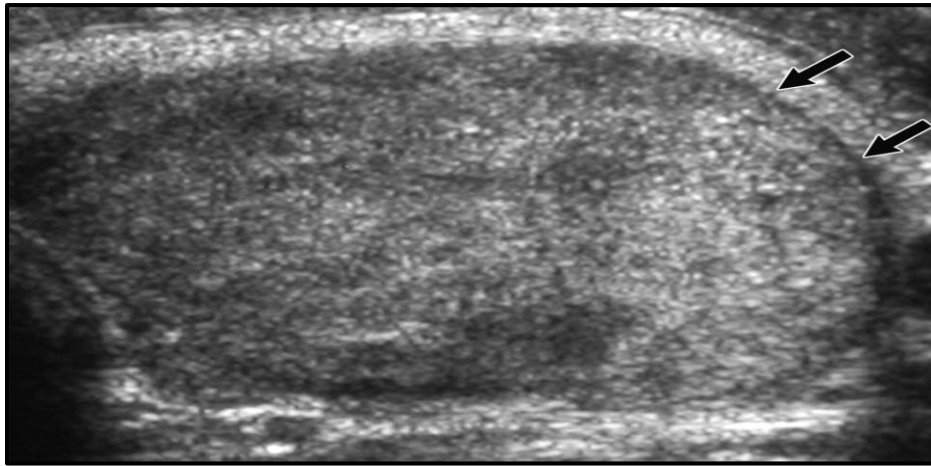
(a) Longitudinal sonogram of the right lobe of the thyroid shows an irregular hypoechoic tumor with microcalcifications.

(b) Longitudinal sonogram of the right neck shows a large lymph node (not thyroid) with internal irregular septation and echogenic foci (microcalcification) (arrows).



## Margins, Contour, and Shape

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



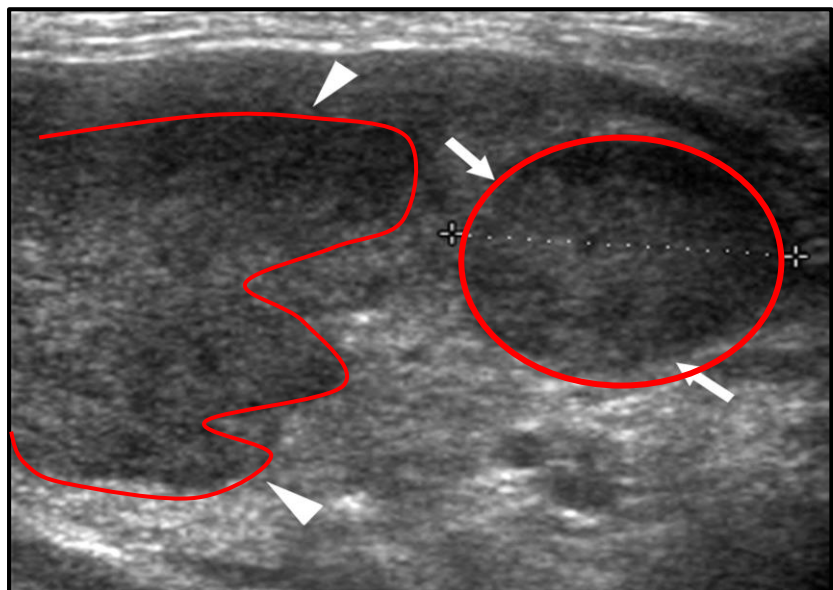
**Follicular adenoma in a 30-year-old woman.** Transverse sonogram of the left lobe of the thyroid shows a **follicular adenoma (benign lesion)** with a **hypoechoic halo (thin black line)** (arrows)

