Nuclear Medicine in Thyroid and Parathyroid Glands

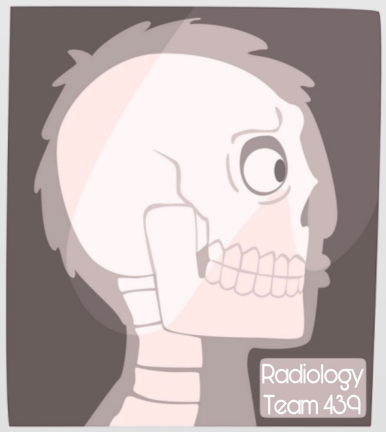
Lecture 20

Objectives

- Describe the physiologic principles of underlying Tc-99m parathyroid scintigraphy .
- Describe the various methods used for parathyroid scintigraphy with emphasis on SPECT and SPECT /CT .
- Identify the common imaging features of pathologic parathyroid glands.
- Discuss causes of false negative and false positive scans.

Color index:

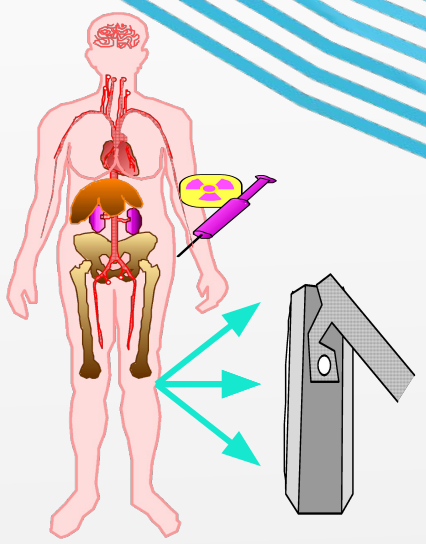
Black: Main text
Red: Important
Yellow: Golden notes
Green : Drs notes 439
Dark green : Drs notes 438
Gray: Extra



❖ Nuclear Medicine

Nuclear Medicine Procedure

- Patient ingest or injected with small amount of radioactive material. known as radiopharmaceuticals which have short half-lives to not harm the patient.
- Radiopharmaceutical localizes in patient according to metabolic properties of that drug.
- Radioactivity decays, emitting gamma rays.
- Gamma rays that exit the patient are imaged. using a Gamma Camera (the grey box in the image) where the patient is the source of radiation.[439,438]



Gamma camera

Example : For the Bones
A phosphate compound is used and it's Labeled by a radioactive material
The labeled phosphate compound will stick to the bone, Radiation will come from the bone Which will be detected by Gamma camera, Showing normal distribution or an Abnormal uptake in the skeleton
*This apply to all organs using different radiopharmaceuticals; as each organ has its own **radiopharmaceuticals** [439,438]

- In **Nuclear medicine** – Radiation comes from the **patient** and is detected by gamma Camera and it concerns about the **function**
- In **Radiology** – The radiation comes from the **x-ray tube (machine)** and it concerns about the structure [439,438]

What are the nuclear medicine imaging methods (types of gamma camera) ?

Conventional tumor imaging :
Planar : 2D
SPECT : 3D
SPECT-CT : 3D (Function and anatomy)
SPECT:Single Photon Emission computed tomography.
for precise detection of abnormal uptake site

Onco PET :
PET : 3D
PET CT : 3D (Function and anatomy)
PET:Positron emission tomography (2 photons)
it's mainly used for oncology patients

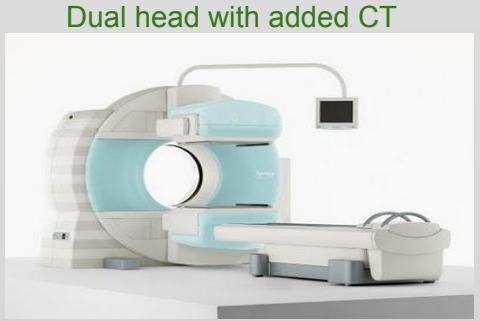
what is the difference between SPECT and PET radionuclides?

- SPECT agent emit single photon in one direction
- PET agent emit two photons in opposite directions

PET CT

SPECT CT
Dual head with added CT

PLANAR / SPECT
Dual head with added CT



❖ Thyroid Scan

Physical Properties SPECT Radionuclides

There re two groups of radioactive materials that are re used in nuclear medicine: SPECT Radionuclides and Positron emitting (PET) Radionuclides [439,438]

Radionuclide	T/2 (Half life) Physical	Type of Radiation	E (Kev)
Technetium-99m(Tc-99m) Most common	6 Hours	Gamma	140
Iodine I 131 (Therapeutic) Mainly used for therapy	8 Days	Gamma / Beta	364/606
Iodine I 123 (Diagnostic) 2nd most common	13.2 Hours	Gamma	159
Gallium citrate (Ga-67)	78.3 Hours	Gamma	90,190,290
Thallium chloride 201 (T1201)	73.1 Hours	X-ray	68-83
Indium 111 (In 111)	2.8 Days	Gamma	173-247
Xenon 133	5.2 Days	Gamma	81
Kripton 81m	13 Seconds	Gamma	190

Doctor said: "Know the first 4 half-life"

- they're the most commonly used
- 80%of procedure in KKUH uses (Tc-99m).
- One day When you order a nuclear study the patient will ask how much of the material will stay in my body?

Iodine I 131:

Mainly used for therapy (hyperthyroidism , cancer), It has a long half life and emit beta rays Iodine 123: is used for diagnosis of thyroid problems and cancer [439,438]

Physical Properties of positron emitting (PET) Radionuclides

"Know the Fluorine 18 and Gallium 68 half-life"

- Fluorine-18 is labeled with glucose, so wherever there is increased glucose consumption the body it will be taken up.
- As in tumors where there is increased glycolysis [439,438]

Radionuclides	T/2 Physical (min)	Positron	Productivity
Carbon 11	20	0.96	Accelerator
Nitrogen-13	10	1.19	Accelerator
Oxygen-15	2	1.73	Accelerator
Fluorine 18	110	0.635	Accelerator
Gallium 68	68	1.9	Generator (germanium 68)
Rubidium 82	1.3	3.15	Generator (germanium 68)

Thyroid Scan : Procedure

Can be done using Tc-99m Pertechnetate or I-123

	Tc -99m Pertechnetate	I-123
Dose	0.5-4.0 mCi given IV that mean of the injected amount only 0.5-4.0% ofthe tracer will appear	0.5 mCi orally
Half life	6 Hours	**13 Hours**
Cost	**Not Expensive** (Generator) Available All The Time "Quickscan".	**Expensive** (It needs Cyclotrone) only available once a week
Time of imaging	**20 min post injection** **only one visit** patient comes department , we inject the material, after 20 mins image will be taken	**6 and 24 hours post ingestion** **3 visits** (to take the capsule, take image after 6H , take image after 24H)
Remarks	**Trapped only not organified** gives information only about the trapping (step before organification)	**Trapped and organified**

I-123

- Can be used to prepare the patient for I-131 therapy , it calculate the dose for I-131 therapy by measuring the amount of thyroid uptake
- Gives Information About Trapping and about organification
- **organification :** is the synthesis of thyroxine (T4,T3). Benefits: looking for enzymes ,hormones deficiency.[439,438]

Limitations :

- ❖ Expensive
- ❖ Patient have to come 3 times

Tc-99m Pertechnetate

Alternative for I-123

Limitation:

- ❖ Trapped not orginfifed.

Advantages:

- ❖ Cheap and fast

To assess the organification we use I- 123 not technetium.

When Iodine trapped By The Thyroid gland Thyroid Hormones Are synthesized, then it would be organified to form Thyroxine.

In Tc-99m its not organified so when there's problem organification,we can't use it. [439,438]

❖ Thyroid Uptake

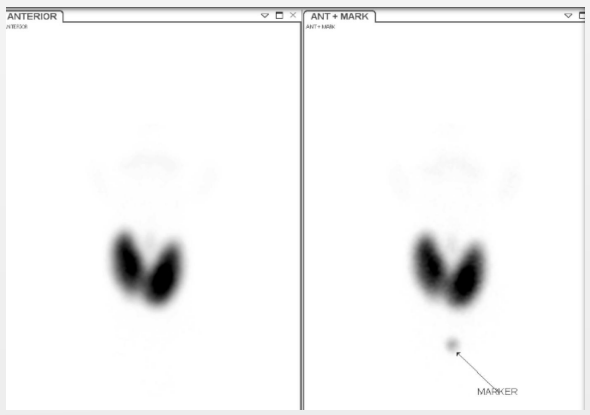
Normal Values Of Thyroid Uptake

I-131 OR I-123 RAIU : if the patient is given 100 µCi

- Normal 4 hour RAIU : 5 - 15%.
- Normal 24 hour RAIU : 8 - 35%

Tc - 99m Uptake (20 min Uptake): if the patient is given 5 mCi

- Normal (0.5 -4 .0%)



Causes of High Thyroid Uptake very important

- **Hyperthyroidism** :
  Grave's Disease or TSH-secreting pituitary adenoma
- **Autonomous toxic nodule**
- **Multinodular toxic goiter** (Plummer's disease)
- **Enzyme defects :** Dyshormonogenesis.
- **Iodine starvation** (Iodine deficiency)
- **Lithium Therapy**
- **Recovery phase of thyroiditis.**
- **Rebound following abrupt withdrawal of antithyroid meds**

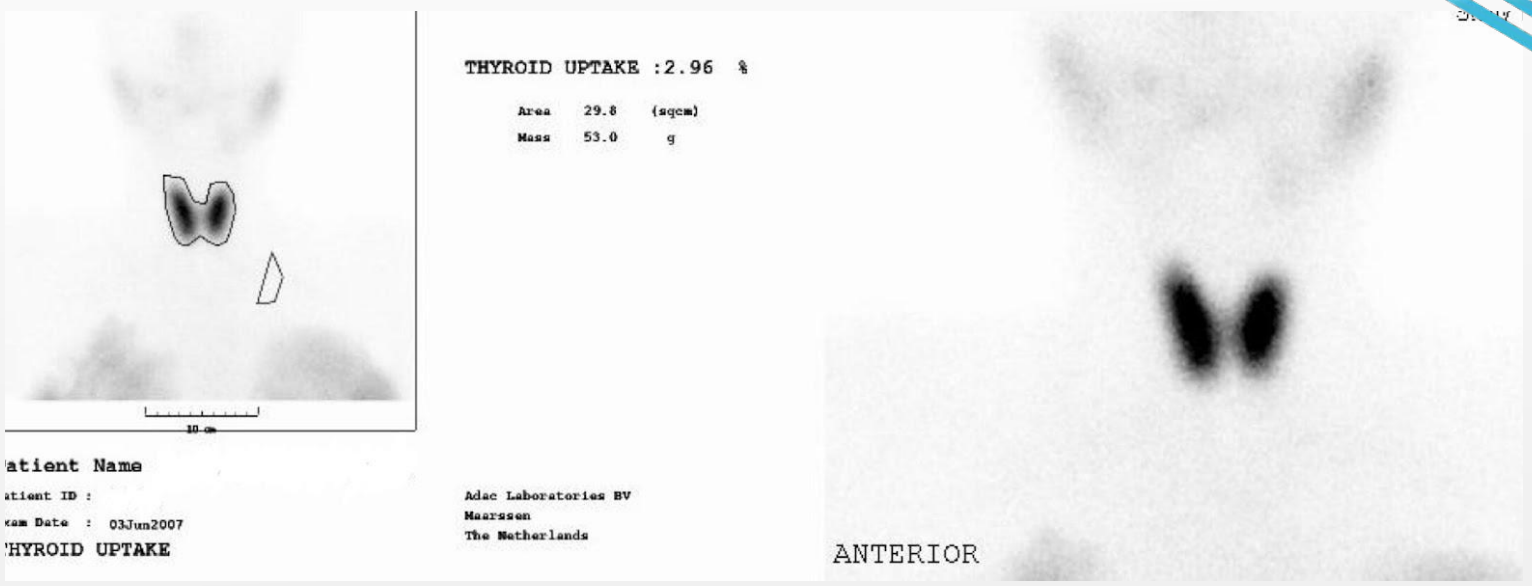
Causes Of Low Thyroid Uptake very important

