

Nuclear Radiology of Thyroid And Parathyroid

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CHAIRMAN OF RADIOLOGY

Radiology Team 429

In this team we used the outlines from the:

Doctor's slides

Lecture notes are in Red

427 Radiology team

Diagnostic Imaging –PETER ARMSTRONG
– 6Th Edition

Sorry we don't hold responsibility for any missing information or perhaps – perhaps -wrong material.

We tried our best to present this lecture in the best way, and we hope what we wrote is enough to cover the subjects.

Team Leaders:

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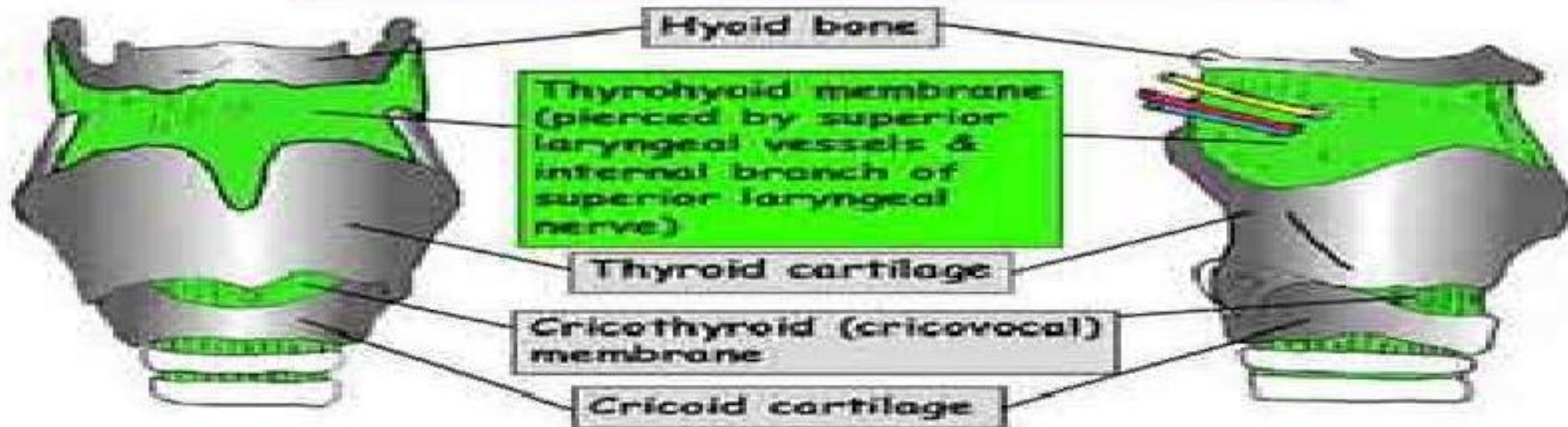
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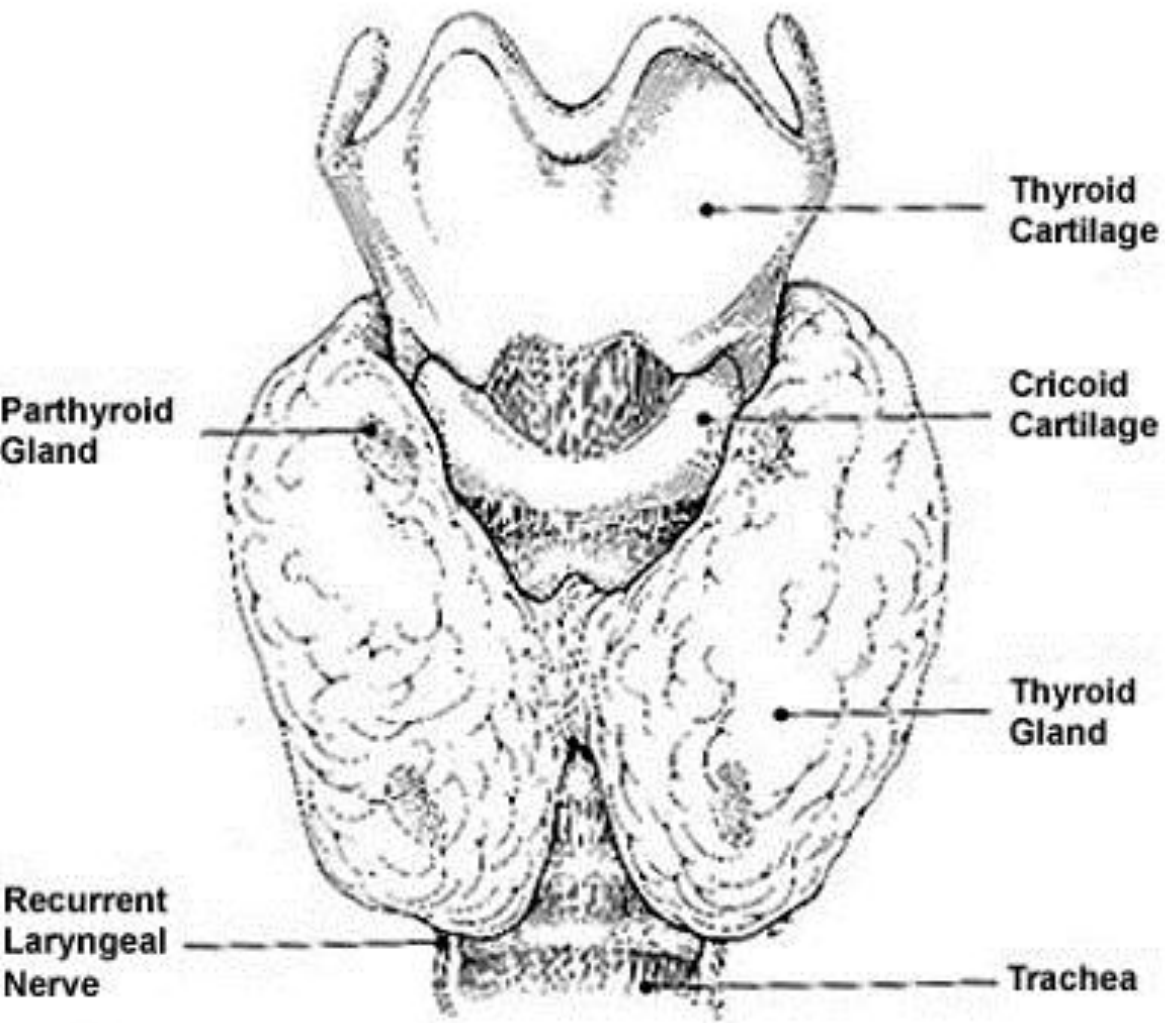
Special Thanks to Arwa Al Madani

Best Wishes :)

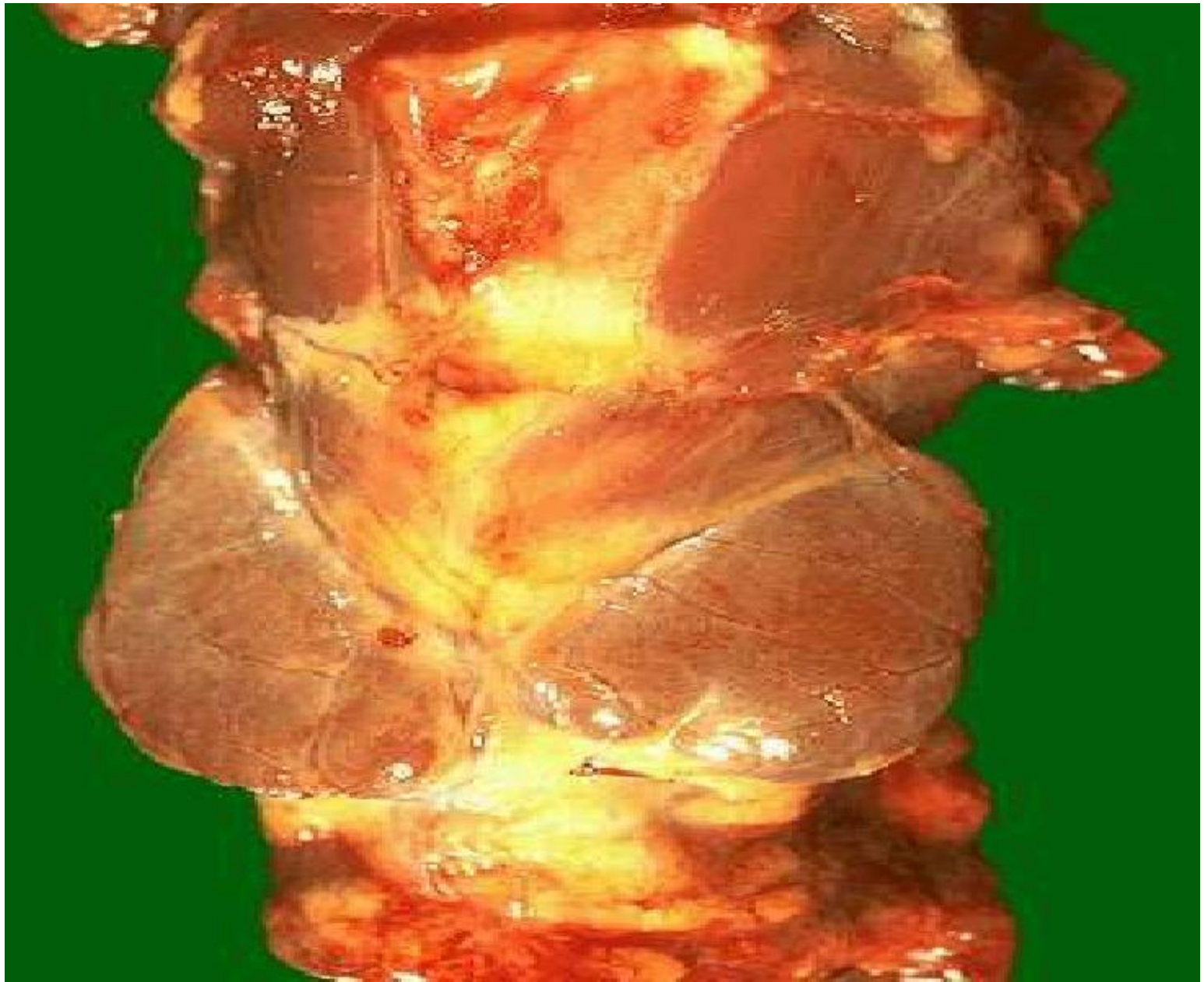
LARYNX - BONES/CARTILAGES



Larynx elevated by: Mylohyoid, digastric, stylohyoid, geniohyoid, thyrohyoid, stylopharyngeus, palatopharyngeus, salpingopharyngeus, inferior constrictor



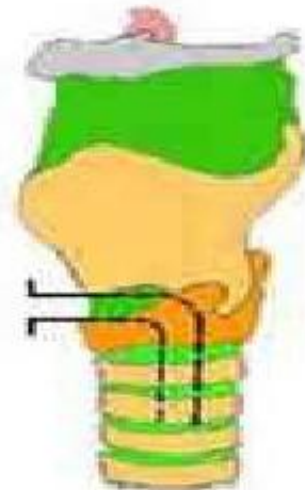
Thyroid is directly related to the thyroid cartilage
Above it