## Vascularity

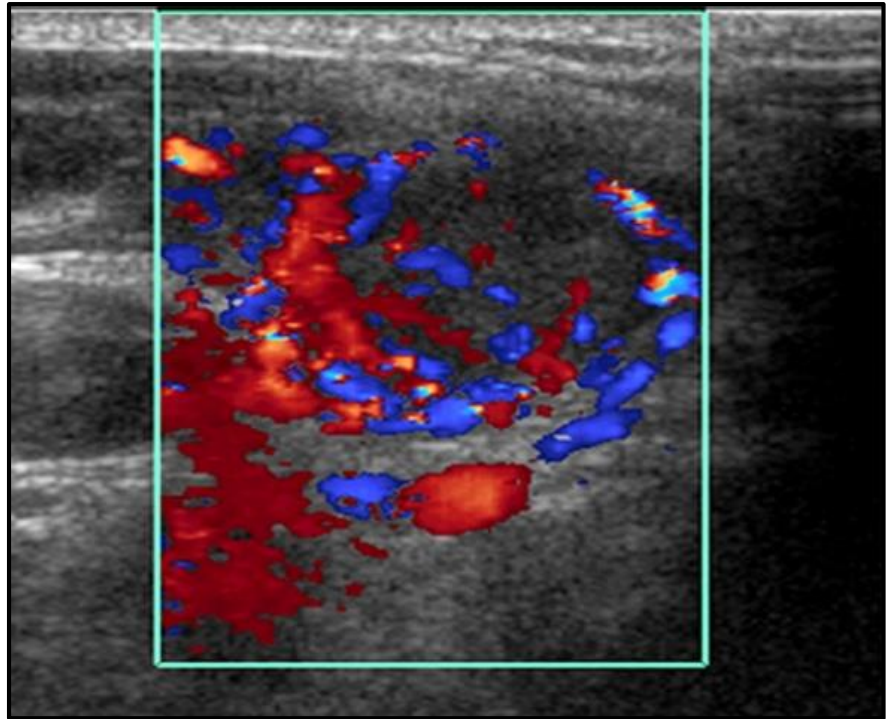
- Papillary thyroid carcinomas had some intrinsic blood flow (internal vascularity is more likely to be malignant)
- Avascular nodule is very unlikely to be malignant.

**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).

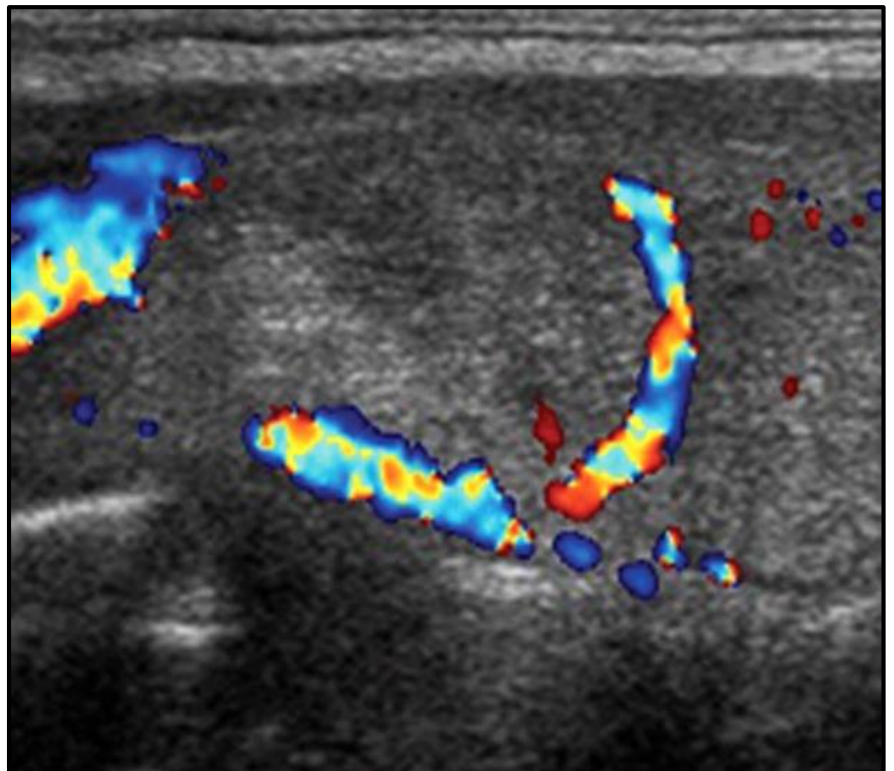


Color Doppler sonogram of the round nodule shows increased internal vascularity



**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 .



## Hypoechoic Solid Nodule

Marked **hypoechoogenicity** 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 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 Feature