- **Parenchymal Destruction:**
  - Acute, Subacute and Chronic Lymphocytic Thyroiditis
- **Hypothyroidism**:
  - Primary or Secondary (insufficient pituitary TSH secretion)
  - Surgical/Radioiodine Ablation of Thyroid
- **Blocked Trapping:**
  - Iodine load (most common): Iodinated contrast
  - Exogenous thyroid hormone replacement depressing TSH levels (thyrotoxicosis factitia)
  - Ectopic thyroid: Struma Ovarii
- **Blocked Organification:**
  - Antithyroid medication (PTU): Note Tc-99m uptake should not be affected

Not every high uptake means the gland is hyperactive!
E.g. if there is an iodine starvation is some areas of the gland, there will be an increasing in the uptake but the thyroid will not be overactive
Also not every low uptake means hypothyroidism,
E.g. in thyroiditis there is low intake but once it's cured it'll return back to normal

❖ Thyroid Uptake and metastases

Tc-99m Thyroid scan and uptake Imaging plus uptake studies



Thyroid uptake here is 2.96% which is normal - No Defects or Nodules [439,438]

THYROID METASTASES STUDY (I-123 orI-131 as Sodium Iodide)

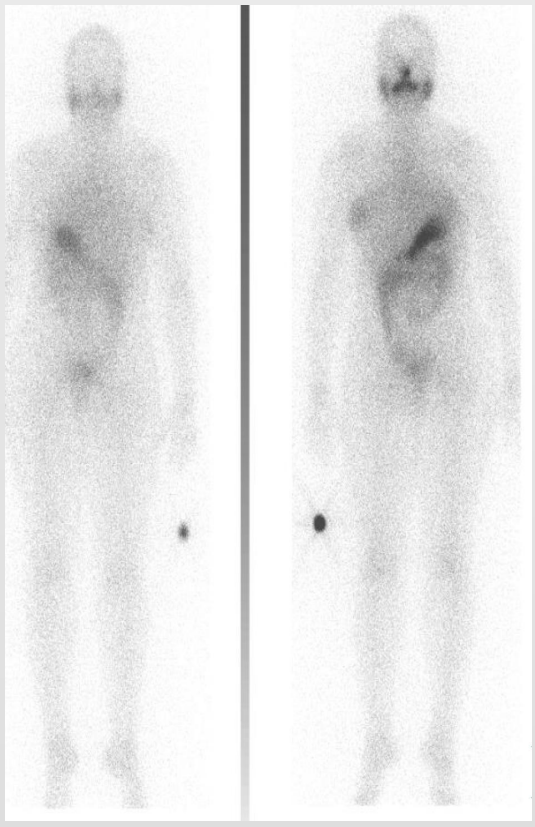
Indications

- Detection and localization of persistent or recurrent functioning thyroid cancer

I-123 is commonly used in thyroid cancer patient post thyroidectomy
- Assess the extent of surgery after thyroidectomy
- Detect Lung or Bone metastases

Image A
thyroid cancer patient that underwent thyroidectomy
Anterior view → No thyroid tissue with normal physiological uptake of iodine in the stomach and bladder

Negative Iodine whole body scan (there's no remainant; no local disease or metastases, patient is free from the disease [439,438]



Posterior view Anterior view

Negative Iodine whole body scan

In both posterior and anterior

Patient Preparation

- Stimulation of potentially functioning thyroid tissue:
  A. Inject recombinant human thyrotropin on 2 consecutive days and administer the radiopharmaceutical on the 3rd day
  B. Withdraw thyroid replacement hormones :
    1. Thyroxine (T-4) for at least 4 weeks.
    2. Triiodothyronine (T-3) for at least 10 days.
- The patient must not have had i.v iodinated contrast material(IVP, CT with contrast, myelogram, angiogram) for at least 3 weeks
- The patient should be NPO for at least 4 hours prior to radiopharmaceutical administration and for at least 1 hour afterwards

* Also The patient must avoid Iodine-containing food such as fish.

Radiopharmaceutical, Dose, & Technique of Administration

- Radiopharmaceutical: Oral administration
  a. I-123 as sodium iodide : 2 mCi
  b. I-131 as sodium iodide : 2-10 mCi

Thyroid tissue uptake is TSH dependent, so prior to whole body scan 2 Exogenous TSH injections must be given to the patient to find out any metastases after thyroid cancer treatment

- Imaging using Gamma camera : Whole body scan

» I-123 or I-131 Whole Body Scan (WBS)

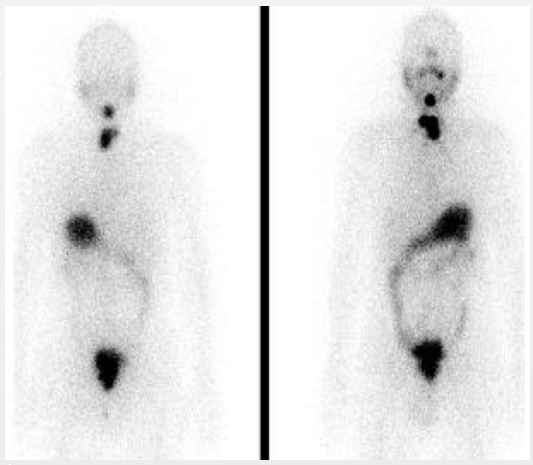
» Planar Vs SPECT CT

Local Recurrence

Partial thyroidectomy
unsuccessful thyroidectomy (multiple thyroid tissue is left in planar image)[439,438]

* This patient is post- operative which supposed there is no uptake of iodine in the neck (the thyroid is removed!).
Which means this is **Local Recurrence**

Posterior view Anterior view



Trans Axial Sagittal

Coronal

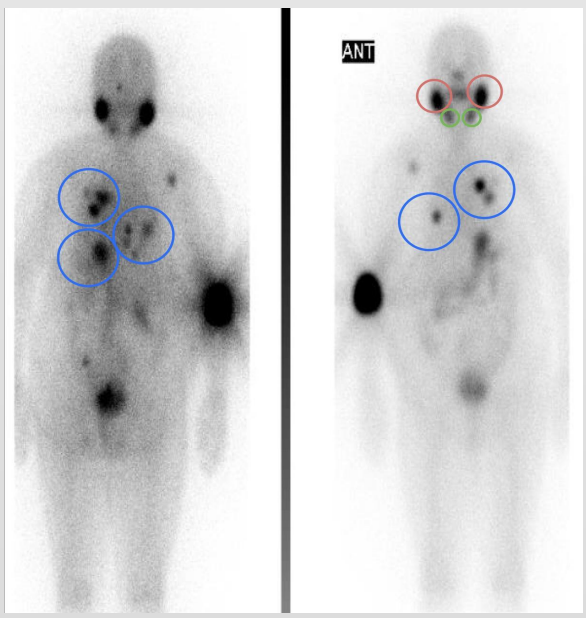
To know the exact location of abnormality, you have to do **SPECT CT**
(knowing the exact site helps the surgeon decide which surgical approach to use)

- **Sagittal view** shows remnant in front of the trachea
- **Trans Axial view** shows that is antero-lateral to the trachea

Red thing → Remnant in thyroglossal cyst

How to completely remove it? Give the patient **I-131**[439,438]

Bone Metastases

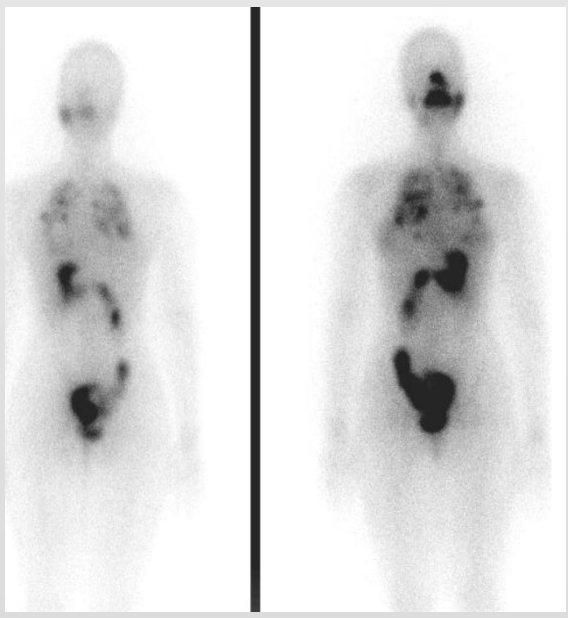


- No thyroid uptake ; because it's removed
- Abnormal uptake in the ribs and left humerus "Indicates bone metastases "
- Normal iodine uptake in salivary glands

Pink → parotid gland Green → Submandibular gland

What type of cancer? **Thyroid follicular carcinoma**

Lung Metastases



Diffuse lung uptake with focal area of higher uptake; Indicating Lung metastases

Especially follicular type because it has hematogenous spread

What type of cancer? **Thyroid follicular carcinoma**

❖ Thyroid Scan

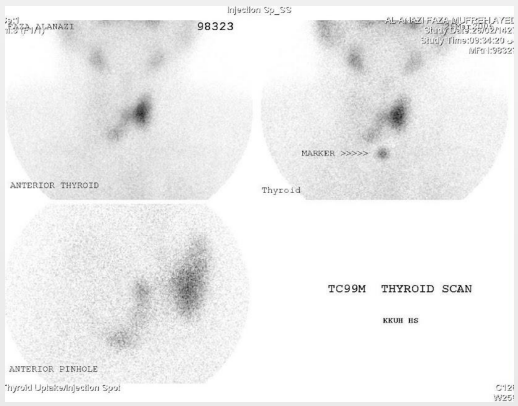
When is thyroid scanning helpful?

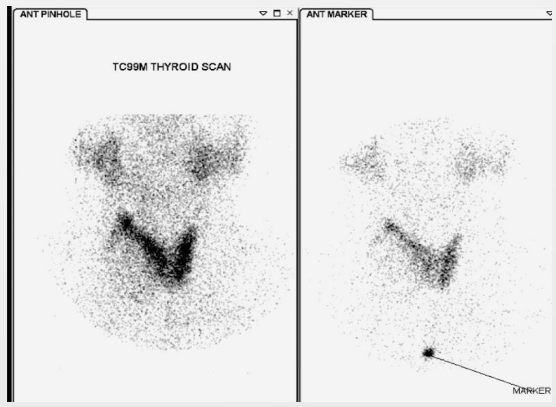
Indications for Thyroid Scan

- Evaluation of thyroid nodules : Number & type
- Evaluation of congenital hypothyroidism : Agenesis Vs. Dyshormonogenesis.
- Evaluation of neck masses : ectopic thyroid, thyroglossal cyst.
- Evaluation of thyrotoxicosis.