LARYNX - SURGICAL ACCESS



Emergency laryngotomy (cricothyroidotomy)
Quick, relatively easy stab through cricothyroid membrane. Insert any small round airway such as biro casing. Anaesthetic not essential. Saves lives



Formal tracheostomy.
Not usually an emergency. Needs full anaesthetic. Ideal for temporary or permanent intubation. Hole cut in 2nd & 3rd tracheal rings, usually after dividing thyroid isthmus. Inferior thyroid veins can be a nuisance



Know the relations

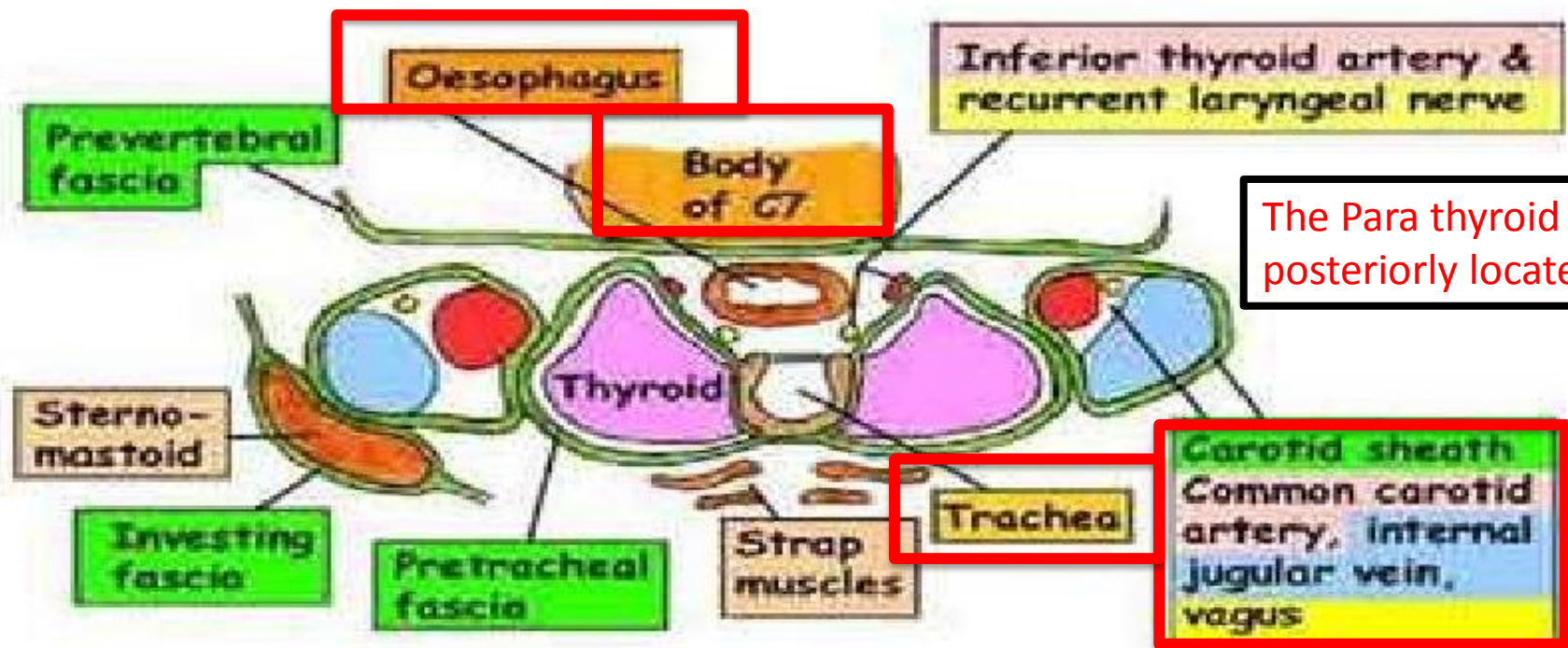
THYROID GLAND - AXIAL SECTION AT C7

Relations of thyroid gland

Posterior: Prevertebral fascia, carotid sheath, parathyroids, trachea

Medial: Recurrent laryngeal nerve, trachea, larynx, oesophagus

Anterior: Pretracheal fascia, sternohyoid, sternothyroid venous arch



Ct scan / axial with iv contracts /have thyroid (have to be humongous enhancement)