## 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 $\geq 1$ cm                                                                                        |
| Solid (or almost entirely solid) or coarse calcifications                               | Strongly consider US-guided FNA if $\geq 1.5$ cm                                                                                      |
| Mixed solid and cystic or almost entirely cystic with solid mural component             | Consider US-guided FNA if $\geq 2$ 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 &  $\geq 1.5$  cm  $\rightarrow$  do FNA

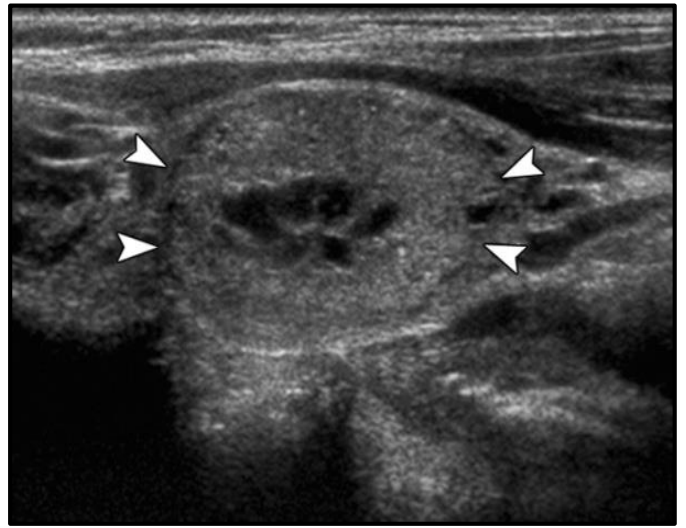
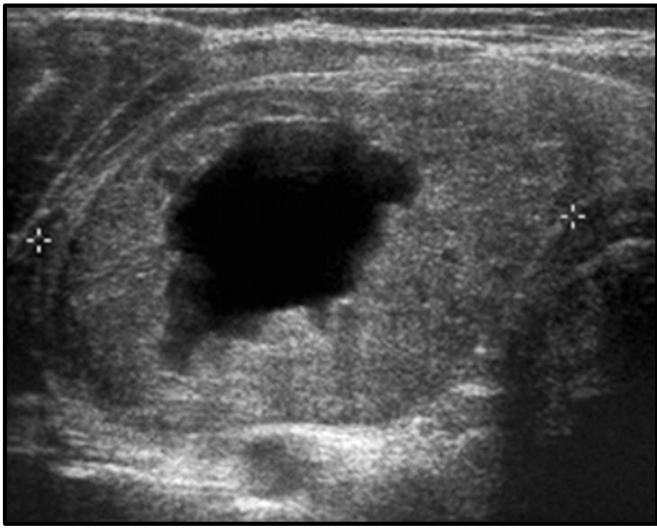
From Team431

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

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

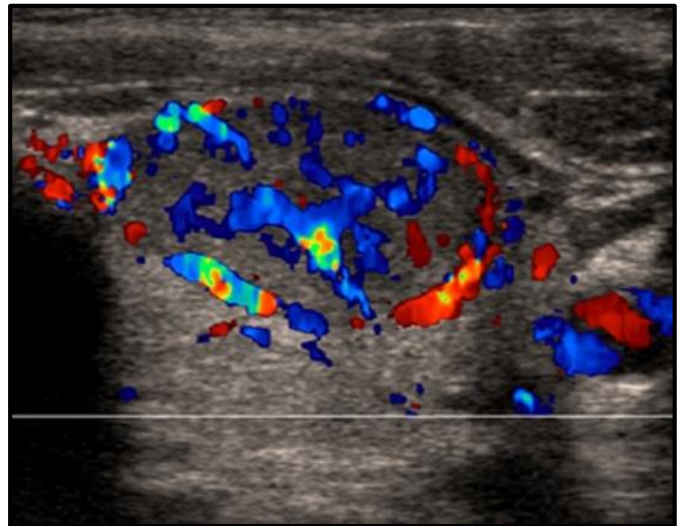
If there is Multiple nodules  $\rightarrow$  choose the most suspicious one and do FNA

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.