Evaluation of thyroid nodules : Single vs MNG

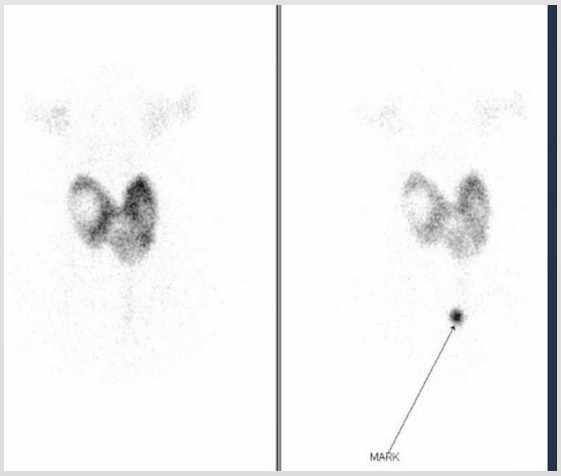
Solitary cold nodule (Single raised nodule)

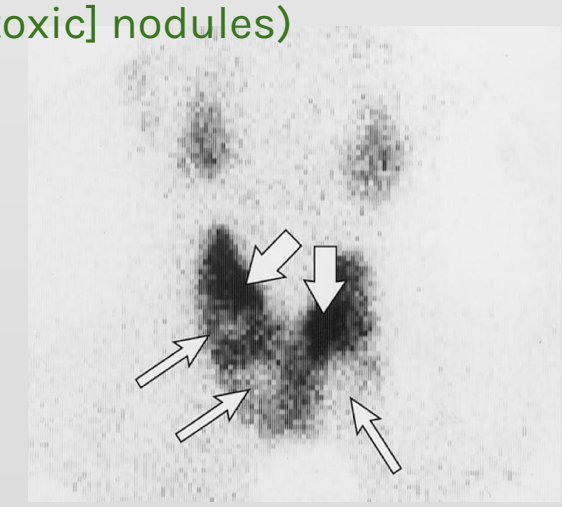




Left lobe → Normal uniform uptake, No defect
Right lobe → Large defect (No uptake at all)
Marker in Suprasternal notch → to see if there is retrosternal extension or not
Cold → No uptake of iodine or Technetium [439,438]

Multinodular goiter (Multiple cold [nox-toxic] nodules)

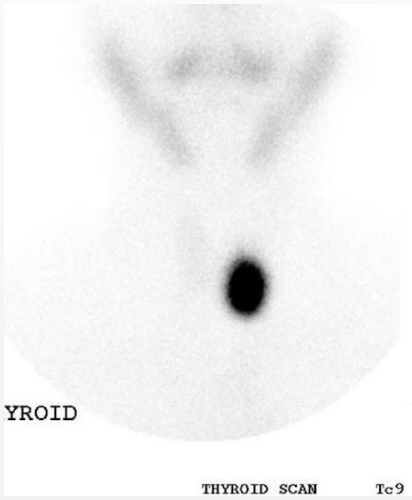


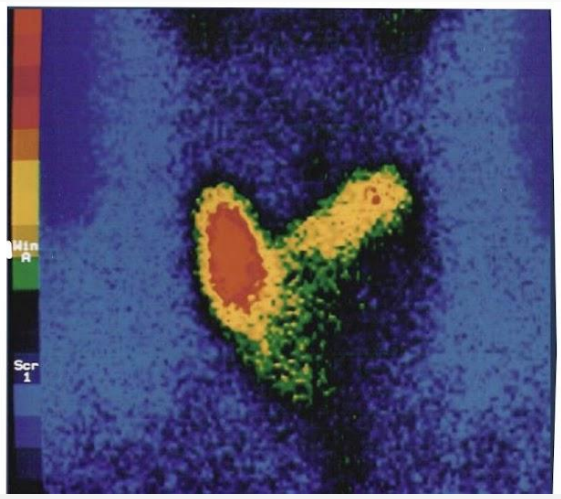


There are Multiple defects
The chance of malignancy is more in Solitary cold nodule than in MNG
As the number of nodules increase, the chance of malignancy decrease [439,438].

Evaluation of thyroid nodules : Hot vs Cold vs warm

you can't see extra-nodular thyroid tissue (normal thyroid around the nodule)[439,438]





you can see the the extra-nodular thyroid tissue[439,438]

Hot : < 5% Malignant

(Autonomous toxic nodule)
a hot nodule that takes up all the tracer, suppressing the rest of the gland and independent on pituitary thyroid axis [439,438]

Cold : 15-20% Malignant

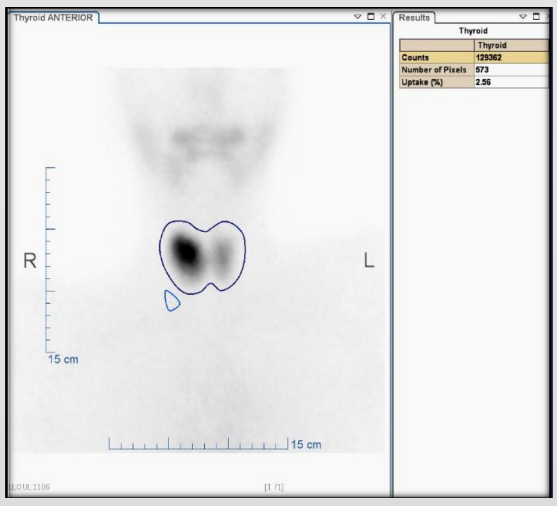
15% (Female) - 20% (Male) **Malignant**
No uptake at all in the affected gland

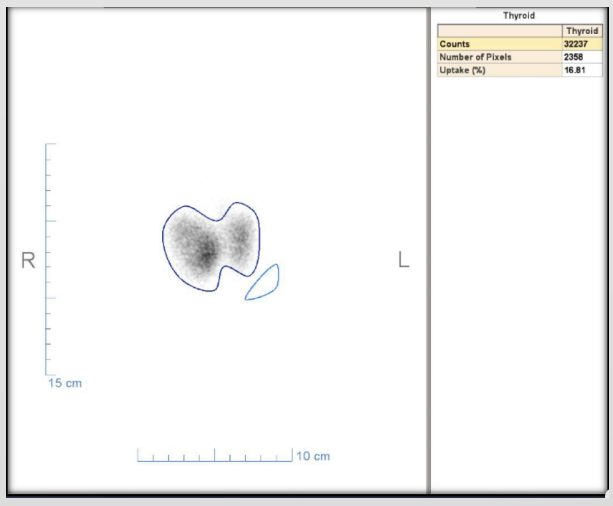
Warm : Suspicious

There is uptake more than the rest of the gland without suppressing the gland (the rest of the gland is seen, Unlike in Hot nodule the rest of the gland is Not seen)
- this image is taken by technetium.
(Warm nodule on Technetium Should be of followed by **iodine 123** to see if it is really hot or cold) [439,438]

Discordance Tc–I 123 Scan

A warm nodule in Tc is worrying it can be cold when done by I123. **Why?**
because Tcm99 is only a trap test whereas I123 is both trap and organification test. [439,438]



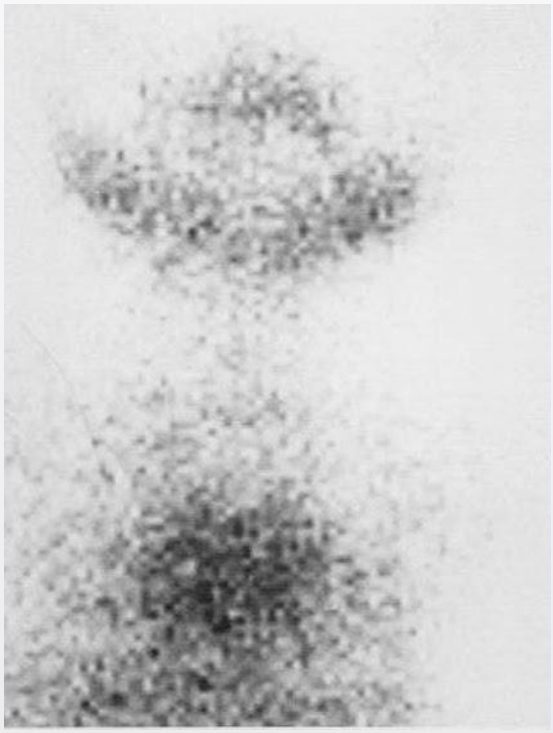


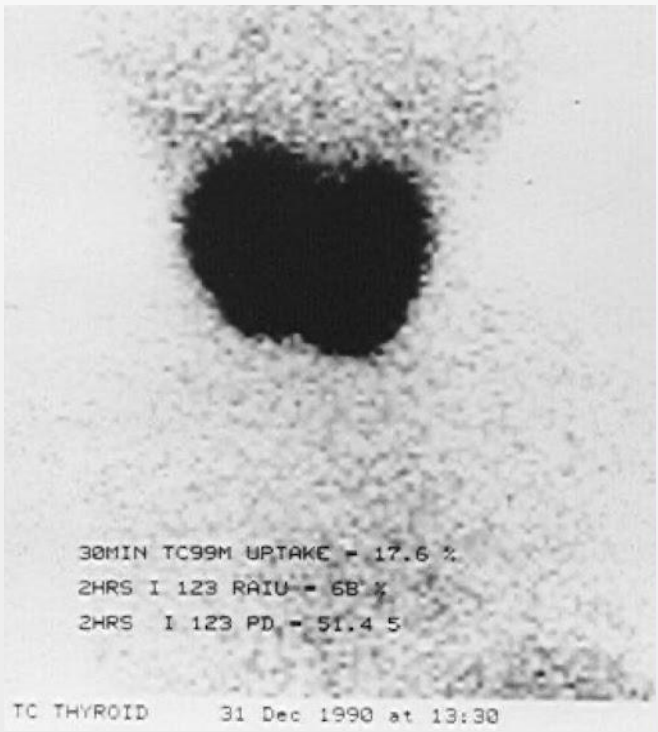
The chance of malignancy of a discordant nodule about 20%

Evaluation of congenital hypothyroidism

Agenesis vs Dyshormonogenesis

TSH tests are routinely ordered for newborns. **If TSH is high** Thyroid scan is done to detect the presence of thyroid gland (US is not used because the base of the tongue can't be seen in case of ectopic thyroid at the base and it can't evaluate the function.) [439,438]





Agenesis

- High TSH
- absent thyroid gland
- Treatment: lifelong thyroxine [439,438]

Dyshormonogenesis

- High TSH
- Enlargement of the gland
- Hypothyroidism
- Thyroid is present (Abnormal)
- Organification defect

