



## Nuclear medicine in thyroid and parathyroid

[ Color index: **Important** ★ | **Notes** | Extra | [Shared notes](#) ]

### ● Objectives:

**Thyroid:** At the end of the lecture you will be able to answer the following questions:

- How is the thyroid scan performed?
- When is thyroid scanning helpful?
- What is significant about whether a nodule is "hot" or "cold"?
- What is the role of nuclear medicine in the treatment of thyroid disorders?

**Parathyroid:** At the end of the lecture you will be able to answer the following questions:

- 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.

### ● Resources:

- 434 & 433 & 432 team
- 435 slides and notes

### ● Done by:

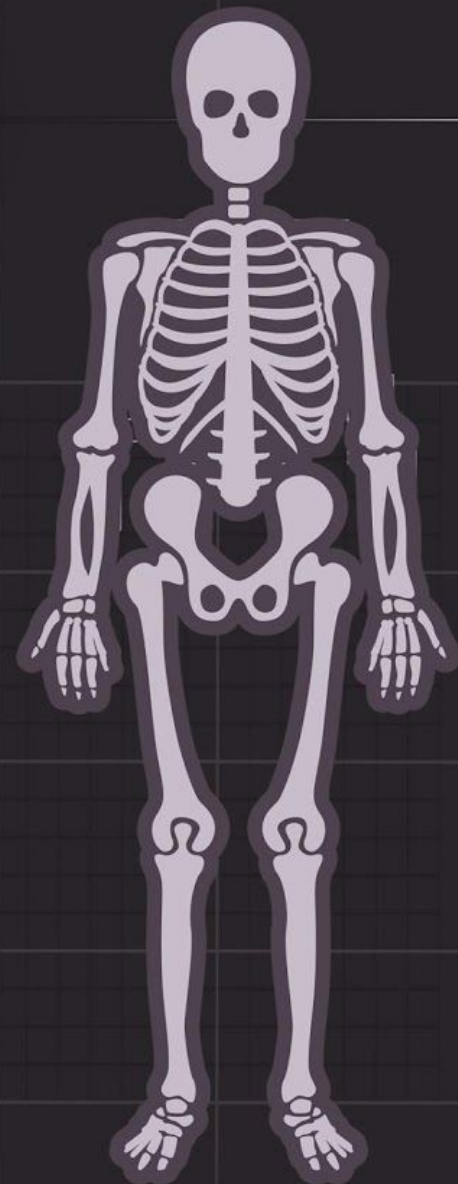
- Samar AlOtaibi
- Munerah AlOmari

### ● Team Leader:

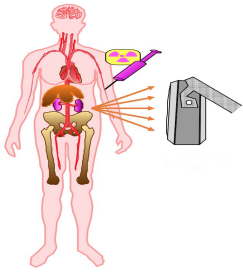
- Amjad Alduhaish
- Mohammed Alsahil

### - Revised by:

- Luluh Alzeghayer



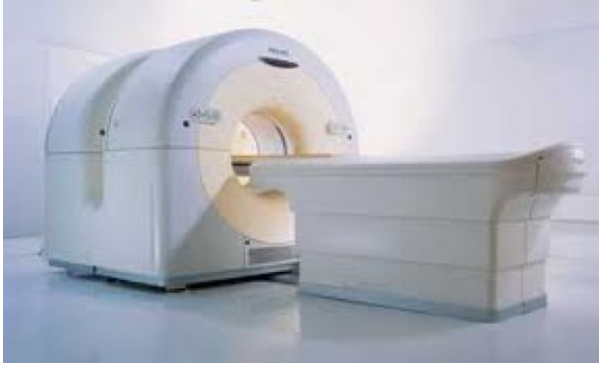


# Nuclear Medicine Procedure



- Patient injected with small amount of radioactive material, **known as: Radiopharmaceuticals.**
- Radiopharmaceutical localizes in patients according to metabolic properties of that drug. **Each organ has its own Radiopharmaceuticals material ex: Bones -> phosphate with radioactive material.**
- Radioactivity decays, emitting gamma rays.
- Gamma rays that exit the patient are imaged, **Detecting the radiation using a Gamma Camera (the grey box in the image)**

## ❖ What are the nuclear medicine imaging methods?

-	Conventional tumor imaging :	Onco PET :
Types	<ul style="list-style-type: none"> <li>● Planar : 2D</li> <li>● SPECT : 3D</li> <li>● SPECT-CT : 3D (Function and anatomy)</li> </ul> <p><b>SPECT:: Single photon emission computed tomography.</b></p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Spect CT</p> </div> <div style="text-align: center;">  <p>Planar/Spect</p> </div> </div>	<ul style="list-style-type: none"> <li>● PET : 3D</li> <li>● PET -CT : 3D (Function and anatomy)</li> </ul> <p><b>PET: Positron emission tomography (2 photons)</b></p> <div style="text-align: center;">  <p>Pet CT</p> </div>