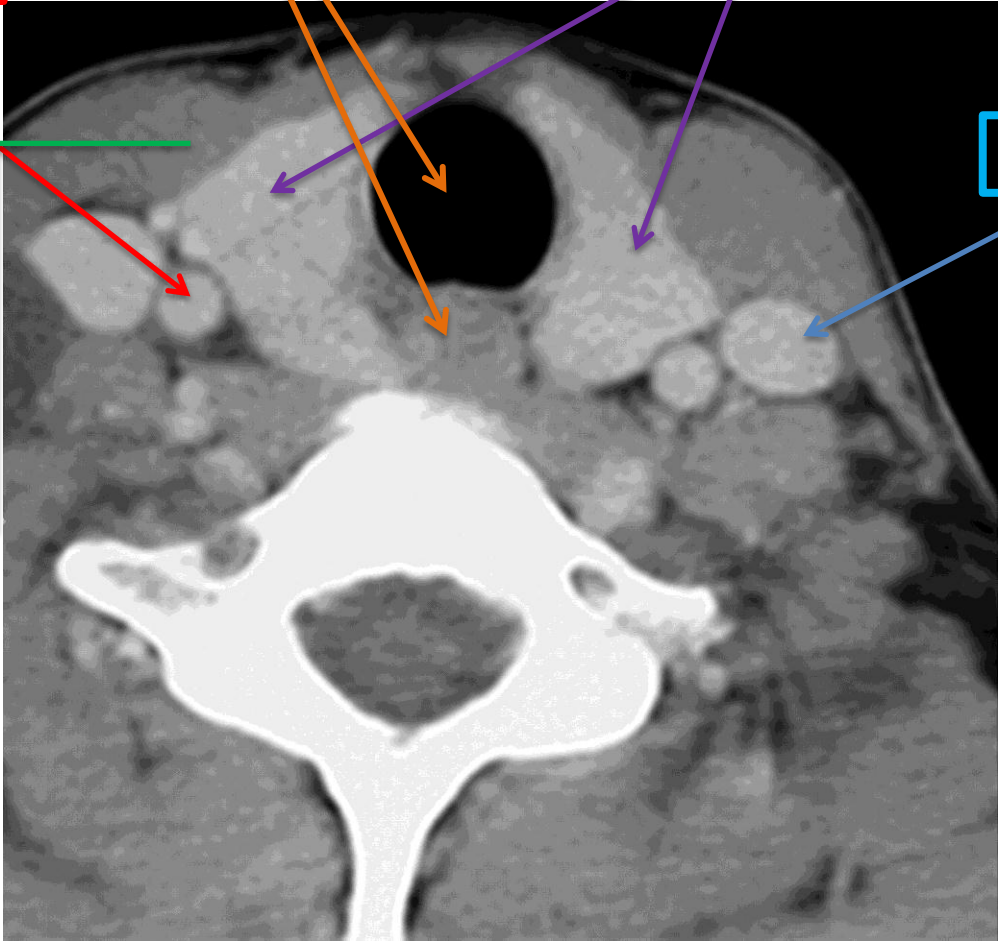
Medially : trachea & esophagus

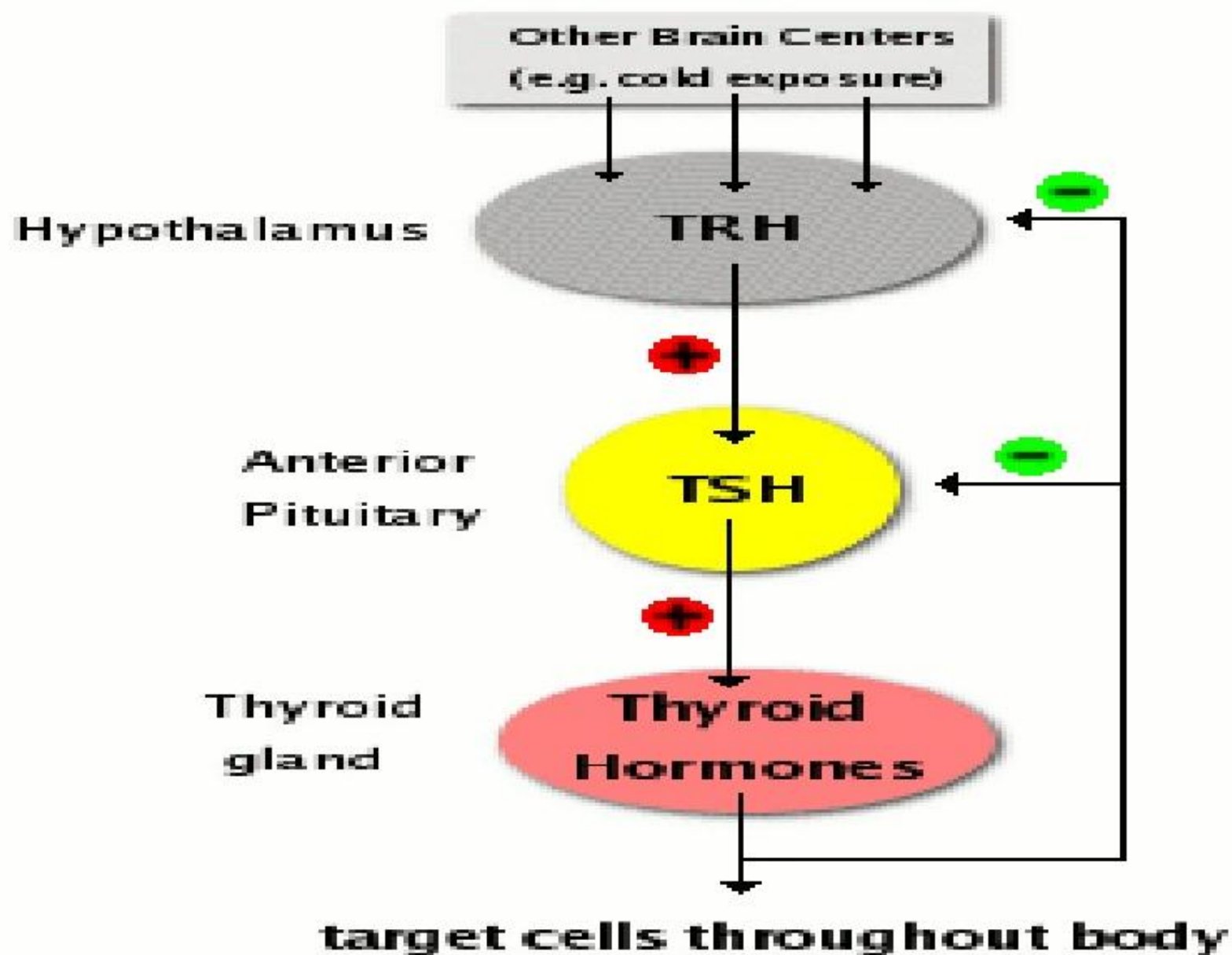
The pyramidal shape of the thyroid

laterally : Carotid

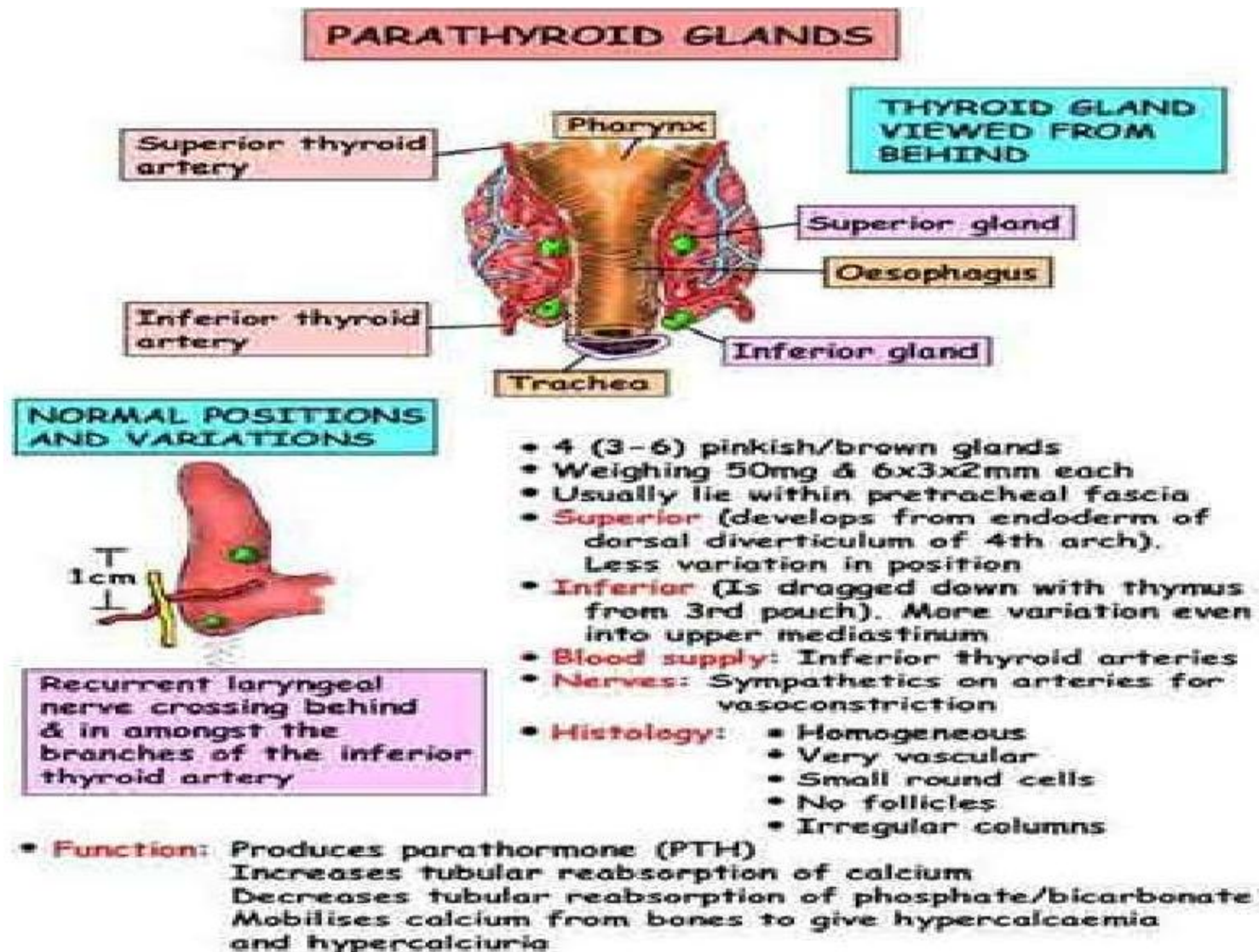
Laterally : Jugular

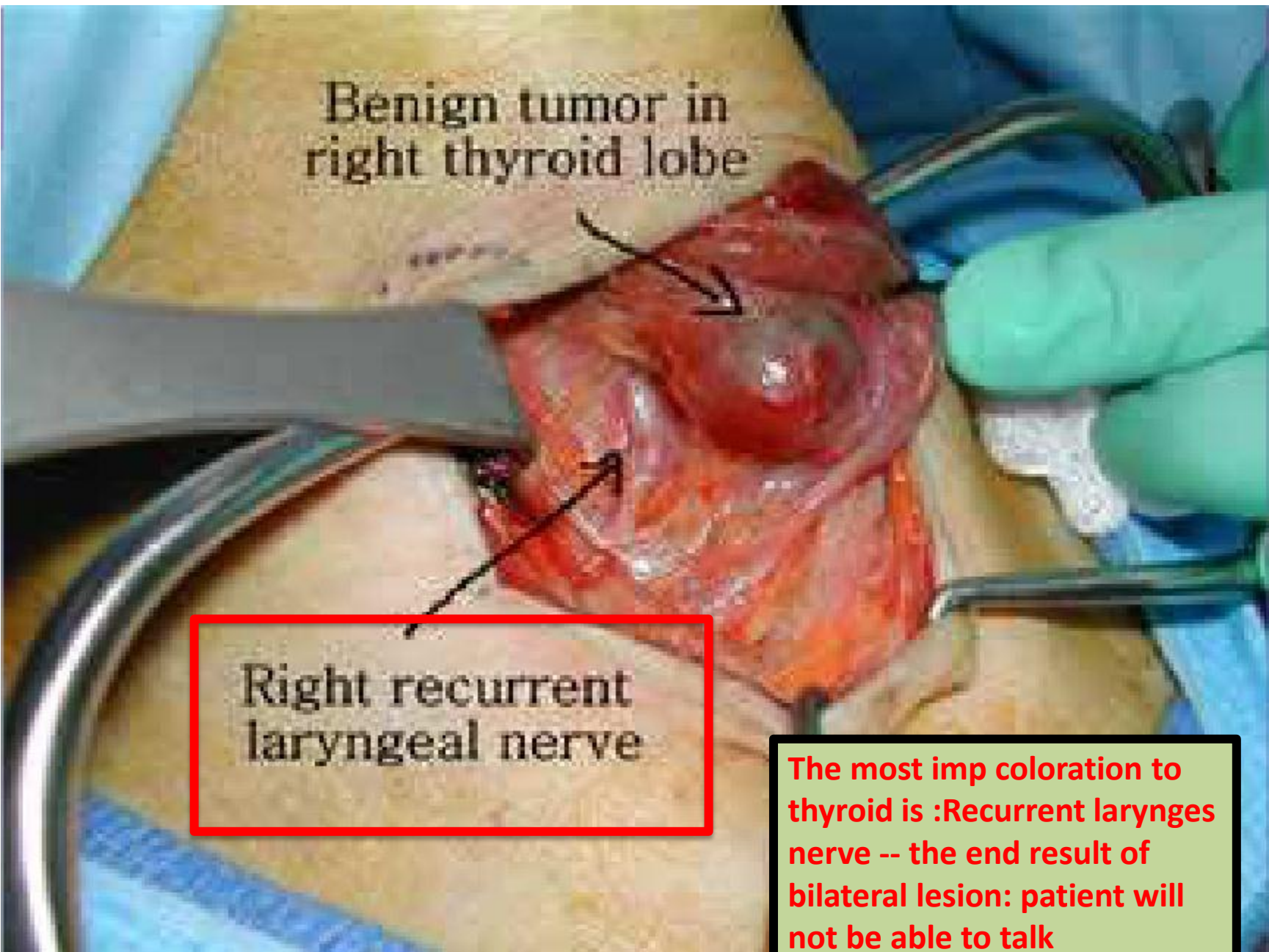
sternocleidomastoid





Anatomy of Parathyroid Glands





Benign tumor in
right thyroid lobe

This is an intraoperative photograph showing a surgical dissection of the thyroid gland. A large, reddish, lobulated mass is visible, identified as a benign tumor. A black arrow points to this mass. Another black arrow points to a pinkish, cord-like structure, identified as the right recurrent laryngeal nerve. The surgical field is held open by retractors, and a gloved hand is visible on the right side of the frame.

Right recurrent
laryngeal nerve

The most imp coloration to
thyroid is :Recurrent larynges
nerve -- the end result of
bilateral lesion: patient will
not be able to talk

Thyroid Diseases

- a) Thyrotoxicosis
- b) Hypothyroidism
- c) Thyroid nodules (benign vs. malignant)

In radiological point view : we don't care about
hypothyroidism

A. Thyrotoxicosis

What is the difference between Thyrotoxicosis and hyperthyroidism ? (MCQ)

- Causes:
- Hyperthyroidism
 - Diffuse toxic goiter (Graves' disease)
 - Single toxic nodule
 - Toxic multi-nodular goiter
- Early phase sub-acute thyroiditis
- Exogenous thyroid hormone intake

A. Thyrotoxicosis

- *Thyrotoxicosis is characterized by hypermetabolism due to increased circulating thyroid hormone.*
- *Hyperthyroidism is thyrotoxicosis caused by a hyperfunctioning thyroid gland (e.g., Graves' disease or toxic nodular goiter)*

Box 5-8 Classification of Thyrotoxicosis Based on Thyroid Hyperfunction or No Thyroid Hyperfunction

Thyroid hyperfunction

- A. Abnormal thyroid stimulator
 - 1. Graves' disease
 - 2. Trophoblastic tumor
 - a. Hydatiform mole, choriocarcinoma uterus or testes
- B. Intrinsic thyroid autonomy
 - 1. Hyperfunctioning adenoma
 - 2. Toxic multinodular goiter
- C. Excess production of TSH (rare)

No thyroid hyperfunction

- A. Disorders of hormone storage
 - 1. Subacute thyroiditis
 - 2. Chronic thyroiditis with transient thyrotoxicosis
- B. Extrathyroid source of hormone
 - 1. Thyrotoxicosis factitia
 - 2. "Hamburger toxicosis" (epidemic caused by thyroid gland contaminated hamburger meat)
 - 3. Ectopic thyroid tissue
 - a. Struma ovarii
 - b. Functioning follicular carcinoma

Imaging

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 organifies it to be incorporated with thyroid hormone.

Thyroid Uptake Probe



Imaging findings

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

How we can scan it?!! And why?!!