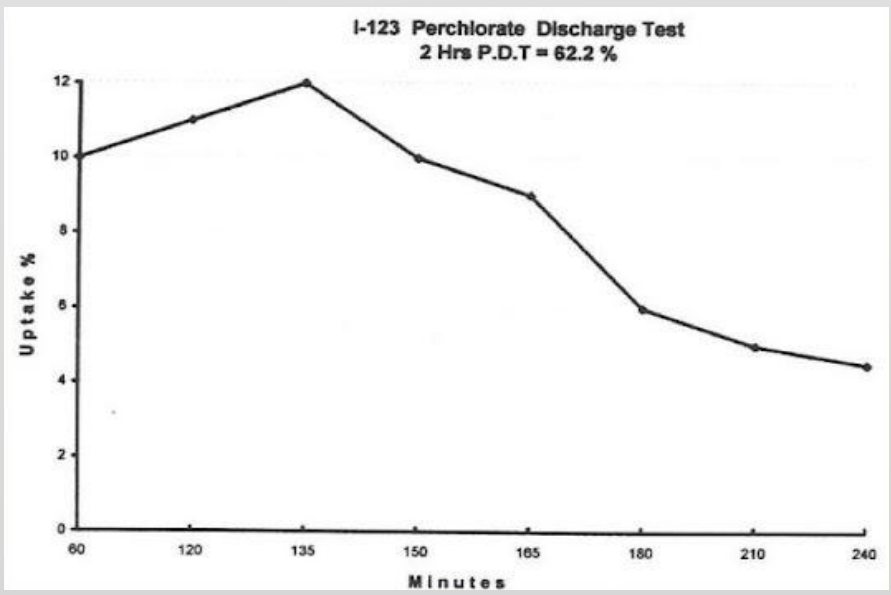
(Defect in thyroid hormone synthesis due to an enzyme defect)

- It uptake more iodine trying to produce thyroxine [439,438]

This is an example of hypothyroidism with high intake the patient will recover by providing the enzyme

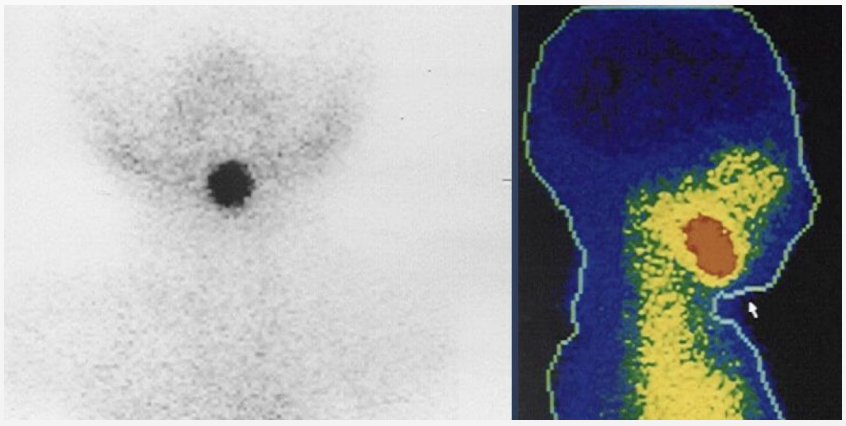
Perchlorate Discharge Test

50 - 80 uCi I-123 orally
2 hrs RAIU 400 mg Kclo4
RAIU/ 15 min for 2 hours
Positive test : >= 15 fall of RAIU below 2 hours. uptake



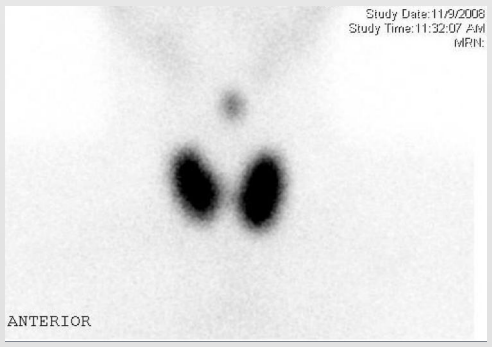
Evaluation of neck masses ectopic thyroid vs thyroglossal cyst

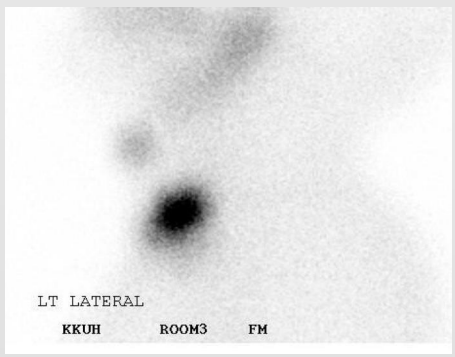
Lingual thyroid

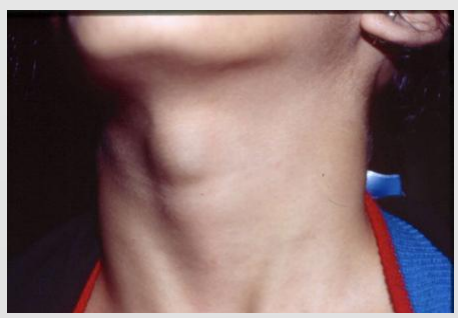


If a patient presented with Mass at the base of the tongue — You should order a thyroid scan
The patient may present with dysphagia or dyspnea
A → Mass at the midline of the neck submental?..
Lateral view (to confirm the diagnosis) → Mass appears at the base if the tongue
Management : removed surgically , and implanted in the arm or in the wall of the abdomen , it will function normally producing thyroid hormone [439,438]
(Remember, Thyroid gland is derived from third pouch)
For Unknown reasons Sometimes it doesn't migrate to its normal position (in front of the thyroid cartilage) It remains arrested at the base of the tongue

Thyroglossal cyst







Patient with midline neck mass
As the thyroid descend through the thyroglossal duct sometimes this duct remains producing a cyst (remnant of thyroid tissue)
Management : Removed surgically [439,438]

❖ Thyrotoxicosis

Evaluation of Thyrotoxicosis

Thyrotoxicosis **IS NOT** synonymous to Hyperthyroidism

Thyrotoxicosis : Is a complex of signs and symptoms due to elevated thyroid hormones in the blood

Hyperthyroidism : Overproduction of thyroid hormones by the thyroid gland (hyperactive gland)

Thyroid scan In thyrotoxicosis is imp ;

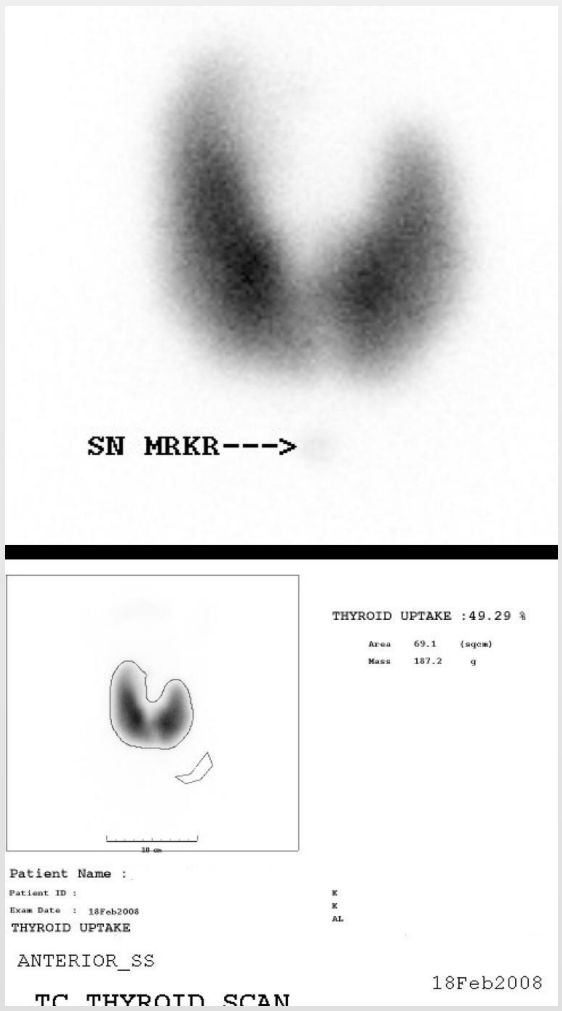
- can help in differentiating between thyrotoxicosis with hyperthyroidism from thyrotoxicosis without hyperthyroidism.
- therapy decision is based on the scan results if its hyperthyroidism or not [439,438]

Thyrotoxicosis with hyperthyroidism

important:

- **Graves' Disease**
- **Neonatal hyperthyroidism**
- **Toxic nodular goiter :**
  - MNTG or Plummer's disease
  - ATN or toxic adenoma
- **Iodine induced** (Jod-Basedow disease)
- **Rare causes :**
  - Excessive HCG by trophoblastic tumor
  - Hypothalamic pituitary neoplasms (TSH induced)

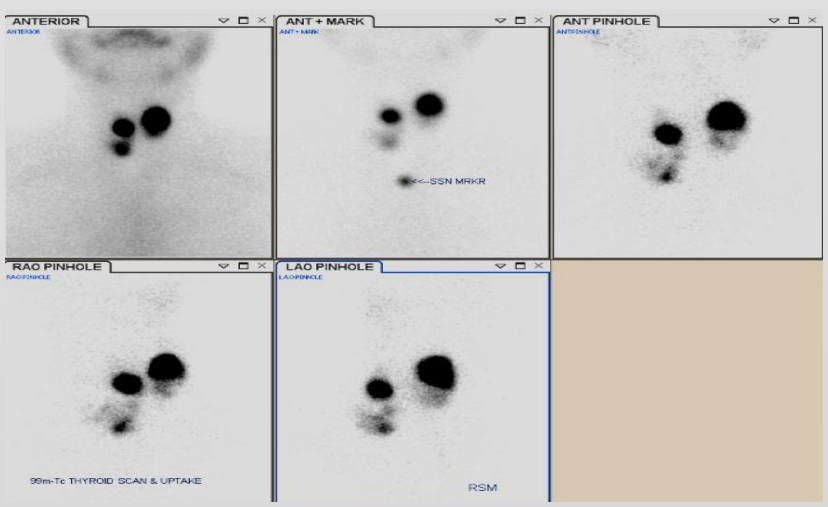
Diffuse enlargement of the thyroid gland in Graves disease With high uptake (49%)

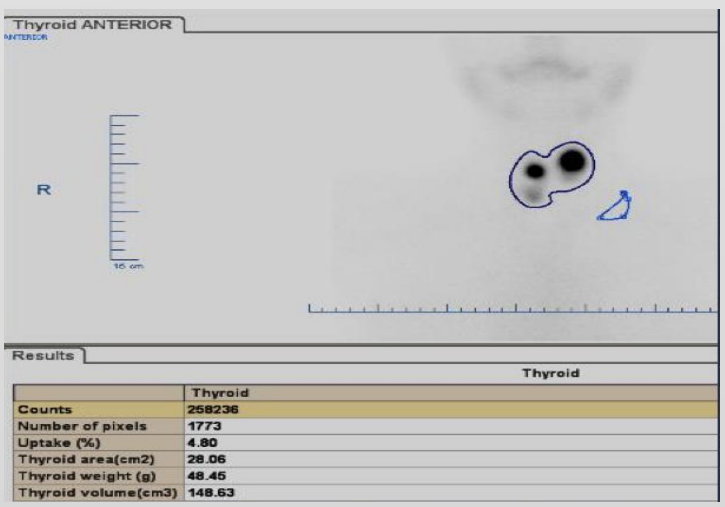


Patients with overproduction of thyroid hormone **need definitive treatment:**

- Antithyroid drugs, Complications: Agranulocytosis
- I 131 therapy
- surgery

Multinodular toxic goiter (MNTG) (Plummer's Disease)