## ❖ Physical Properties **SPECT** Radionuclides:

Radionuclide	T/2 physical	Type of radiation	E(Kev)
★ Technitium 99m(Tc-99m)	6 hrs	Gamma	140
★ Iodine I131	8 days	Gamma and Beta <sup>1 2</sup>	364/606
★ Iodine I123	13.2 hrs	Gamma	159
Gallium Citrate (Ga-67)	78.3 hrs	Gamma	90,190,290
Thallium Chloride 201 (Tl201)	73.1 hrs	X-ray	68-83
Indium 111 (In 111)	2.8 days	Gamma	173,247
Xenon 133	5.2 days	Gamma	81
Krypton 81m	13 sec	Gamma	190

<sup>1</sup> Gamma: like an x ray a photon with no charge or mass, while Beta: a negative charge and it has a mass.

<sup>2</sup> MCQ: The isotope used in nuclear medicine therapy should be? beta not gamma!

❖ **Physical Properties of positron emitting (PET) Radionuclides:** used in oncology.

Radionuclide	T/2 physical	positron energy	Productivity
Carbon 11	20mins	0.96	accelerator
Nitrogen-13	10mins	1.19	accelerator
Oxygen-15	2mins	1.73	accelerator
★ <b>Fluorine 18</b> Most common <sup>3</sup>	<b>110mins</b>	<b>0.635</b>	accelerator
Gallium 68	68mins	1.9	generator (germanium 68)
Rubidium 82	1.3mins	3.15	generator (strontium-82)

## Thyroid scan Procedure<sup>4</sup>

	Tc-99m Pertechnetate	I-123
<b>Dose</b>	0.5-4.0 mCi given IV	0.5 mCi orally
<b>Half life</b>	6 Hours	13 Hours
<b>Cost</b>	Not Expensive (Generator) Available all the time "Quick scan".	Expensive (it needs Cyclotrone) Which is Only available once a week
<b>Time of imaging</b>	20 min post injection <u>only one visit</u> It only take half an hour, the patient comes to department then we inject the material after 20 min an image will be taken; THAT'S IT.	6 and 24 hours post ingestion <u>3 visits:</u> 1- take iodine, 2-6 hrs 3-24hrs. While here the patient come to the department take the capsule/injection then has to come after 6 hours then again after 24 hours.
<b>Remarks</b>	Trapped not organified It only gives information about the trapping which the step before organification	Trapped <b>AND</b> organified if you take a sample after iodine 123, you'll notice that thyroxine is radioactive. Gives information about trapping and about organification which is the synthesis of thyroxine (T4,T3) Its benefits comes when you're looking for enzymes, hormones deficiencies.
<b>Notes</b>	<ul style="list-style-type: none"> <li>● Radiotracer measuring unit is curie (Ci).</li> <li>● When Iodine is trapped by the thyroid gland thyroid hormones are synthesized, then it would be organified to form Thyroxine. In Tc- 99m it is not organified so when there is problem in organification, we can't use it.</li> <li>● <b>To assess the organification we use I- 123.</b></li> </ul>	

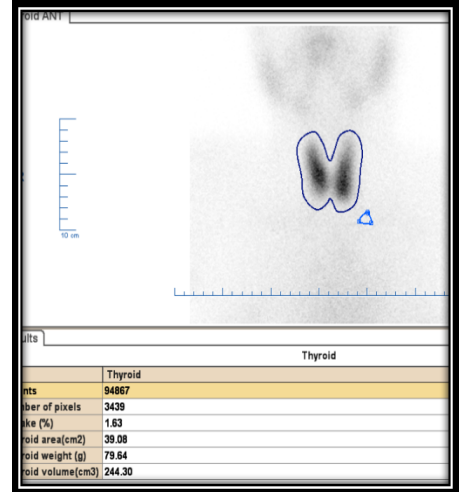
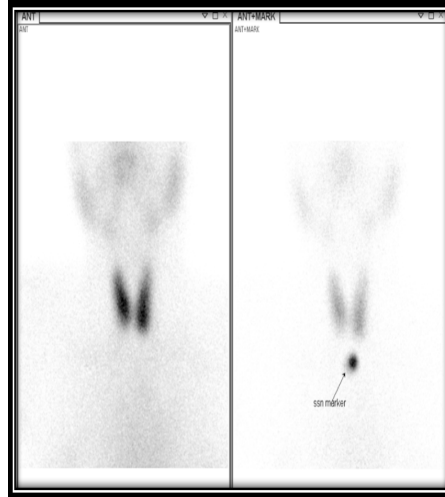
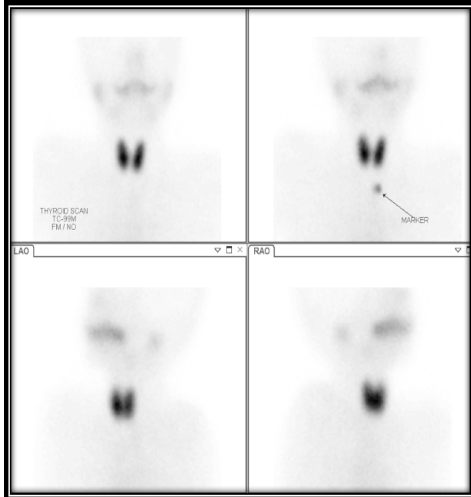
<sup>3</sup> Labeled with glucose, because in cancer there is increase glycolysis.