Radio active iodine , To know we are dealing with active nodule or not

Note: if it take the radioactive iodine

We concern about the nodule if it more than 2 cm

If there is enhancement we think of malignant nodule

1) Diffuse Toxic goiter (Graves' Disease)

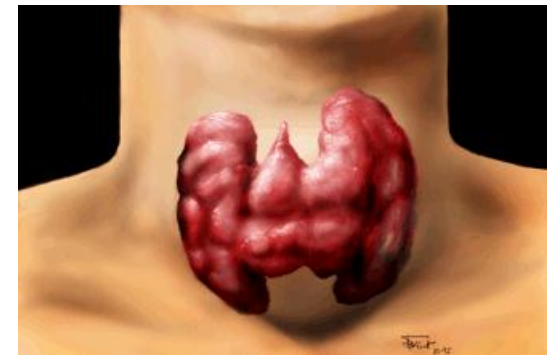
- Diffuse enlargement of thyroid gland.
- Homogeneous uptake
- No significant focal abnormalities (nodules)
- 24-hour RAI uptake is elevated, usually $> 35\%$ (mean of 40%)

1) Diffuse Toxic goiter (Graves' Disease)

- 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

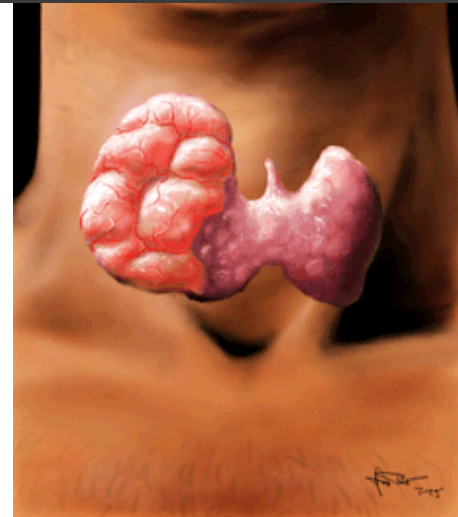
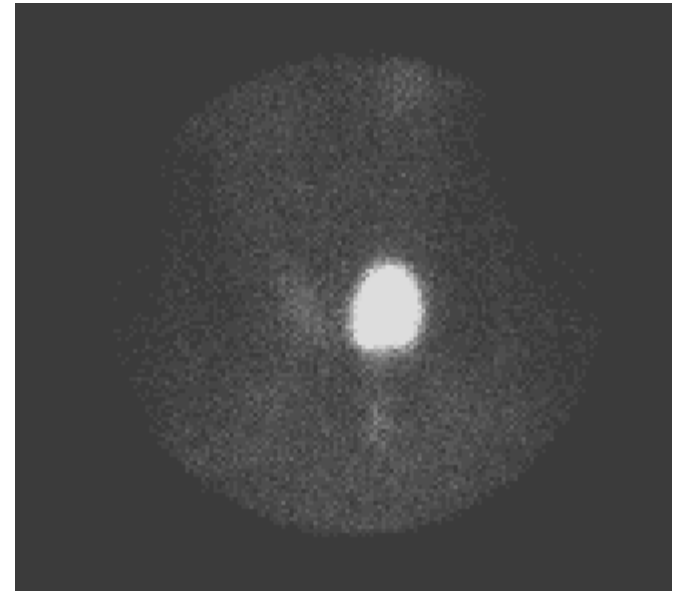


ANTERIOR



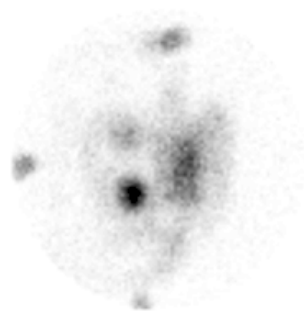
2) Single Toxic Nodule

- 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%.
- It has to be excised





Anterior



Anterior w/marker



LPO



RPO



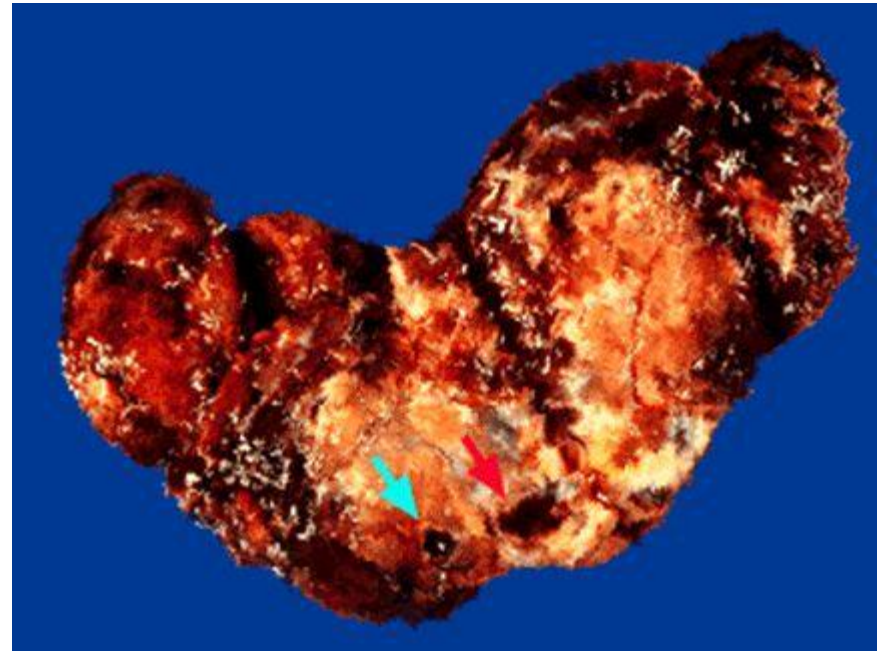
Anterior chest

3) Toxic Multi-Nodular Goiter

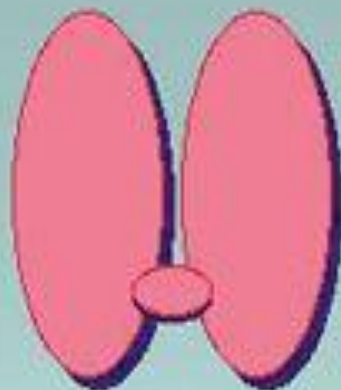
- Mild inhomogeneous uptake in thyroid gland.
- Multiple cold and hot nodules in both thyroid lobes.
- 24-hour uptake is mildly elevated, usually between 20%-30%.

3) Multi-nodular Goiter

- 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.



Thyroid Scan in Thyrotoxicosis



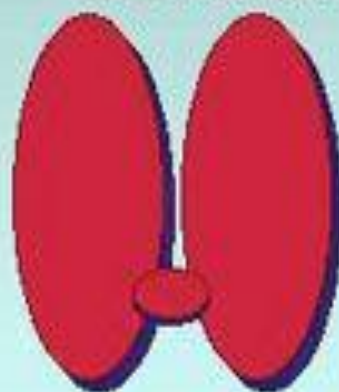
Graves' Disease



Follicular Adenoma



Multinodular Goiter



Subacute Thyroiditis

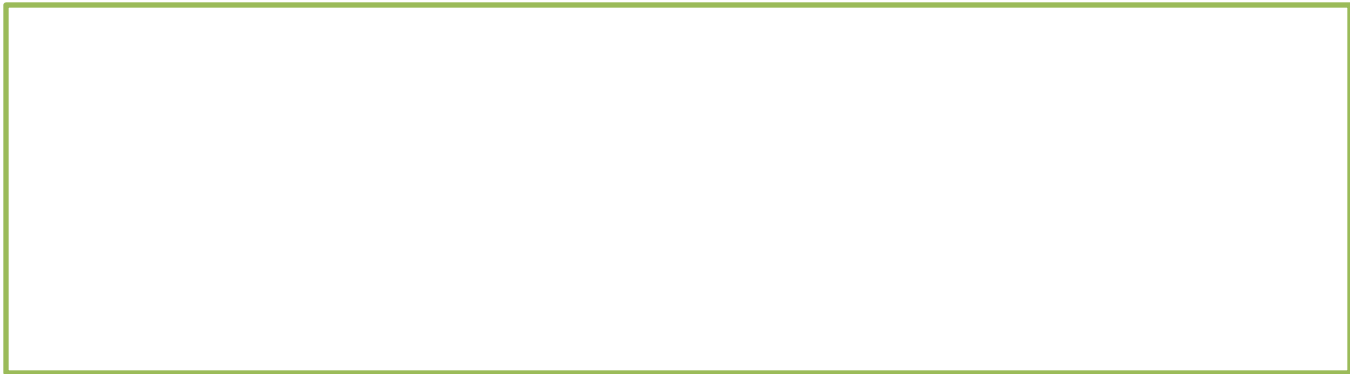
B) Hypothyroidism

- 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.

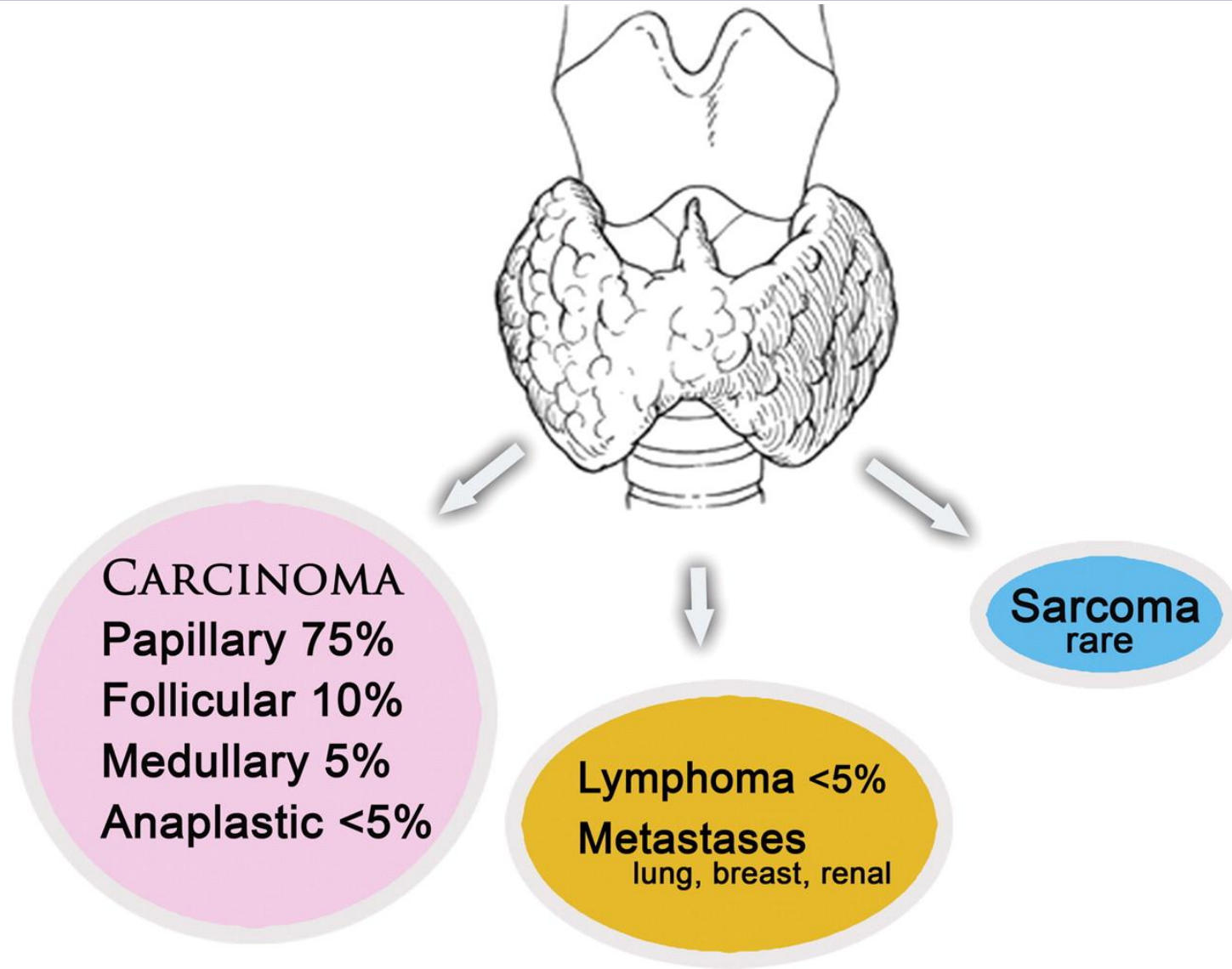
C) Thyroid Nodule

- 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.