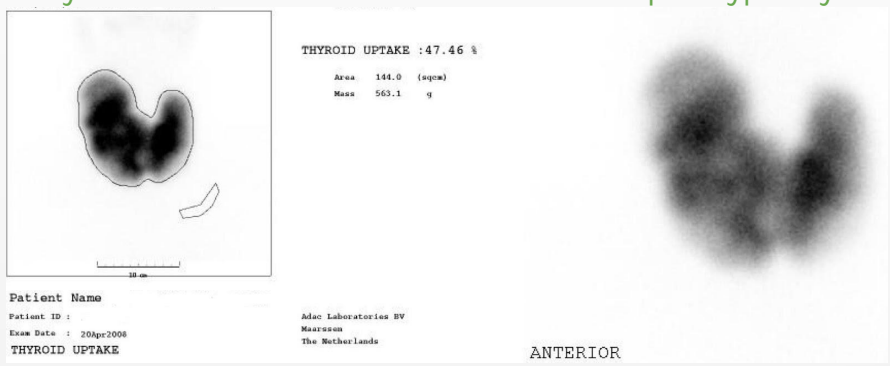




Thyrotoxicosis with Hyperthyroidism

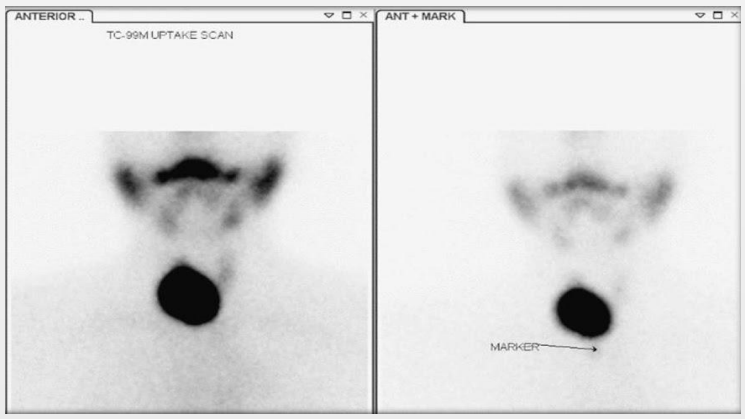
Graves' Disease on top of MNG Nodular Graves Disease (Marine-Lenhart syndrome)

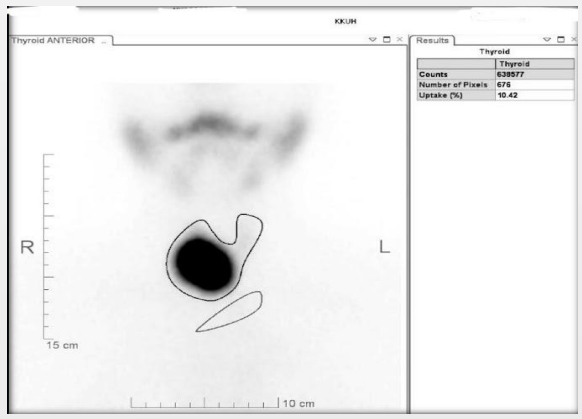
The normal thyroid tissue between the nodules developed hyperthyroidism (graves disease) [439,438]



High uptake (47%)
"Hyperactive"

Autonomous toxic nodule (ATN)





- Very hot nodule, the rest of the gland is not seen
- High uptake (10.4%)
- Autonomic: Not depended on TSH (Releases hormones without the need of TSH)

Management: Iodine therapy * Best case for iodine therapy [439,438]

Thyrotoxicosis without Hyperthyroidism

- **Subacute thyroiditis**

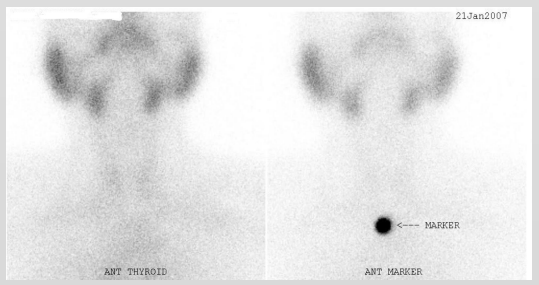
Usually the history tells you that the patient had recent infection,
95% normally recover, 5% will have complete hypothyroidism..

- **Chronic thyroiditis with transient thyrotoxicosis**

- **Thyrotoxicosis factitia** (exogenous hormone) taking thyroxine to lose weight [439,438]

- **Thyroid extract** (e.g.Hamburger thyrotoxicosis)
  "ingestion of thyroid hormone from contaminated meat"
- **Ectopic thyroid :**
  - Metastatic thyroid carcinoma
  - Struma ovarii

Treatment: treat the underlying cause + symptomatic relief.
they don't need definitive treatment; once the underlying cause is treated function of the thyroid gland returns back to normal



Subacute thyroiditis

❖ Radioactive therapy

Radioactive Iodine Therapy for Hyperthyroidism

- **Isotope used** : I 131 used for therapy; because it emits beta rays [439,438]
- **Physical Properties** : Solution or capsule
- **Main side effect** : Hypothyroidism
  -because you're destroying the thyroid tissue by I-131 [439,438]
  -The patient needs thyroxine therapy for life

- **Dose** :
  a. Calculated : Considering weight and uptake of the gland
  b. Empirical :
  Graves: 5-15 mCi
  ATN : 15-20 mCi

Radioactive Iodine Therapy for Thyroid Cancer

Isotope used : I 131 To destroy thyroid remnants and treat metastasis
Physical Properties : Solution or capsule

- **Thyroid remnant** : 80-100 mCi
- **Lymph Node Mets** : 100 mCi
- **Local Recurrence** : 100 mCi • Lung Mets : 150 mCi
- **Bone Mets** : 200 mCi

Doctor said: you don't have to memorize the doses BUT know that I 131 can be used to :

- Therapy of Graves, ATN and hyperthyroidism
- Treat metastasis and remnant in thyroid cancer [439,438]

❖ Parathyroid scan

Normal and Ectopic Parathyroid Glands

The <u>third</u> pair of pouches:
proliferates into the **<u>inferior</u>** parathyroid glands and the thymus

The <u>fourth</u> pair of pouches:
proliferates into the **<u>superior</u>** parathyroid glands and the lateral angle of the thyroid gland.

Because the inferior parathyroid glands undergo more extensive migration during embryogenesis, they are more likely to be found in ectopic locations.

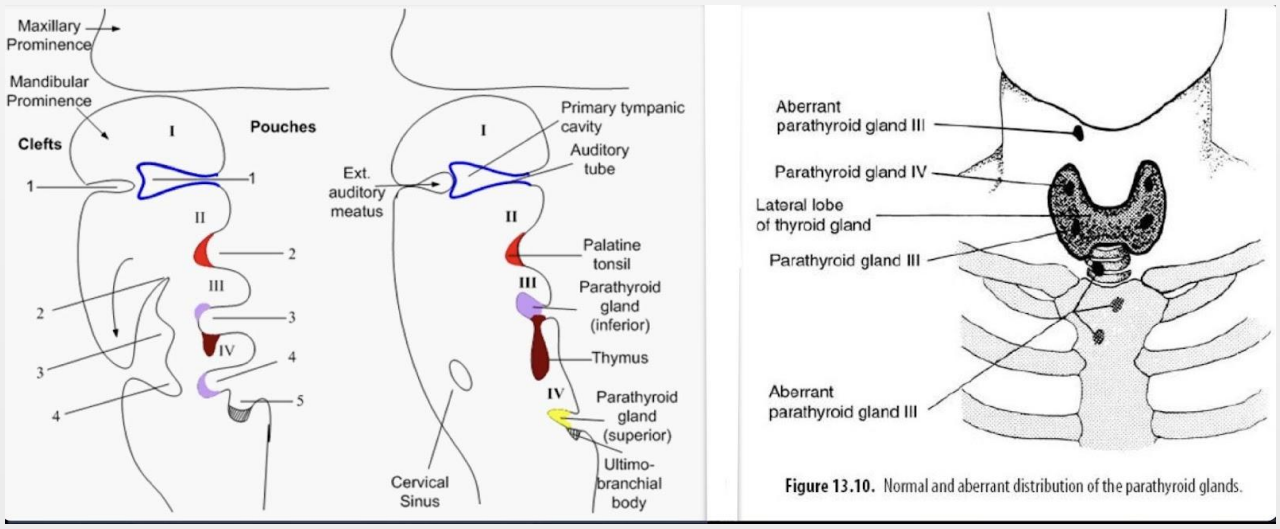
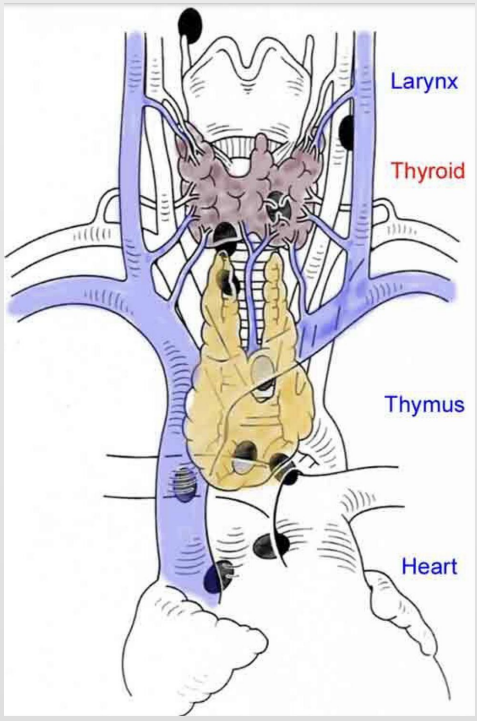


Figure 13.10. Normal and aberrant distribution of the parathyroid glands.

Ectopic Parathyroid Glands

Location of an ectopic parathyroid glands

- Submandibular
- Retropharyngeal
- Retroesophageal
- Posterosuperior mediastinal
- Intrathyroidal
- Within the tracheoesophageal groove Carotid sheath
- Thyrothymic ligament
- Intrathymic
- Antero-superior mediastinal.



Value of parathyroid scan :

- screening for ectopic parathyroid gland
  (Screen the neck from the submandibular area to the upper mediastinum)
- Localization of ectopic (abnormal) parathyroid gland [439,438]
- Also it can be used to detect eutopic parathyroid gland “in right place”

While US it’s only used to detect the eutopic parathyroid gland

Diagnosis of hyperparathyroidism by :
its tumor marker the Parathyroid hormone (PTH) and high calcium

Parathyroid Scan Techniques

- TL-201 _ Tc-99m subtraction
- Tc -99m Sestamibi (Dual Phase) Gold standard
- Tc -99m Tetrofosmin (Dual Phase)

Radiopharmaceutical	99mTc / 201Tl Subtraction	99mTc sestamibi
Activity administered	80 MBq (2 mCi) 201Tl; 370 MBq (10 mCi) 99mTc	925 MBq (25 mCi)
Images acquired	Inject Tl .rst and acquire 15-min 100 000 count view of neck and mediastinum. Then acquire similar Tc images without moving patient. Subtract Tc data from Tl after normalization to equal count densities	Anterior (and oblique) views at 15 min and at 2–3 h; SPECT as needed

Tc -99m-Sestamibi

The Parathyroid Study depicts hypertrophied parathyroid tissue, probably because of uptake of Tc-99m-sestamibi in the mitochondria of hyperactive cells.

Indications : Detect and localize parathyroid adenomas .
Patient Preparation : None
Radiopharmaceutical, Dose, & Technique of Administration

- **Radiopharmaceutical:** 25 mCi Tc -99m-sestamibi I.V
- **Patient position:** Supine with head and neck extended and immobilized.
- **Gamma camera Imaging field:**
  1. Neck. 2. Upper two thirds of the mediastinum

Acquire images at 15 minutes and 2-3 hours post injection.
SPECT/SPECT CT images improves localization.