<sup>4</sup> Using Gamma emitter so the radiation to the patient will be low unlike beta very high

## ❖ Thyroid scan procedure cont.:

<b>Patient Preparation:</b>	<p><b>The patient must be off thyroid hormones:</b></p> <ol style="list-style-type: none"> <li>1. Thyroxine (T-4) for at least 3-4 weeks.</li> <li>2. Triiodothyronine (T-3) for at least 10 days.</li> </ol> <p><b>The patient must not be taking antithyroid medications:</b></p> <ol style="list-style-type: none"> <li>1. Propylthiouracil (PTU) and tapazole for at least 3-5 days.</li> </ol> <p><b>The patient must not have i.v iodinated contrast agents:</b></p> <ul style="list-style-type: none"> <li>- (IVP, CT with contrast, myelogram, angiogram) for at least 3 weeks.</li> </ul> <p>Also patient must avoid iodine-containing food such as fish.</p>
<b>Radiopharmaceutical and doses:</b>	<ol style="list-style-type: none"> <li>1. <u>Tc-99m</u> as sodium pertechnetate 0.5 -4.0 mCi given Intravenously. or,</li> <li>2. <u>I-123</u> Sodium Iodide 0.5 mCi orally.</li> </ol>
<b>Gamma camera:</b>	Small or large field of view.
<b>Patient position:</b>	Supine with chin tilted up <b>facing the camera.</b>
<b>Imaging:</b>	<ol style="list-style-type: none"> <li>1. <b>20 min. post injection of Tc99 m:</b> ANT(Anterior), LAO(Left anterior oblique) and RAO (Right anterior oblique) images obtained.</li> <li>2. <b>6 and 24 hours post oral dose for I-123:</b> ANT, LAO and RAO images .</li> </ol>

### Normal Tc-99m Thyroid Scan and Uptake



**Marker:** Suprasternal notch.  
A marker should be putted on the suprasternal notch it's very important in the case of retrosternal- goiter; different views will be obtained in order to appreciate any defects

**RAO:** right anterior oblique.  
**LAO:** left anterior oblique.

**SSN:** ssn suprasternal notch  
**Why?** To check how far it is from the sternum.

**Normal Thyroid uptake in Tc-99m:**  
0.5-4%  
in this image it's 1.63 (normal)

## ❖ THYROID UPTAKE MEASUREMENT (I-123 Sodium Iodide)<sup>5</sup>:

- The Thyroid Uptake Measurement measures the metabolic activity of the thyroid gland as reflected by its extraction of iodine from the blood.

<b>★ Indications:</b>	<ol style="list-style-type: none"> <li>1. <b>Diagnosis of Grave's disease.</b></li> <li>2. <b>Evaluation of subacute and chronic thyroiditis.</b></li> <li>3. <b>Thyroid Cancer.</b></li> </ol>	
<b>Patient Preparation:</b> (will not be asked)	<ul style="list-style-type: none"> <li>● <b>Must be off thyroid hormones :</b> 1. Thyroxine (T-4) for at least 3-4 weeks. 2. Triiodothyronine (T-3) for at least 10 days.</li> <li>● <b>Must not be taking antithyroid medications :</b> 1. Propylthiouracil (PTU) and tapazole for at least 3-5 days.</li> <li>● <b>Must not have had intravenous or intrathecal iodinated contrast material (IVP, CT with contrast, myelogram, angiogram) for at least 3 weeks.</b></li> <li>● <b>Other agents may interfere, but usually only to a small extent.</b></li> <li>● <b>NPO 2-4 hours before and for at least 1 hour after ingesting the radiopharmaceutical.</b></li> </ul> <p>● هناك كبسولتان "تحتويان على نفس النسبة" واحدة موجودة في المختبر والأخرى تعطى للمريضة، بعد يوم من بلع المريضة للكبسولة المعطاة يتم حساب نسبة الأيودين في كبسولتها ومقارنته بكبسولة المختبر.</p>	
	<b>Uptake only</b>	<b>Imaging plus uptake studies</b>
<b>Equipment:</b>	Uptake probe (single crystal probe with flat field collimator).	Gamma camera
<b>Radiopharmaceutical:</b> Dose given orally One capsule.	I-123: 100 $\mu$ Ci.	I-123: 500 $\mu$ Ci.
	<b>What is the difference between Uptake only &amp; imaging Plus uptake?</b>	
	<u>Uptake only:</u> Gives information about the activity.	<u>Imaging + Uptake:</u> Give information about the shape and activity.
<b>Notes</b>	Thyroid uptake measurements may be determined using Tc-99m-pertechnetate.	
<b>Patient position</b>	Sitting.	
<b>Detector field of view:</b>	Neck.	