Thyroid Cancer



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

Imaging

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 **in malignancies**
 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.

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

1- Microcalcifications

Thyroid calcifications may occur in both benign and malignant diseases. They are classified as *microcalcifications*, coarse calcifications and peripheral calcifications.

Thyroid Microcalcifications are psammoma bodies (*refer to Figures next 2 slides*). Found in 29%–59% of all primary thyroid carcinomas most commonly in **papillary thyroid carcinoma**. Their occurrence has also been described in follicular and anaplastic thyroid carcinomas as well as in benign conditions such as follicular adenoma and Hashimoto thyroiditis.

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%. Microcalcifications

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

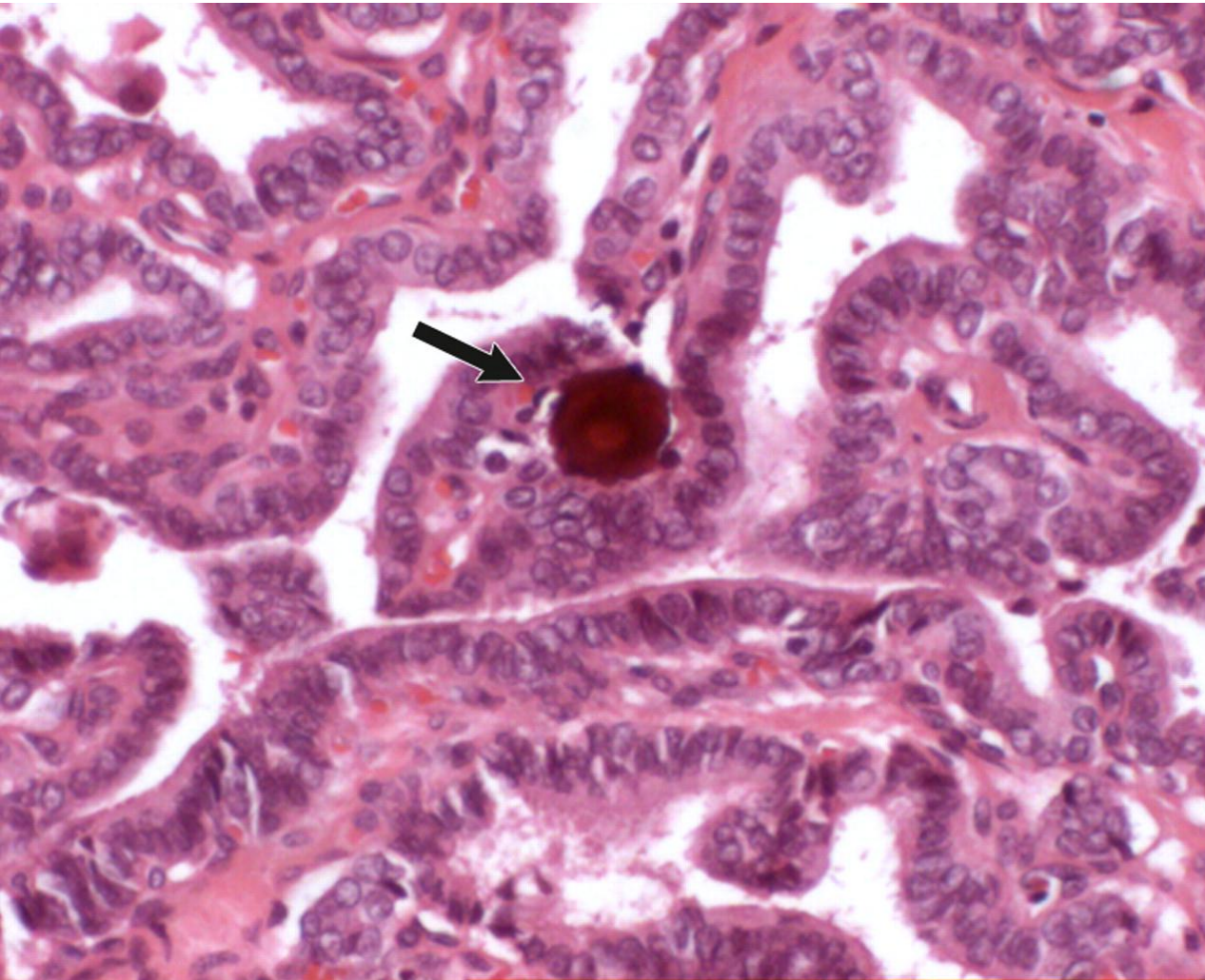


Figure Description:

A ***Psammoma Body*** (arrow)
10–100- μ m
round laminar
crystalline
calcification
- or calcific
deposits.

Hoang J K et al. Radiographics 2007;27:847-860
<http://radiographics.rsna.org/content/27/3/847.full.pdf+html>

RadioGraphics

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



Hoang J K et al. Radiographics 2007;27:847-860

Figure Description

Transverse sonogram of the right lobe of the thyroid demonstrates ***Punctuate Echogenic Foci*** without a posterior acoustic shadowing, findings are always indicative of microcalcifications (arrows).

2- Local invasion & Lymph Node metastasis

Direct tumor invasion of adjacent soft tissue and metastases to lymph nodes are highly specific signs of thyroid malignancy.

Aggressive **local invasion** is common with anaplastic thyroid carcinoma, lymphoma, and sarcoma. At US, direct tumor invasion of adjacent soft tissues may appear as a subtle extension of the tumor beyond the contours of the thyroid gland or as frank invasion of adjacent structures.

Some US feature may arouse suspicion about **Lymph node** metastasis, in particular, including: rounded bulging shape, increased size, replaced fatty hilum, irregular margins, heterogenous echotexture, calcifications and vascularity throughout the lymph node (instead of the usual normal central hilar vessels at the doppler imaging)

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

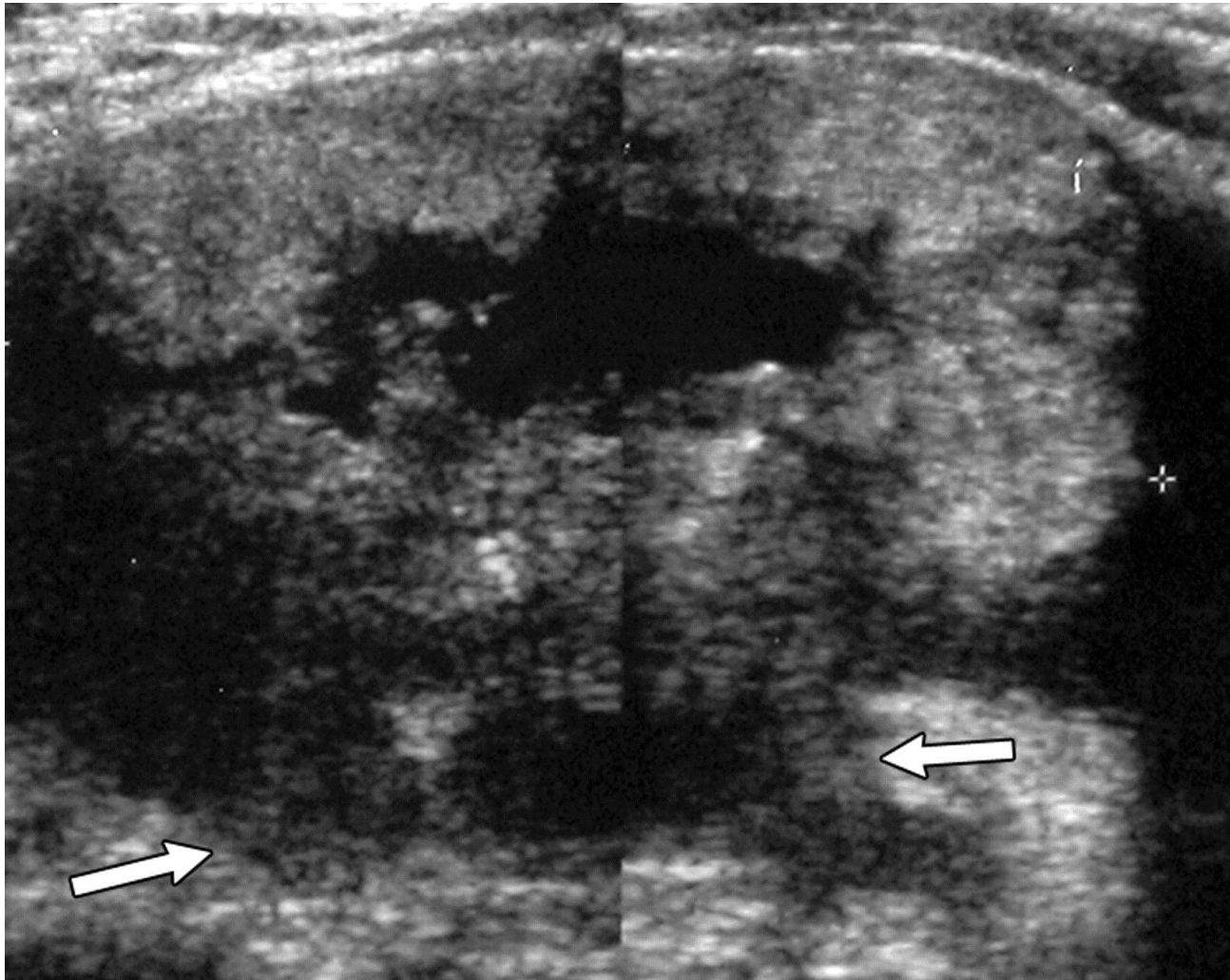


Figure Description

Transverse sonogram of the left lobe of the thyroid shows an advanced tumor with ***infiltrative posterior margins*** (arrows) and ***invasion*** of prevertebral muscle.