Give the patient 25 mCi. Scan the patient after 15-20 min and after 2-3 hours.
If there is an abnormal uptake proceed to do SPECT; to localize the abnormal parathyroid gland

Tl-Tc99m subtraction :

Several protocols have been developed for routine subtraction of thyroid tissue from parathyroid tissue. rarely used

Dual phase MIBI Scan (Or Tetrofosmin)

Normal parathyroid glands are small and not visualized (5mg)

Abnormal parathyroid glands can be visualized

Right lower parathyroid adenoma

Early image

Sestamibi goes to the thyroid and abnormal parathyroid

2-3 Hours image

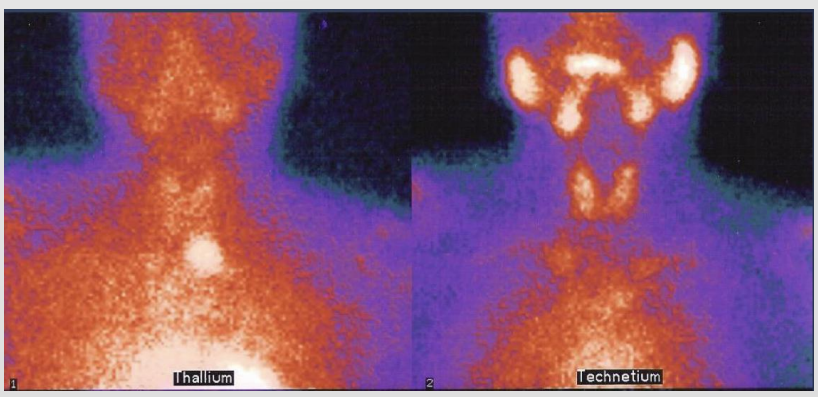
Washout from the thyroid and remain in the abnormal parathyroid [439,438]

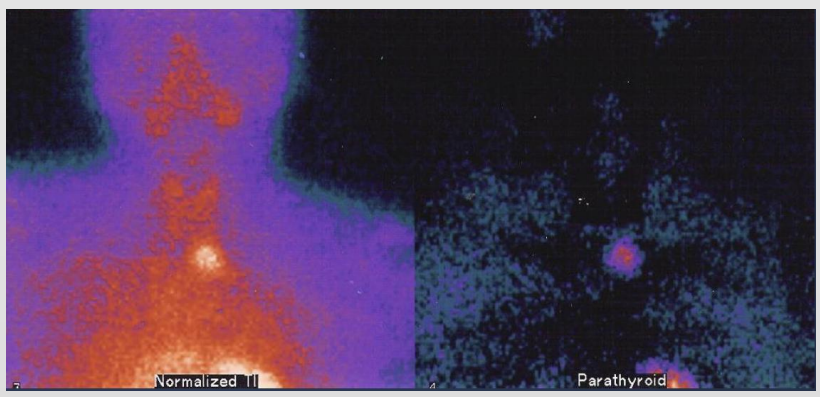
Don't request Sestamibi scan to see the normal parathyroid gland

It should be requested to:

- Determine from where the high PTH is coming from
- patient with abnormal parathyroid gland

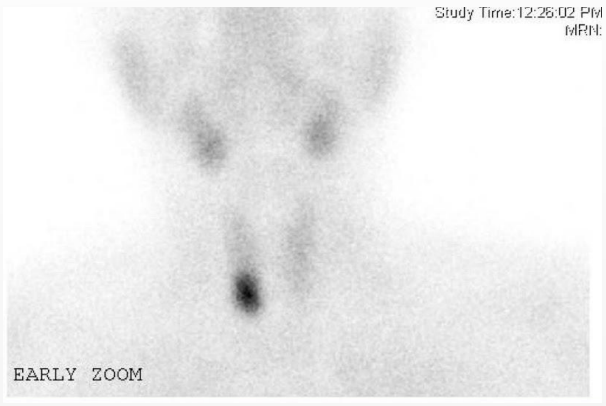
Tc-Tl Subtraction Scan

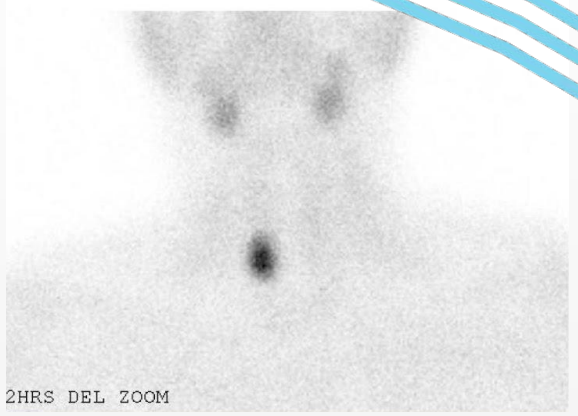




1. thallium is given to the patient, it will go to the thyroid and abnormal parathyroid.
2. Then only technetium is given which goes to the thyroid only
3. Subtract the images of technetium thyroid scan from the thallium scan, to visualize the parathyroid gland [439,438]

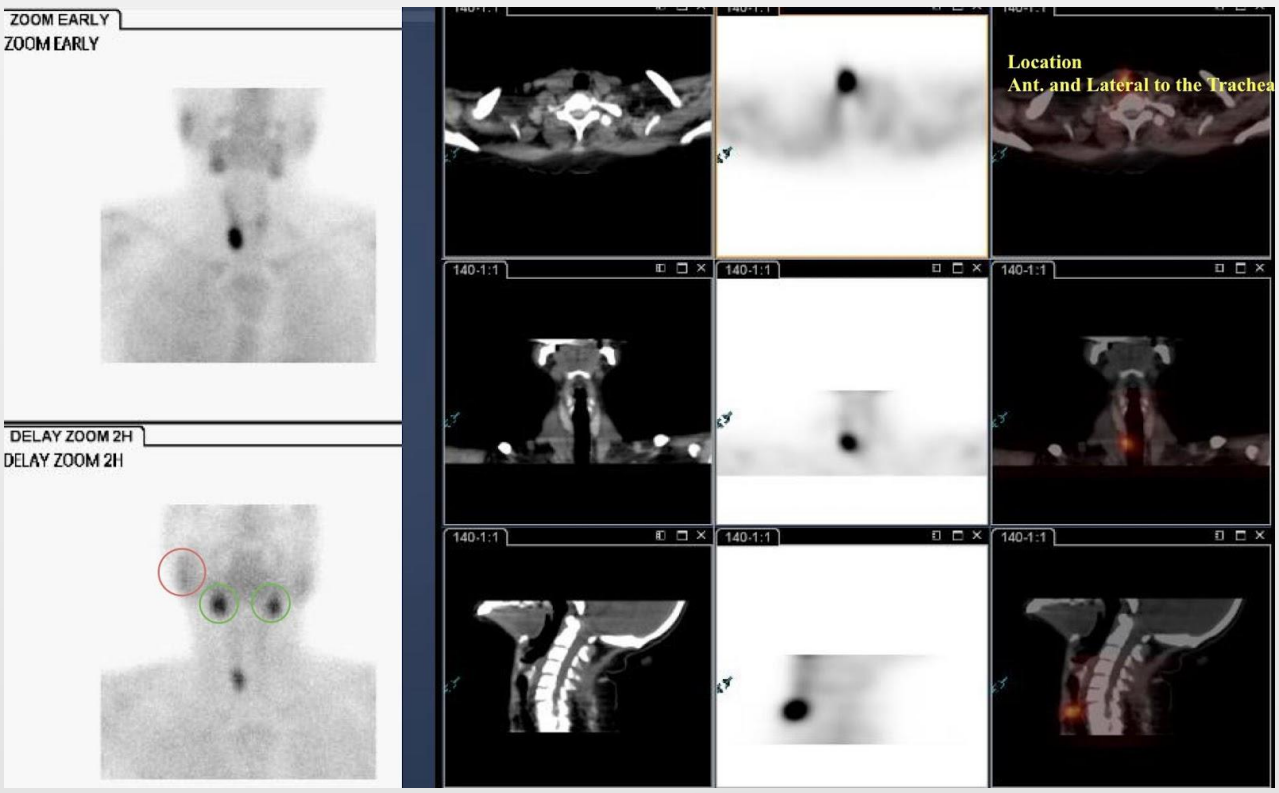
Sestamibi dual phase





Early image: goes to thyroid and abnormal parathyroid
2H delay image: washout from the thyroid gland and retention of activity in right lower parathyroid adenoma [439,438]

Sestamibi Dual Phase (Planar vs SPECT CT)

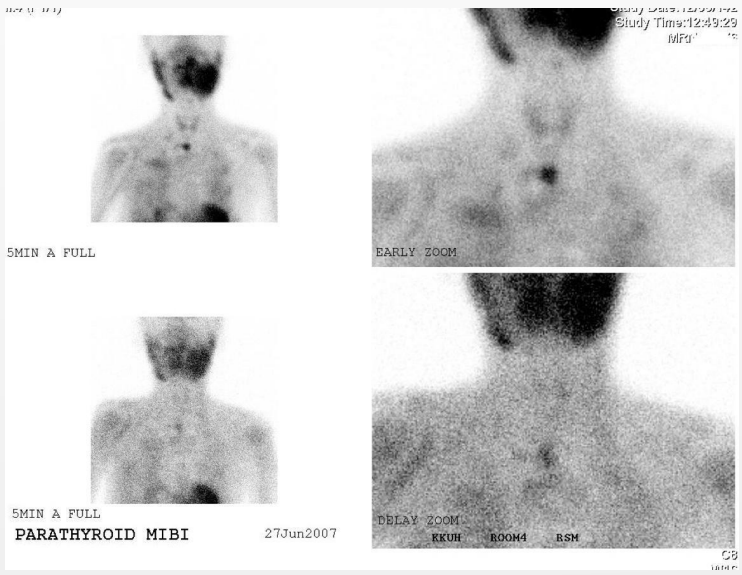


Planar image
Early image: goes to thyroid and abnormal parathyroid
- Pink: Submandibular gland - Green : parotid gland
delay image: washout from the thyroid gland and retention in the right inferior parathyroid lobe

SPECT CT : For precise localization of the parathyroid adenoma
Site of adenoma : Lateral and anterior to the trachea (easy to remove it by a small anterior incision) [439,438]