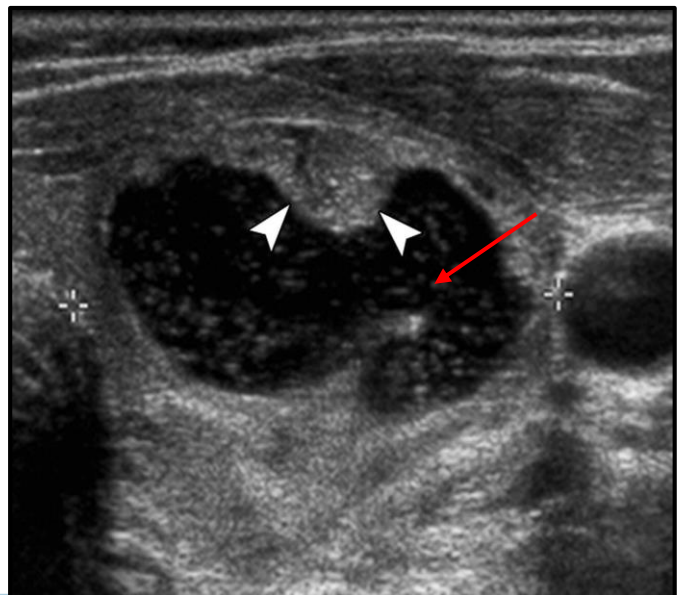


US images of thyroid nodules of **varying parenchymal composition (solid to cystic)** both are benign

color Doppler mode **shows marked internal vascularity**, indicating **increased likelihood that nodule is malignant**. This was a papillary carcinoma.



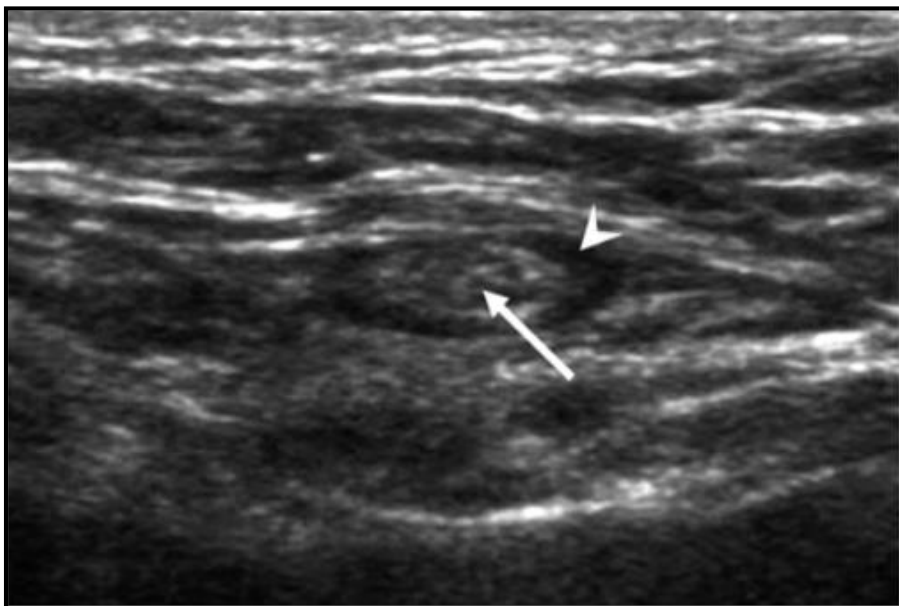
cystic nodule (calipers) with peripheral solid component with **multiple echogenic spots** (which means a complicated cyst) (arrowheads). And the posterior enhancement indicates that the lesion is cystic not solid (benign)