Hoang J K et al. Radiographics 2007;27:847-860

RadioGraphics

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

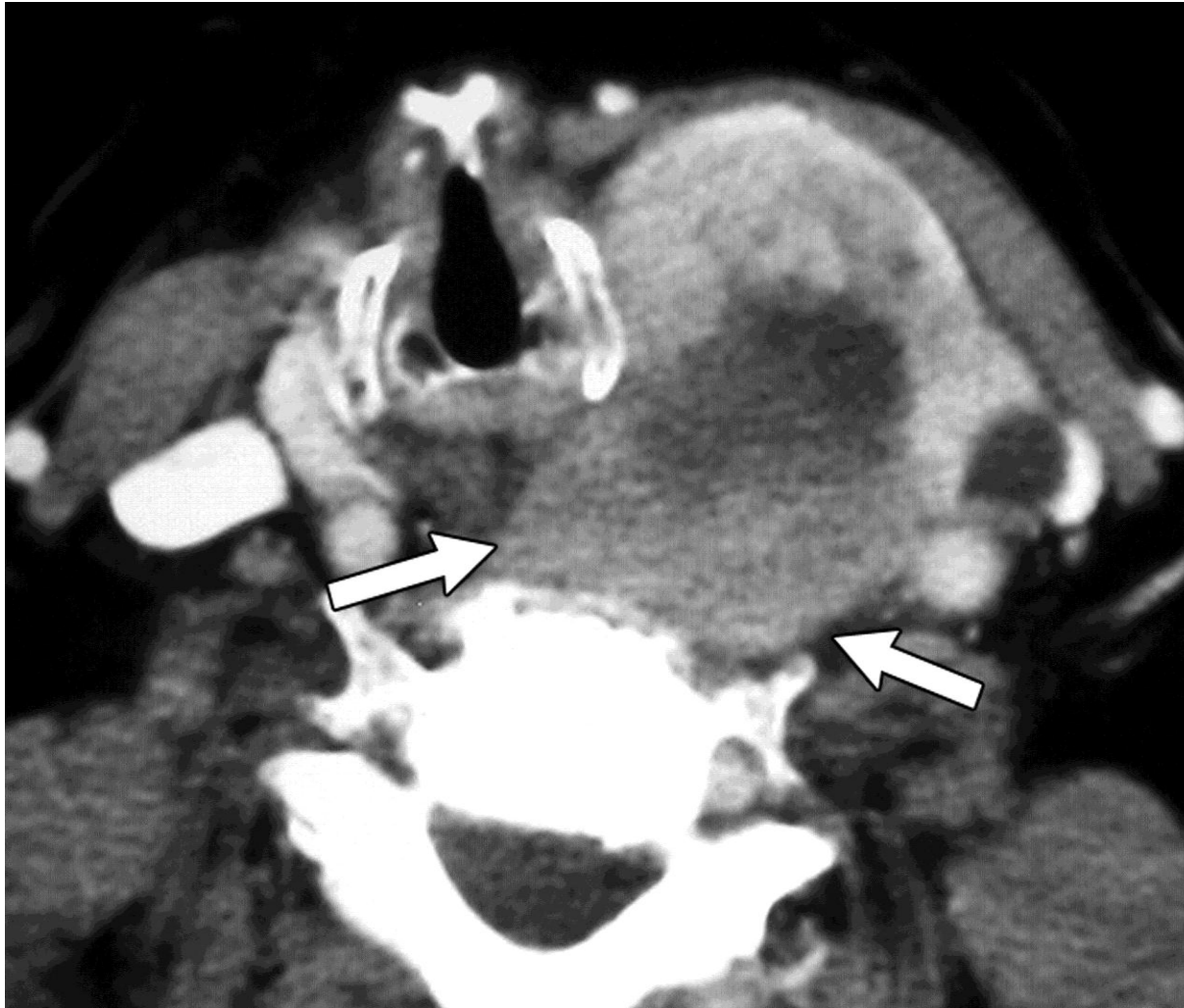


Figure Description

Axial contrast-enhanced CT image shows a large tumor that has ***invaded*** the prevertebral muscle (arrows).

Hoang J K et al. Radiographics 2007;27:847-860

RadioGraphics

3- Margins, Contour, and Shape

The **halo** or **hypoechoic rim** around a thyroid nodule is produced by a pseudocapsule of fibrous connective tissue, a compressed thyroid parenchyma, and chronic inflammatory infiltrates.

Such completely uniform halo around a nodule is highly suggestive of benignity, with a specificity of 95%. However, a halo is absent at US in more than half of all benign thyroid nodules. Moreover, 10%–24% of papillary thyroid carcinomas have either a complete or an incomplete halo.

US: Follicular adenoma in a 30-year-old woman.

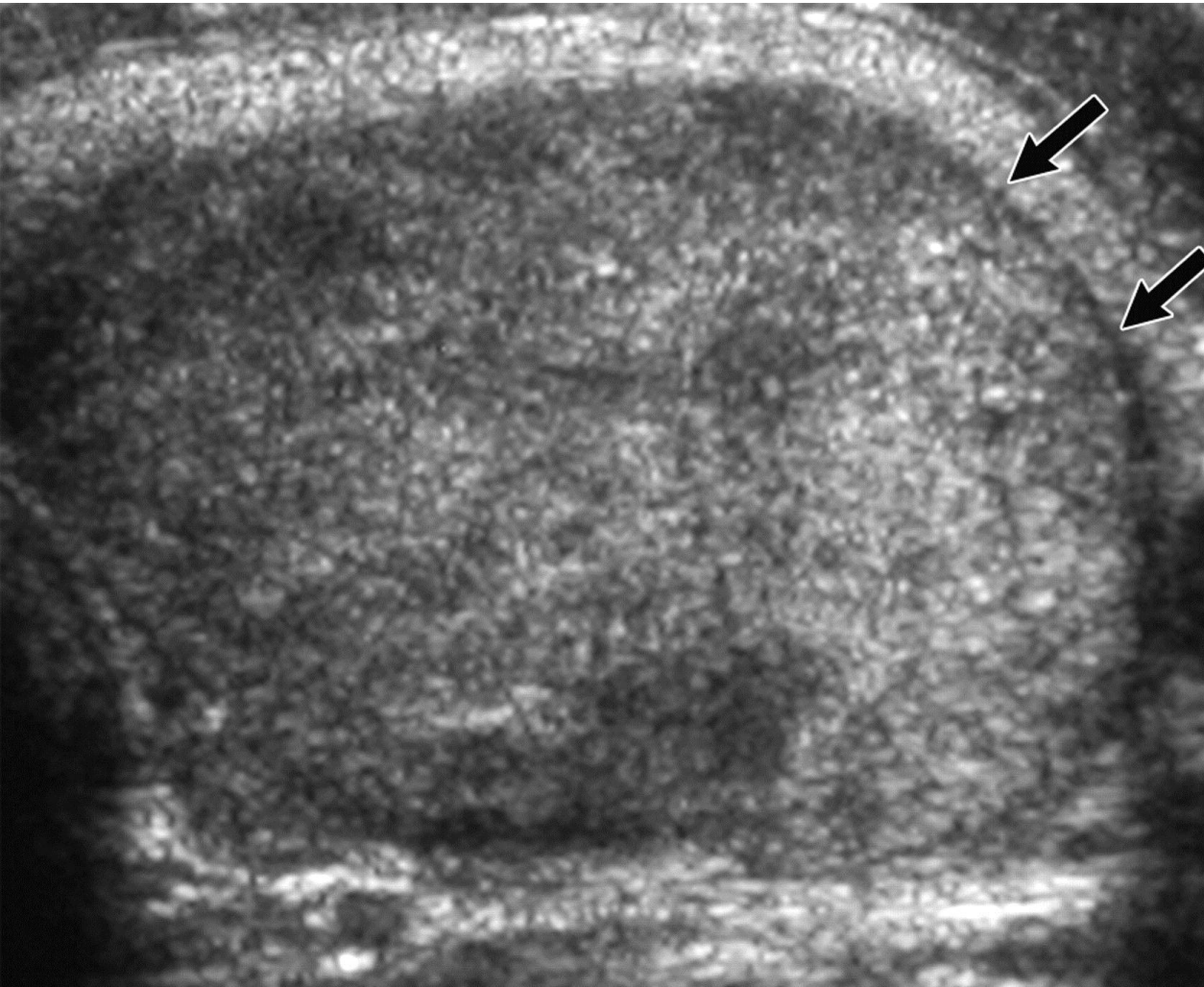


Figure Description

Transverse sonogram of the left lobe of the thyroid shows a follicular adenoma with a ***hypoechoic halo*** (arrows).

Hoang J K et al. Radiographics 2007;27:847-860

4- Hypoechoic Solid Nodule

Malignant nodules, both carcinoma and lymphoma, typically appear solid and hypoechoic when compared with normal thyroid parenchyma.

Marked hypoechogenicity is very suggestive of malignancy.