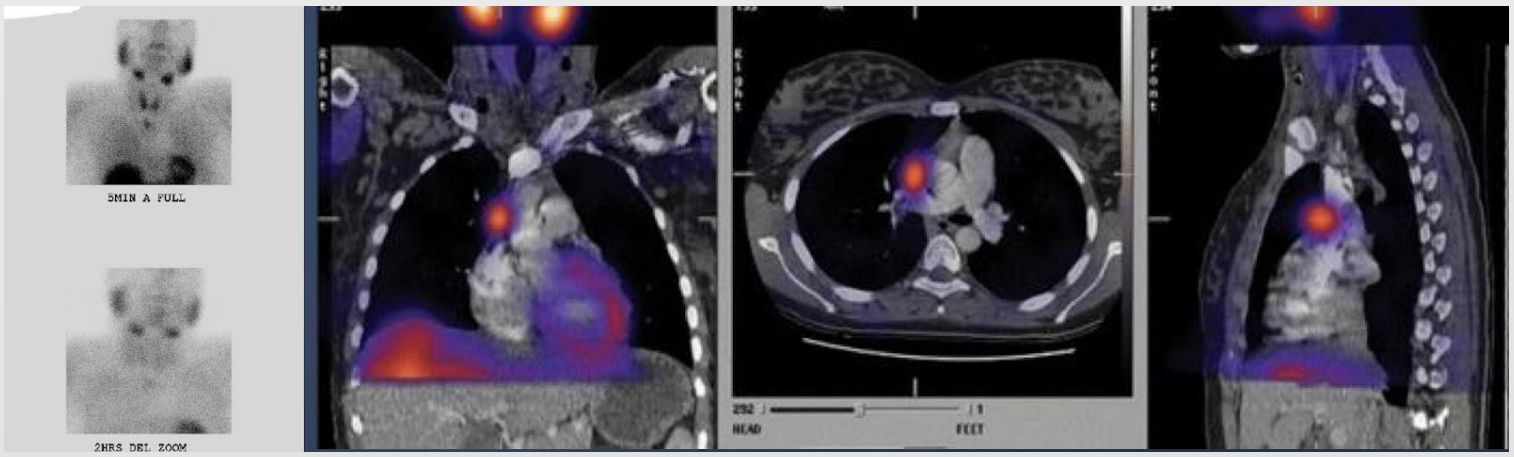
Ectopic Parathyroid : 16% of total adenomas

Focal retention of tracer in the upper mediastinum, for precise localization of the parathyroid adenoma request SPECT CT [439,438]



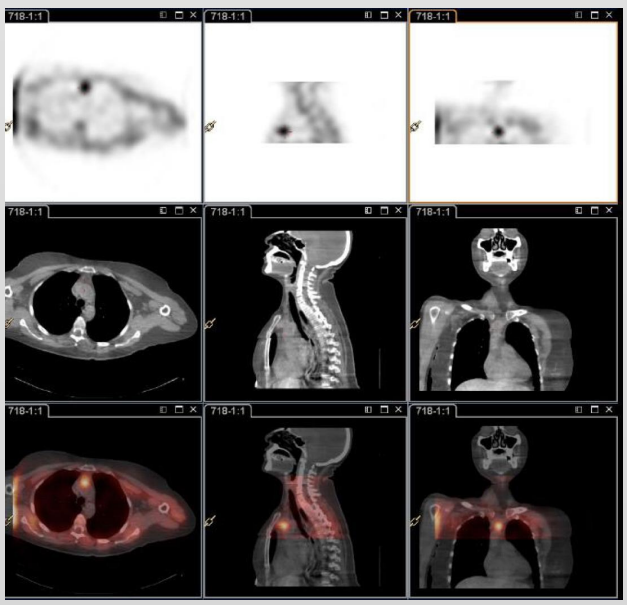
Ectopic Parathyroid Adenoma
PLANAR vs SPECT/CT

- Abnormal uptake is close to the aortic arch, need help from thoracic surgeon [439,438]
- SPECT-CT images accurately localize the adenoma and guide the surgeon to the best surgical approach



Ectopic parathyroid adenoma
Antero-superior mediastinum

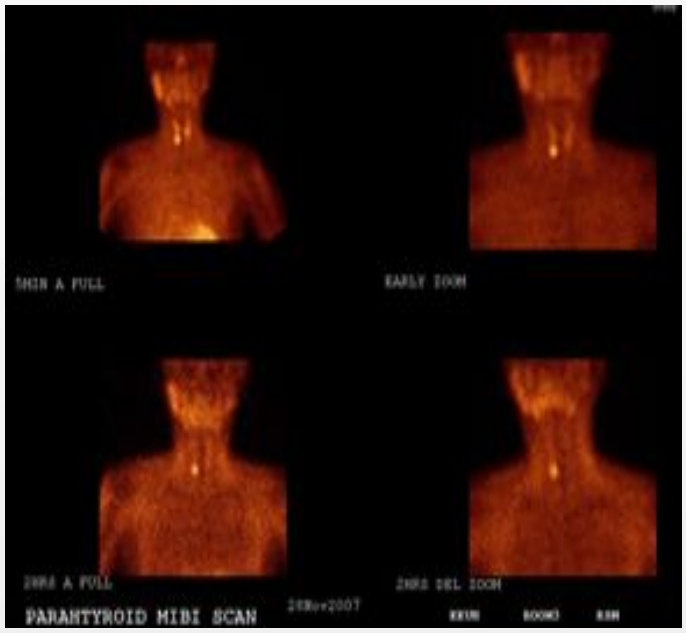
Lesion is Easy to be managed as it's located posterior to the sternum (retrosternal) parathyroid adenoma can be removed by a small incision superior to the mediastinal area [439,438]



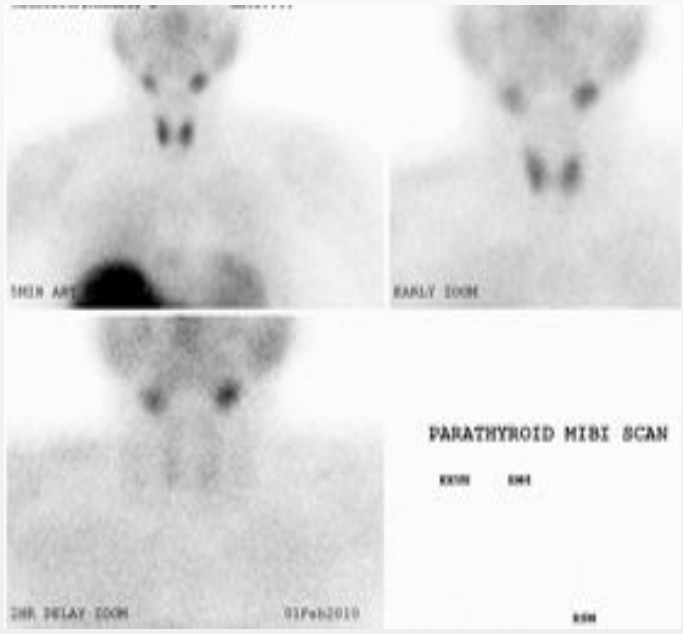
❖ Sestamibi scan

Sestamibi Parathyroid Scan Results :

High PTH /High Ca “TP:True Positive”



High PTH / High Ca “FN:False negative”



Mechanism of sestamibi uptake: >is the cause of the FN result

SESTAMIBI : METHOXYISOBUTYLISONITRILE.

- Its parathyroid uptake was first reported by Coakley et al. in 1989.
- Mechanism of MIBI uptake and retention is still unclear. Multifactors have been proposed:

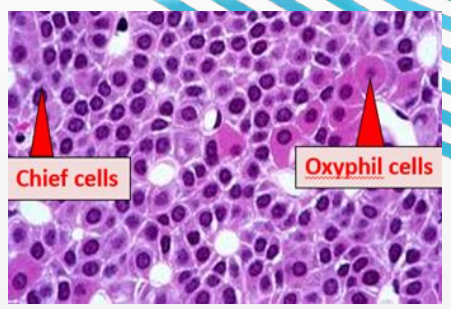
  - **Biochemical properties of the tracer:**
    Lipophilicity: The lipophilic sestamibi molecule is concentrated by mitochondria. This explains why adenomas with an abundance of mitochondrial-rich oxyphil cells retain the sestamibi Cationic charge.

  - **Cell Type:** A predominance of oxyphil cells within an adenoma is more likely to lead to a positive scan.

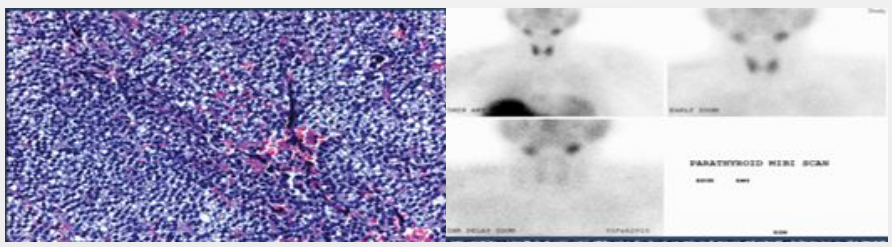
  - **Local factors:** Blood flow, trans-capillary exchange, interstitial transport and negative intracellular charge of both mitochondria and membranes.

❖ Sestamibi scan

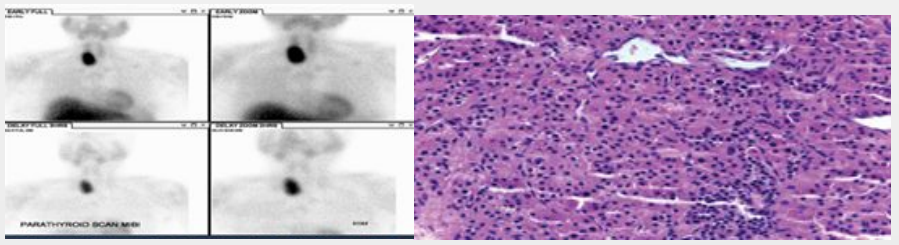
Normal parathyroid glands comprise 2 cell types:



- **Chief cells:** responsible for PTH production.
- **Oxyphil cells:** eosinophilic cells whose cytoplasm is composed almost entirely of mitochondria.
  - **While the normal oxyphil cell does not synthesize and secrete PTH, the oxyphil cells of pathologic parathyroid glands do secrete the hormone.**
- Sestamibi concentrates in the mitochondria. if the adenoma derived from oxyphilic cell it will show on sestamibi (the scan will be **positive)** and if the tumor derived from Chief cell it will not show on sestamibi (it will not uptake the sestamibi and the scan will be **negative**) we do MRI -and ultrasound- to confirm adenoma from chief cells.



Parathyroid adenoma composed entirely of glycogen-rich chief cells.



Parathyroid adenoma composed mainly of mitochondrial-rich oxyphil cells.

What is the cause of the FN Sestamibi scan results?

- **Histologic type:** False-negative scans can occur with parathyroid glands containing predominantly clear cells.
- **Size and Location:** Smaller-volume parathyroid adenomas and those in the upper position are less likely to be localized with sestamibi scans.
- **Number of adenomas:** FN rate is increased with MGD compared with patients with a single adenoma.
- **Decreased tracer concentration:** Possible association:
  - P-glycoprotein expression.
  - Multidrug resistance–related protein expression.
- **Variability of radiotracer uptake in parathyroid adenomas:** Related to differences in perfusion and metabolic activity.
  Even with refinements in sestamibi scanning, the fact that all parathyroid adenomas are not created equal on a cellular level may inevitably lead to FN scans in a certain number of cases.

False-Positive Scintigraphic Findings:

In the clinical setting of hyperparathyroidism, false-positive findings are uncommon.

- Solitary thyroid adenoma or a multinodular goiter.
- Benign or malignant tumors: breast, lung, and head and neck carcinomas and their lymph node and osseous metastases, as well as bronchial carcinoids.
- Primary thyroid lymphomas.
- Cervical L.N. metastasis from PTC carcinoma.
- Reactive lymph nodes.
- Remnant thymus.
- PTH-secreting paraganglioma.
- Enlarged submandibular salivary gland.