## US features of malignant lymph node

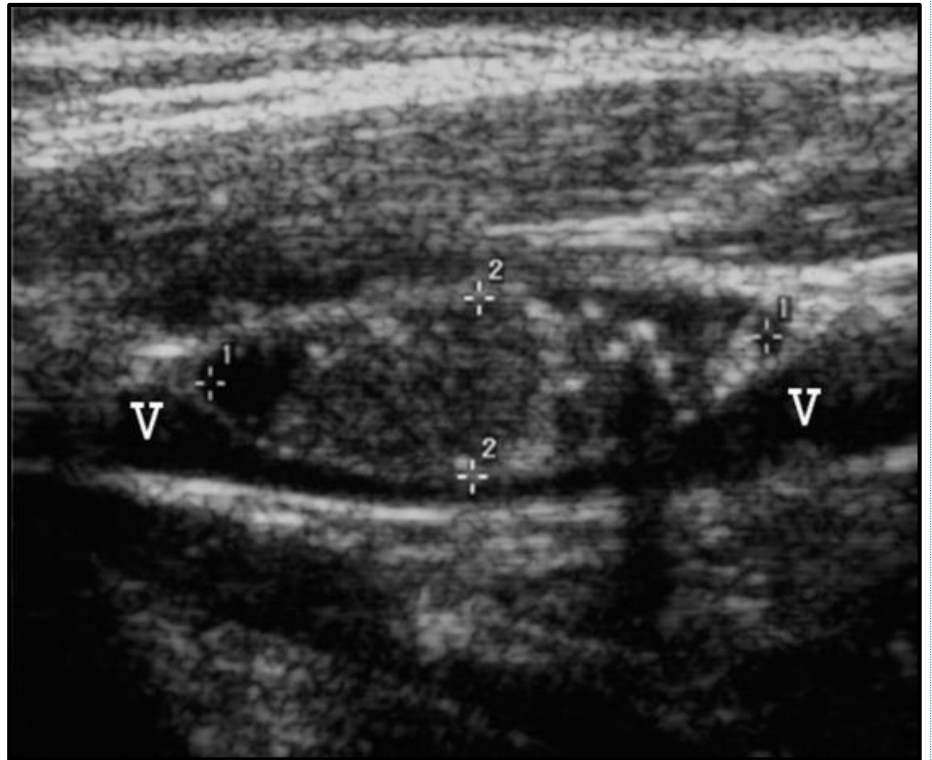
- rounded bulging shape
- increased size,
- replaced fatty hilum
- irregular margins
- heterogeneous echotexture
- calcifications
- **cystic areas** (here it indicates malignancy unlike in thyroid nodules)
- vascularity throughout the lymph node instead of normal central hilar vessels at Doppler imaging



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 punctuate echogenicities**, consistent with **microcalcifications**, shows mass effect on internal jugular vein (V) and **no fatty hilum**. Node was proved to be metastatic papillary carcinoma.



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.