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



Figure Description

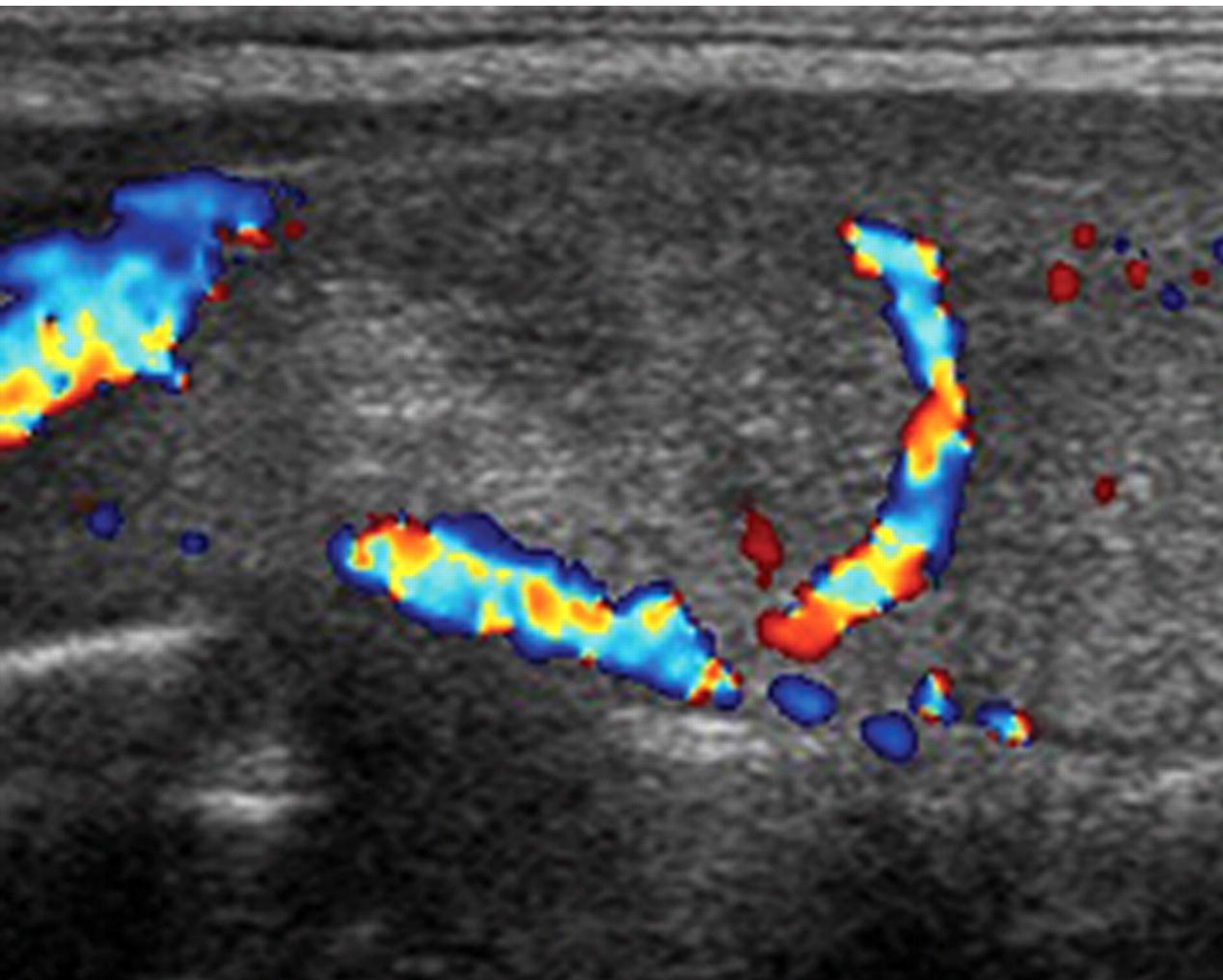
Transverse sonogram of the left lobe of the thyroid shows a large heterogeneous mass (between calipers) with marked hypoechogenicity when compared with the strap muscles (SM). A normal isthmus (arrow) also is visible. IJV = internal jugular vein.

5- Other; Vascularity

Vascular flow within a thyroid nodule can be detected with color or power Doppler US. The most common pattern of vascularity in thyroid malignancy is marked intrinsic hypervascularity, which is defined as flow in the central part of the tumor that is greater than that in the surrounding thyroid parenchyma (*refer to figure next slide*). This occurs in 69%–74% of all thyroid malignancies. However, it is not a specific sign of thyroid malignancy.

All papillary thyroid carcinomas in their study had some intrinsic blood flow, and they concluded that a completely avascular nodule is very unlikely to be malignant.

Doppler US: Follicular adenoma in a 36-year-old woman.



Hoang J K et al. Radiographics 2007;27:847-860

RadioGraphics

Figure Description

Longitudinal color Doppler sonogram of the right lobe of the thyroid shows ***perinodular flow*** around a follicular adenoma.

5- Other; 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.

The risk of malignancy in a thyroid with multiple nodules is comparable to that with a solitary nodule.

Follicular thyroid carcinoma is frequently found in a multinodular thyroid, and papillary thyroid carcinoma is multifocal in 20% of cases.

5- Other; 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.

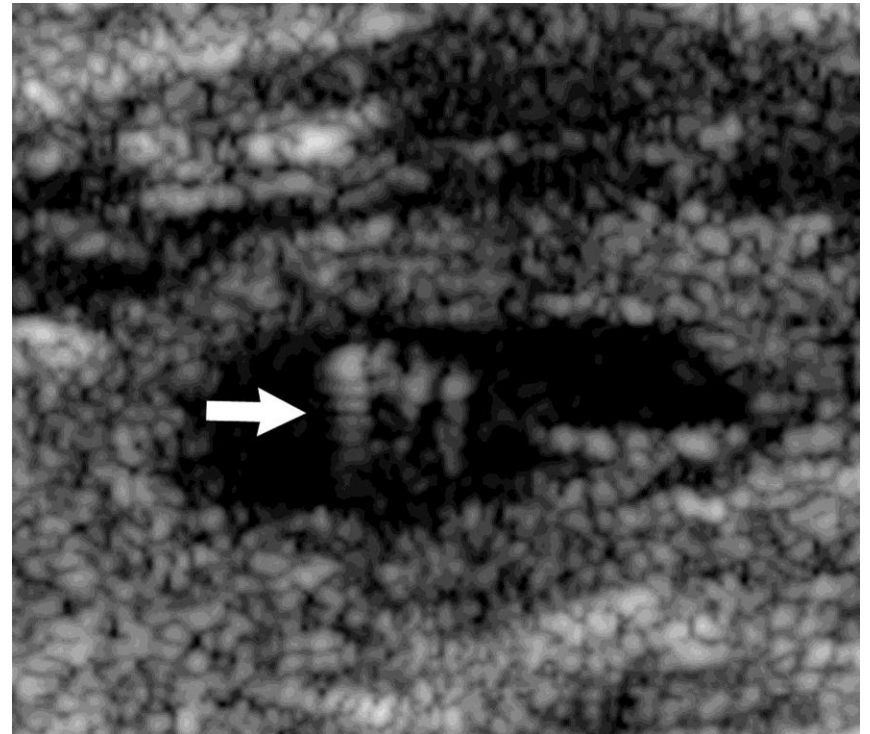
Recommendations for Thyroid Nodules 1 cm or Larger in Maximum Diameter

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*

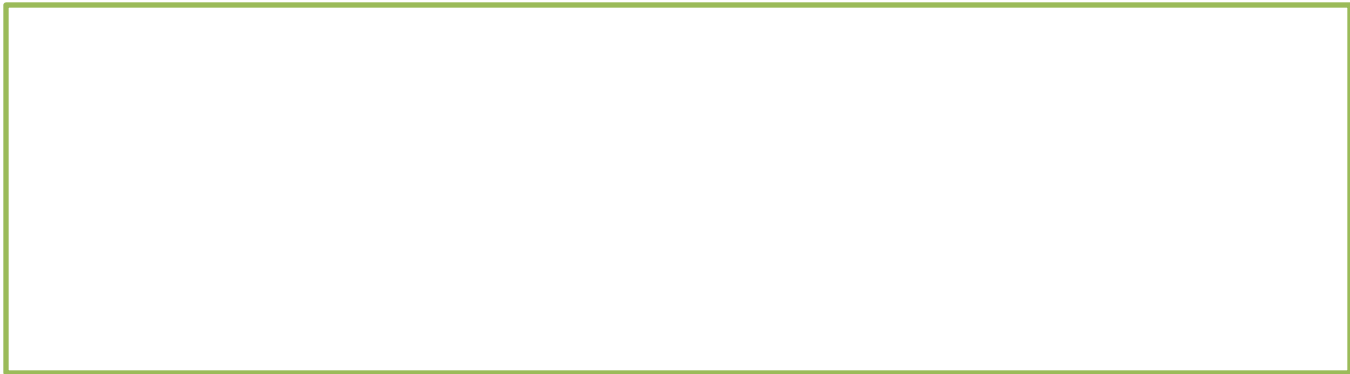
Thyroid Cancer

Example 6

- Benign thyroid nodule in a 51-year-old woman.
- Transverse sonogram of the right lobe of the thyroid shows a colloid nodule with a ring-down artifact (arrow), a finding indicative of inspissated colloid calcification.



Parathyroid



1. Primary hyperparathyroidism

- *Hyperparathyroidism* is a disorder caused by excessive production of parathyroid hormone
- Leads to hypercalcemia, recurrent nephrolithiasis, peptic ulcers, and mental changes.
- In most cases primary hyperparathyroidism is due to a single parathyroid adenoma (80% of patients).

2. Secondary hyperparathyroidism

- Typically related to chronic renal impairment.
- In such cases the plasma Ca level is decreased and this results in secondary stimulation of parathyroid hormone (PTH) from the parathyroid gland

Renal osteodystrophy

- **Pathophysiology:**
 - Secondary hyperparathyroidism from hyperplasia of parathyroid glands in chronic renal failure from phosphate retention and low serum calcium
 - Osteomalacia secondary to abnormal vitamin D metabolism and aluminum intoxication
 - Common among chronic renal failure

Renal osteodystrophy

Imaging characteristics: Radiography

1. BEST DIAGNOSTIC CLUE: Rugger jersey spine

- Bands of hazy sclerosis paralleling endplates
- Usually involves the axial and appendicular spine

2. Osteosclerosis and/or osteopenia

3. Changes of hyperparathyroidism

- Resorption secondary trabeculae
- Cortical thinning
- Erosions at entheses, endplates, sacroiliac joints
- Subperiosteal bone resorption
- Brown tumors: Lytic lesion, no matrix, sharp zone transition

4. Changes of osteomalacia/rickets

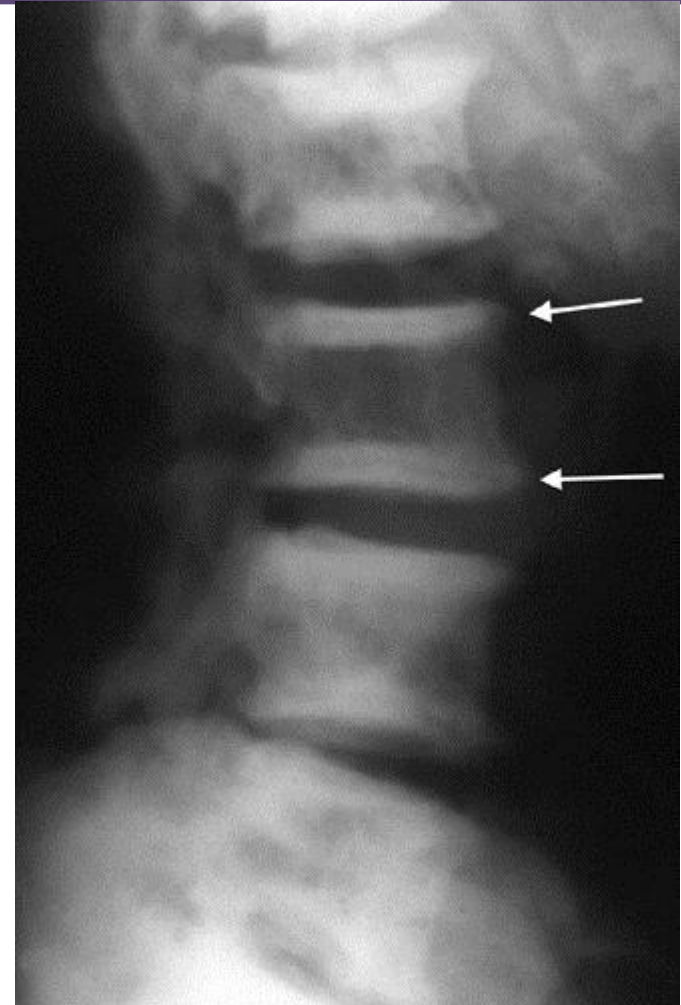
- Blurred, coarse bone trabeculae
- Children: Fraying, cupping metaphyses

5. Retarded skeletal age

6. Pathologic fracture

Renal osteodystrophy

- Cervical vertebrae
- Dense sclerotic end plate
- Chondrocalcinosis: technically, it refers to the visible presence of calcification within tissues on an imaging study.