Points To Remember Before Proceeding For Parathyroid Imaging:

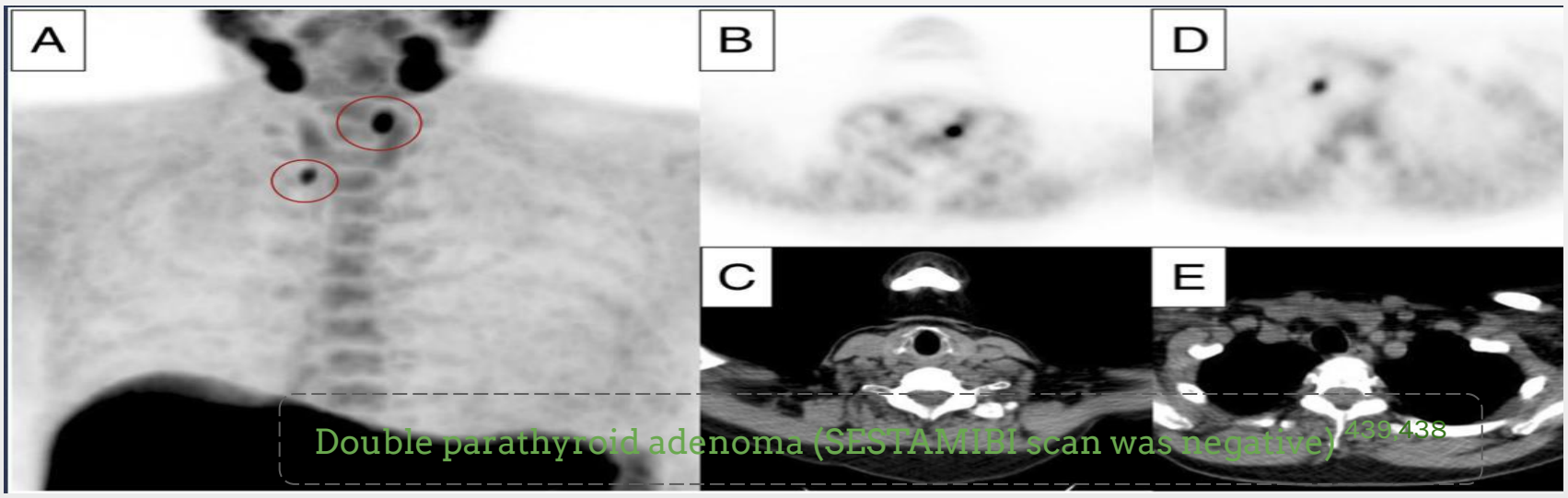
- **Imaging is not for diagnosis:** High Ca and PTH establish the diagnosis.
- **Imaging does not identify normal parathyroids:** These are too small to be seen (20-30mg).
- **Imaging should detect abnormal parathyroid(s) and indicate the approximate size and the precise relationship to the thyroid gland:** lateral, SPECT and SPECT /CT.
- **Imaging should identify ectopic glands:** SPECT and SPECT/CT. "Full neck and upper mediastinum"
- Optimal imaging should be able to **differentiate** patients with single adenoma from those with MGD.
- Imaging should identify **thyroid nodules** which may require concurrent surgical resection.

❖ Parathyroid imaging

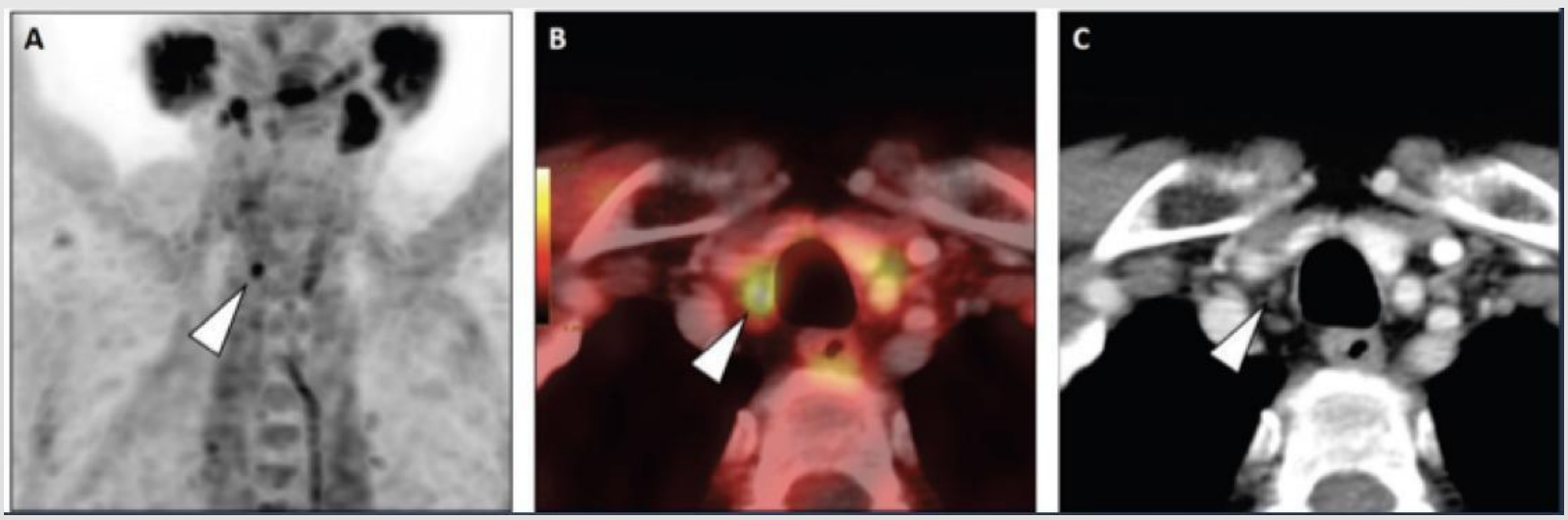
18f-fluorocholine PET/CT:

- New radiopharmaceuticals for parathyroid imaging
- Very sensitive for chief cells and oxyphils.
- Very expensive “one dose could cost 16000 SR!”.
- Used when there is high PTH & **-ve Sestamibi scan**

18f-fluorocholine parathyroid scan:



Double parathyroid adenoma (SESTAMIBI scan was negative)[439,438]



Focal hyperactivity posterior to the right caudal pole of right thyroid lobe and, histologically confirmed as parathyroid adenoma.
Previous imaging by neck US and MIBI was inconclusive

DON'T FORGET (by 432 team)

- Technetium half-life is **6 hours.**
- **To assess the organification we use I123** not Tc-99.
- **The gold standard tracer in RAIU is 123.**
- If patient is on thyroxine s/he should stop it 3-4 weeks before thyroid scan.
- If patient is on antithyroid s/he should stop it 3-5 days before thyroid scan.
- The patient **should not** have any I.V contrast for at least 3- weeks before scan.
- RAIU is to determine how much of the dose we give to the patient is taken by the thyroid gland.
- I 123 is used for **diagnosis** while I 131 for **therapy** (cancer or hyperthyroidism).
- Causes of abnormal thyroid uptake. (either high or low)
- A common cause of thyroid cancer is **irradiation.**
- In thyroid cancer the uptake is most likely **normal**.
- Hot nodules have **no chance** (<5%) of being malignant.
- Cold nodules have 15% chance of malignancy in females and **higher in males 20%.**
- **The most common cause of hot nodule is ATN.**
- **<u>Indication of thyroid nuclear imaging include:</u>**
  - *Evaluation of thyroid nodules.*
  - *Evaluation of congenital hypothyroidism: Agenesis Vs. Dyshormonogenesis.*
  - *Evaluation of neck masses: ectopic thyroid, thyroglossal cyst.*
  - *Evaluation of thyrotoxicosis.*
- Perchlorate discharge test is used **to confirm dyshormonogenesis.**
- **RAIU is used also to evaluate:**
  - *Thyroiditis : subacute and chronic thyroiditis.*
  - *Thyroid Cancer : Remnants uptake in preparation for therapy. (after surgery how much remnants is left, to prepare for I 131 therapy).*
- **<u>Lactating mothers should stop breastfeeding according to the following:</u>**
  - **Completely after I 131 therapy**
  - **3 weeks before diagnostic I 131**
  - **12 h after 99mTc.**
- The main side effect of radioactive iodine therapy for hyperthyroidism is hypothyroidism.
- Parathyroid imaging needs combination of several modalities. Sestamibi and MRI are the best combination.
- Parathyroid scan results depends on the **histological type of adenoma.**
- Normal parathyroid scan doesn't exclude parathyroid adenoma.

Summary

Thyroid scan procedure	
Tc-99m	**I-123**
Not expensive, half time is 6 hrs, 20 mins after injection in one time visit. Trapped NOT oragnified.	Expensive, half time is 13 hrs, 3 time visit. Trapped AND organified

Thyroid scan indication
Evaluation of thyroid nodules: No. & type (hot vs cold nodule). Evaluation of congenital hypothyroidism. Evaluation of neck masses. Evaluation of thyrotoxicosis.

Evaluation of thyroid nodule		
Hot	**Cold**	**Warm**
due to high activity, suppresses the other parts of the gland , <5% of malignancy, ATN as an example	no uptake of the affected part, higher chance of malignancy	the uptake is slightly higher than the others, suspicious....

Evaluation of neck masses	
Ectopic thyroid	**Thyroglossal cyst:**
Ex. lingual thyroid(base of the tongue), functional	forms from remnants of thyroglossal duct

Parathyroid gland
99m sestamibi (dual phase) is the GOLD STANDARD. adenoma rising from chief cells will have negative parathyroid scan (false -ve) adenoma rising from oxyphil cells will have positive parathyroid scan (true +ve)

1- Which ONE of the following agents is used for parathyroid
a. Tc-99m MDB
b. Tc-99m SESTAMIBI
c. Gallium-67
d. TI201

2- which of the following is true in parathyroid imaging:
a. Imaging doesn't identify ectopic glands
b. Imaging doesn't identify normal parathyroid
c. Imaging is considered a diagnostic method
d. Imaging doesn't identify thyroid nodules

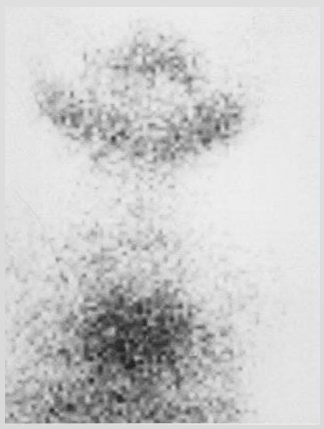
3- half time of I-123 is:
a. 16 hrs
b. 13 hrs
c. 8 hrs
d. 24 hrs

4- Sestamibi scan concentrates in:
a. Nucleus
b. Golgi
c. Mitochondria
d. Endoplasmic reticulum

5- the nodule with the lowest chances of being malignant:
a. hot nodules
b. cold nodules
c. warm nodules

6- Thyrotoxicosis with hyperthyroidism
a. subacute thyroiditis
b. thyroid extract
c. jod-basedow disease
d. ectopic thyroid

7- newborn presented with Elevated TSH and low T4, thyroid Scan shows :
a. dyshormonogenesis
b. Agenesis
c. thyroid aplasia.



Answers
1)B
2)b
3)b
4)c
5)a
6)c
7) b

Team leaders

- Reem Alamri
- Alwateen Alaradi
- Bandar Alharbi

Team members

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- Farah Albakr
- Sara Alrashidi
- Nouf Albrikan
- Renad Alosaimi
- Duaa Alhumoudi
- Norah Almasaad
- Salem Alshihri
- Ibrahim Alabdulkarim
- Mohamed Albabtain
- Abdulaziz Alamri
- Abdulrahman Alswat
- Munib Alkhateb
- Mohammed Alkathiri
- Omar Alhalabi
- Homoud Algadheb

Work done by