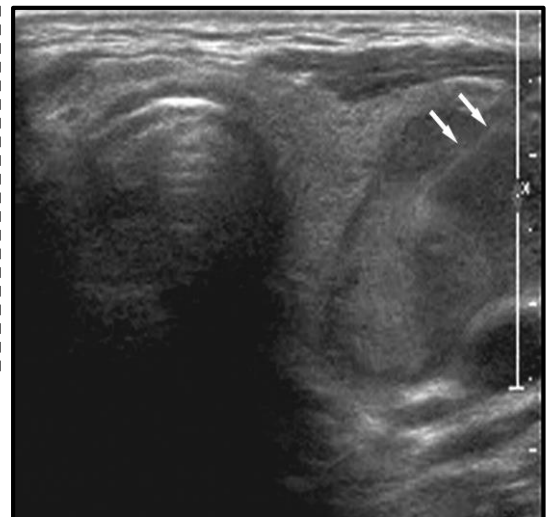
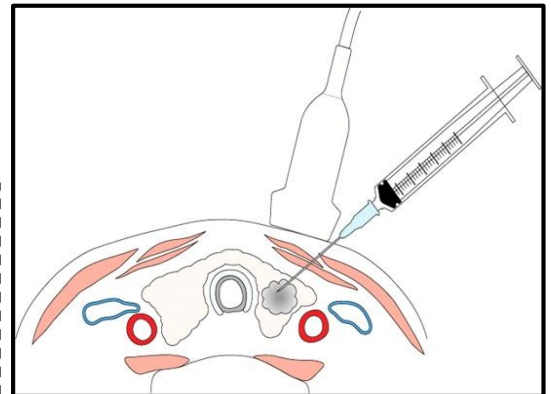
## US-guided FNA Technique

- 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.

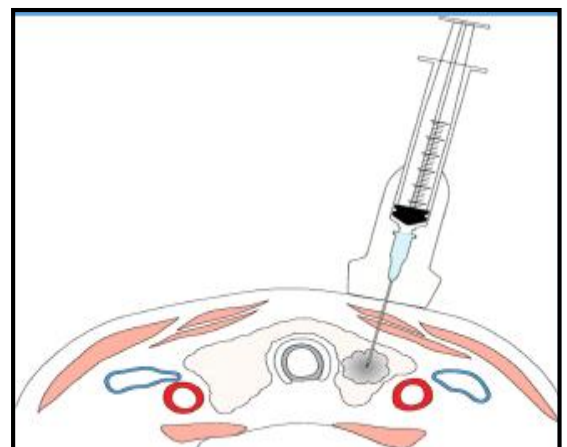
-This positioning helps maximize the number of needle-generated reflected echoes perpendicular to the sound wave and is preferred by many operators.

- 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's less likely that the carotid artery or jugular vein may be punctured. In an ultrasound only the tip of the needle will appear.



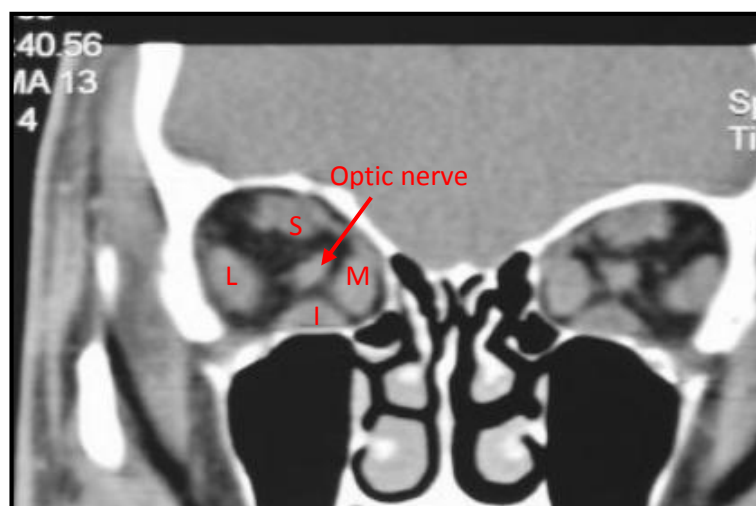
# Thyroid Ophthalmopathy Graves' Disease

Clinical history:

Slow onset (months), painless.