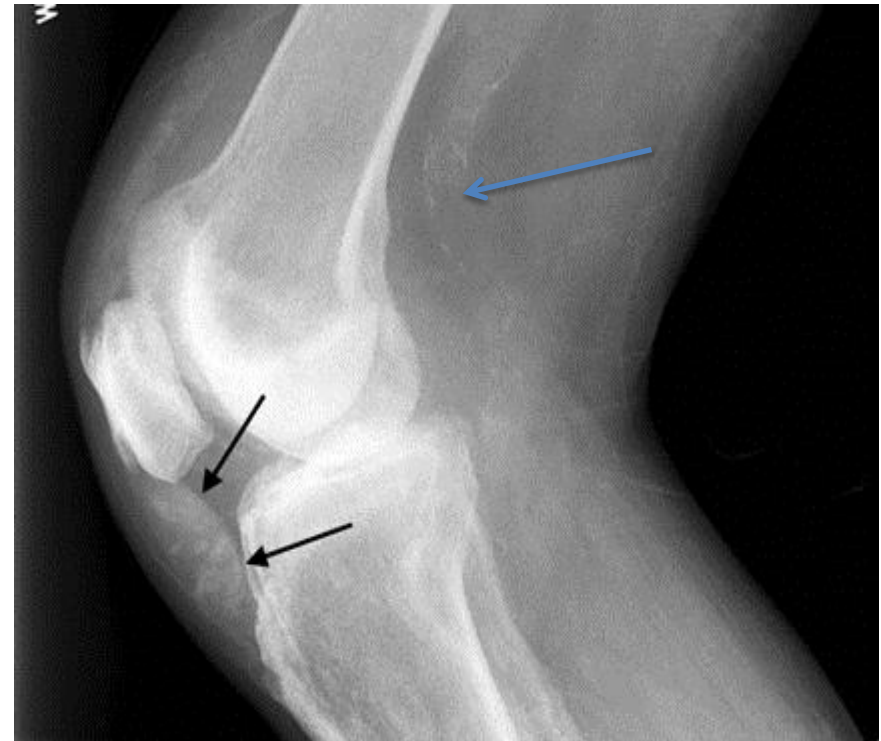
Renal osteodystrophy

- Wrist x-ray
- Concavation within the joint
- Chondro Calcinosis :
classification of
cartilage
- Osteopenia



Renal osteodystrophy

- Patella tendon: concave calcification
- Calcification of artery, posterior to the tibia (blue arrow)



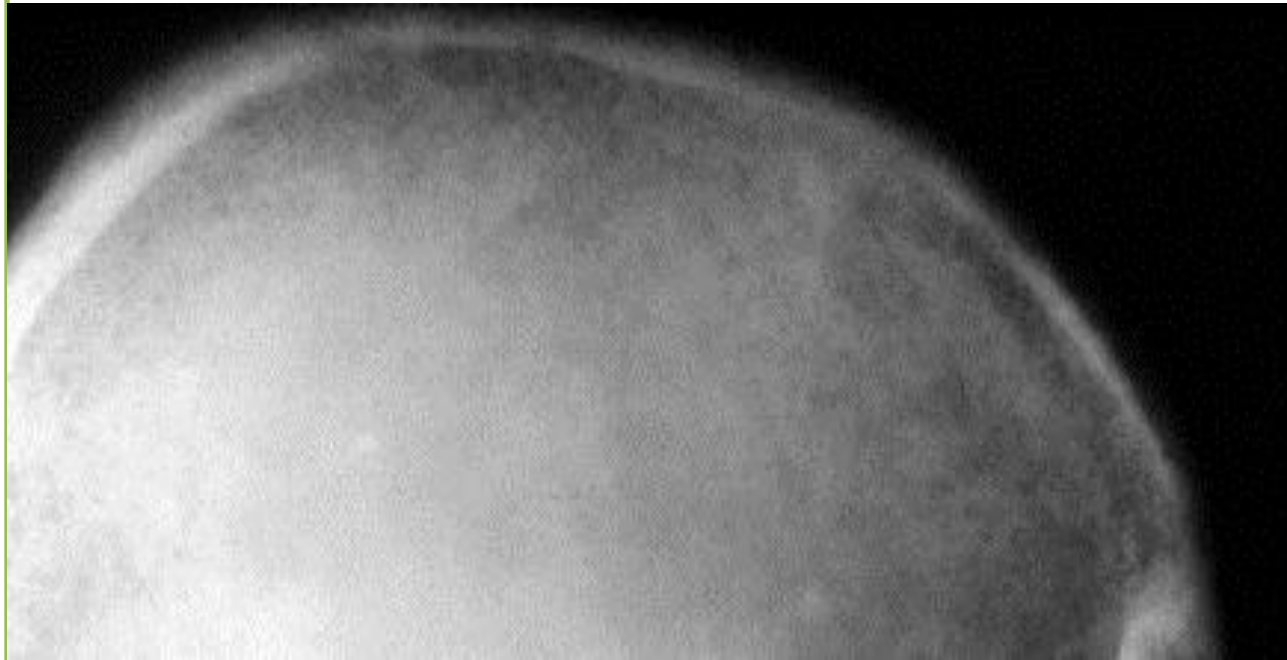
Renal osteodystrophy

- Anteroposterior radiograph of the finger in a patient with renal failure
- Reveals sub periosteal resorption along the radial aspect of the middle phalanx (arrows), as well as reabsorption of the distal tuft (arrowheads)



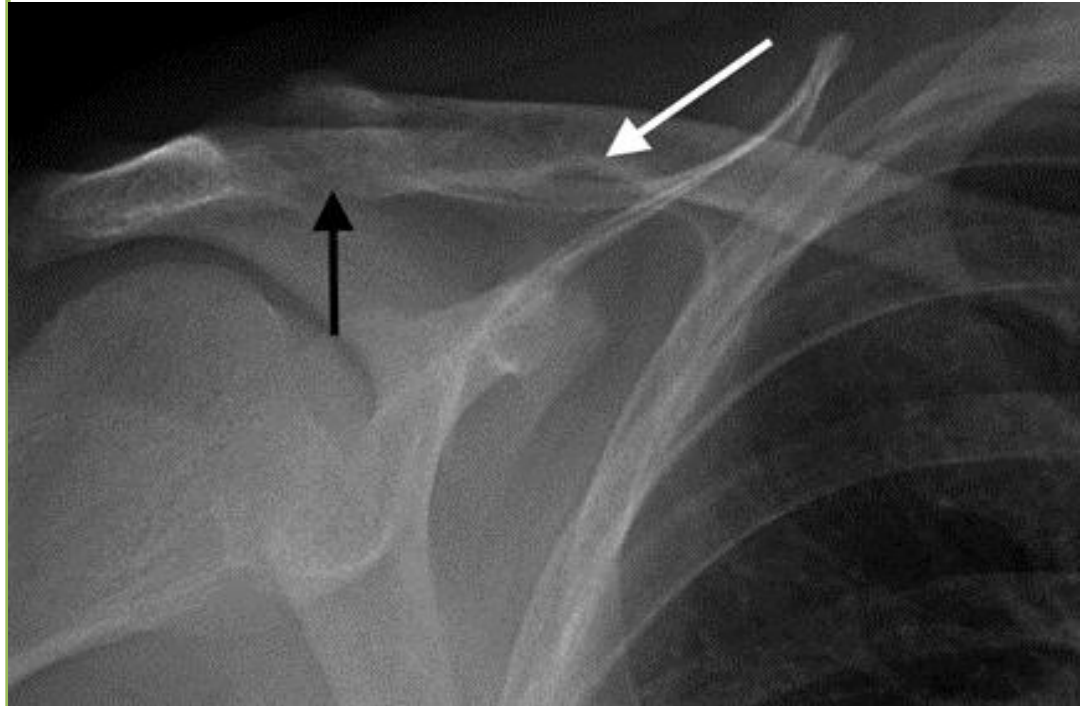
Renal osteodystrophy

- Lateral radiograph of the calvarium reveals punctatetrabecular bone resorption that has a salt-and-pepper appearance.



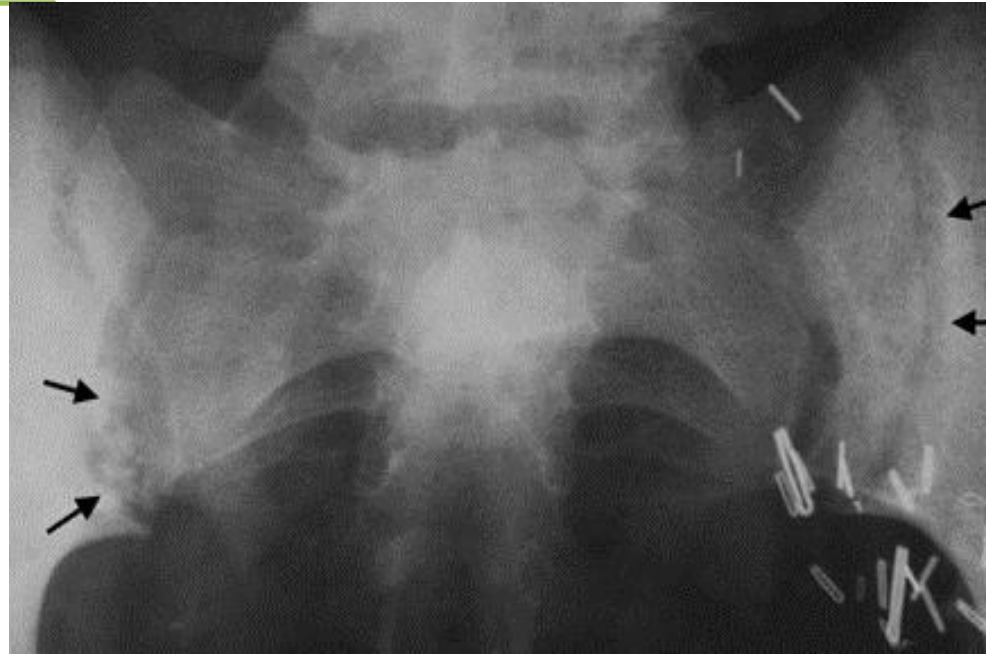
Renal osteodystrophy

- Anteroposterior radiograph of the shoulder in a patient with renal failure
- Reveals sub ligamentous resorption underlying the clavicular attachment of the coracoclavicular ligament (white arrow) and subchondral erosion of the distal clavicle (black arrow).



Renal osteodystrophy

- Anteroposterior radiograph of the sacroiliac joints reveals subchondral erosion at the articular surface bilaterally (arrows)
- Left: sacral renal transplant



Renal osteodystrophy

- Within the femoral artery