## 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, typically then are **inferior** and **medial recti** muscles
- **Lateral rectus muscle: last to become involved; rarely/never the only muscle involved**
- Muscle enlargement characteristically involves the body of the muscle, sparing the tendinous attachment to the globe.
- **I'M SLOW (inferior,medial,superior,lateral) → the order of the involvement (from 431)**
- **Coronal imaging** is the method of choice for assessing muscle thickness
- Patients need not be hyperthyroid (some are euthyroid)



# Parathyroid disease

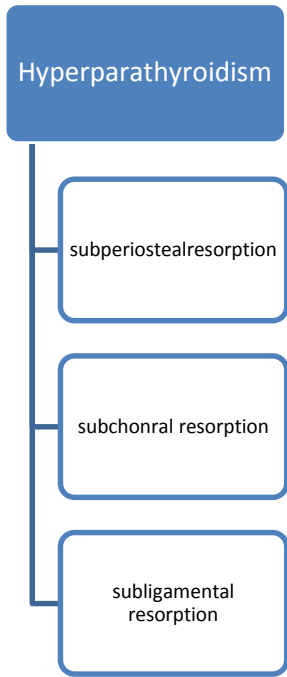
## Renal osteo-dystrophy

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

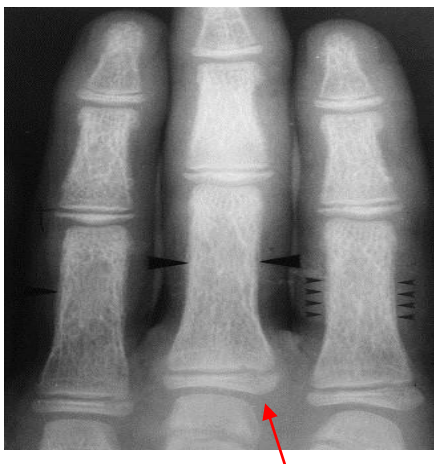


- Coronal CT of the lumbar vertebra e with multiple sclerotic bands at their ends.
- Rugger jersey spine
- Typical for renal osteodystrophy

- Additional signs of hyperparathyroidism such as:
  - 1) Resorption of secondary trabeculae
  - 2) Cortical thinning
  - 3) Subperiosteal bone resorption
  - 4) Brown tumors are often present
    - Both axial and appendicular skeleton involved.
    - Increased risk for pathologic fracture ( because it's a lytic lesion)



Calcification of the soft tissue (presentation of secondary hyperparathyroidism)

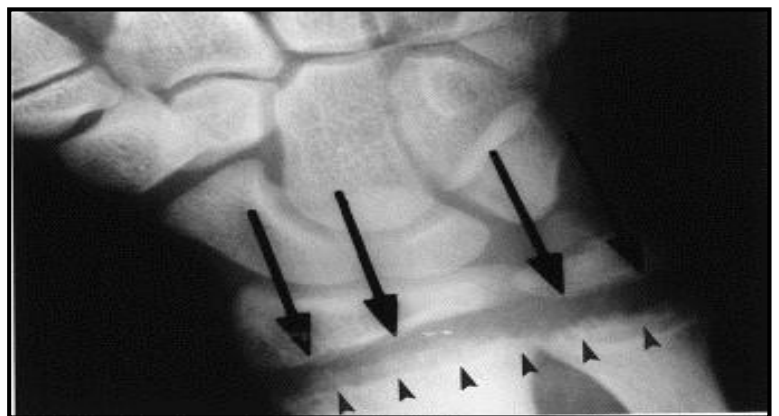


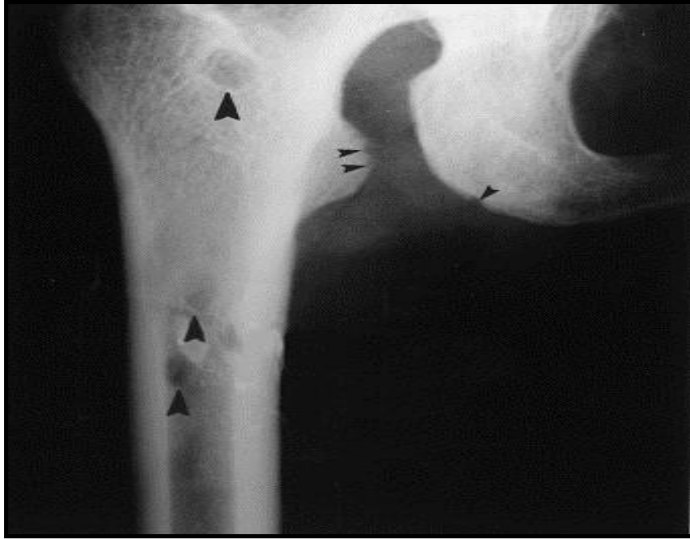
Subchondral resorption



Typical subperiosteal bone resorption at the radial aspects of the middle phalanges (small arrows) with bone resorption at the margins of the distal interphalangeal joints (arrowheads) and paraarticular soft tissue swelling of the proximal interphalangeal joint (thin arrows).

- Subligamentous resorption (at the site of attachment to the ligament)
- There is flaring in the wrist bone as well – hair like opacity- (mini arrow heads)





Brown Tumors (lytic lesion within bones)



"Rugger jersey spine"

## SUMMARY

- ❖ Thyroid location is between C5-T1, overlying 2<sup>nd</sup>-4<sup>th</sup> rings.
- ❖ Thyroid scan is a very helpful tool in differentiating between various causes of thyrotoxicosis.
- ❖ Radioactive iodine(RAI) is used for thyroid scan and uptake.
- ❖ Thyroid Nodule workup: 1<sup>st</sup> US-Scan , the Best is FNA and Nuclear (hot/cold/staging carcinomas).
- ❖ Early phase subacute thyroiditis has no nodules unlike toxic multinodular goiter which has cold and hot nodules.
- ❖ The malignant features of thyroid nodules are micro calcifications , local invasion, lymph node metastasis and a nodule that is taller than its width and markedly reduced echogenicity.
- ❖ Psammoma Bodies is the most specific feature of thyroid malignancy.
- ❖ Uniform Halo is Highly suggestive of benignity.
- ❖ Presence of multiple nodules should never be dismissed as a sign of benignity.
- ❖ Cystic areas in lymph nodes indicate malignancy unlike in thyroid nodules.
- ❖ Nonspecific ultrasound features of thyroid nodules for predicting or excluding malignancies: size of the nodule, number of nodules, interval growth of a nodule.
- ❖ Thyroid diseases are more common in women (benign) unlike in men. Which makes us worry about finding nodules in men because they are most likely malignant.
- ❖ All extra-Ocular muscle involvement is the most common scenario and the order of muscles with the highest incidence is **I'M SLOW(++Inferior, medial, superior,lateral --)**.
- ❖ **Coronal imaging** is the method of choice for assessing muscle thickness .  
Most important findings in renal osteo-dystrophy are: osteopenia, characteristic finding of osteosclerosis "Ruger jersey spine", cortical thinning, Brown tumors are often present.



## Questions

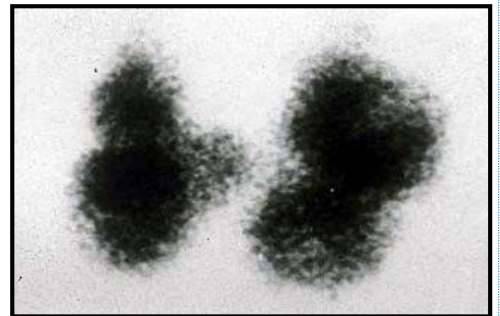
1) A 35 year old female presents with advanced SLE. The following x-ray represents:

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



2) A female patient came to the clinic with enlarged thyroid. She mentioned that she has been eating and sweating a lot lately, and been feeling tired in the past weeks. What's her diagnosis according to the nuclear scan?

- a. Grave's disease
- b. Sub-acute thyroiditis
- c. Hashimoto disease
- d. Toxic multinodular goiter



3) The nuclear scan type that's used for parathyroid is ?

- a) TC99 Sestambi.
- b) TC99 MDP.
- c) I123.
- d) I131.

**432 Radiology Team Leaders**

*Leader's Name*  
*Email address*

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### Answers:

1st Q : A

2nd Q : D.

3<sup>rd</sup> Q : A.