## ❖ THYROID UPTAKE MEASUREMENT **without imaging** (I-123 Sodium Iodide):

<b>Acquisition Protocol:</b> الدكتور ما تعمق بالشرح ابدأ	<ul style="list-style-type: none"> <li>● Place I-123 capsule(s) in neck phantom.</li> <li>● Acquire counts for 1 minute, record the counts, time of acquisition, and time of day on the thyroid Uptake Worksheet.</li> <li>● Immediately administer the capsule(s) to the patient.</li> <li>● At 6 hours position the probe in front of the patient's neck.</li> <li>● Acquire counts for 1 minute for I-123 and record the counts, time of acquisition, and time of day on the Worksheet.</li> <li>● Position the probe over the thigh for 6 hour "background" measurement.</li> <li>● Acquire counts for 1 minute for I-123 and for 2 minutes for I-131; record the counts, time of acquisition, and time of day on the Worksheet.</li> </ul> <p>-Using the Thyroid Uptake Worksheet, calculate the 6 hour thyroid uptakes.</p> <p>-Remember to correct the standard counts for decay.</p> <p>-Twenty four hour uptake measurement in the same way as the 6 hours.</p>
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<sup>5</sup> Simply it is a test with or without imaging, we would like to know if I am giving an iodine how much of what I gave will go to the thyroid.

## Normal Values Of Thyroid Uptake<sup>6</sup>

I131 or I123 RAIU (4&24 hours)	Tc- 99m Uptake (20 min Uptake)
<ul style="list-style-type: none"> <li>• Normal 4 hour RAIU : 5 - 15%</li> <li>• Normal 24 hour RAIU : 8 - 35%</li> </ul>	<ul style="list-style-type: none"> <li>• Normal (0.5 -4 .0%)</li> </ul>

### ❖ Causes of Thyroid Uptake: **IMP!** ★

High thyroid uptake	Low thyroid uptake
<ul style="list-style-type: none"> <li>→ <b>Hyperthyroidism:</b> Grave's Disease, TSH-secreting pituitary adenoma</li> <li>→ <b>Autonomous toxic nodule.</b></li> <li>→ <b>Multinodular toxic goiter</b> (Plummer's Disease).</li> <li>→ <b>Enzyme defects:</b> Dyshormonogenesis.</li> <li>→ <b>Iodine starvation</b> (Iodine deficiency) <i>like those who lives in alps .</i></li> <li>→ <b>Lithium Therapy</b></li> <li>→ <b>Recovery phase of thyroiditis.</b></li> <li>→ <b>Rebound</b> following abrupt withdrawal of antithyroid meds</li> </ul>	<ul style="list-style-type: none"> <li>→ <b>Parenchymal Destruction:</b> Acute, Subacute and Chronic Lymphocytic Thyroiditis.</li> <li>→ <b>Hypothyroidism:</b> <ul style="list-style-type: none"> <li>- Primary or Secondary (insufficient pituitary TSH secretion).</li> <li>- Surgical/Radioiodine Ablation of Thyroid</li> </ul> </li> <li>→ <b>Blocked Trapping:</b> <ul style="list-style-type: none"> <li>- Iodine load (most common): Iodinated contrast material, Food rich in iodide: fish , cabbage.</li> <li>- Exogenous thyroid hormone replacement depressing TSH levels (thyrotoxicosis factitia).</li> <li>- Ectopic thyroid: Struma Ovarii</li> </ul> </li> <li>→ <b>Blocked Organification:</b> <ul style="list-style-type: none"> <li>- Antithyroid medication (PTU): Note- Tc-99m uptake should not be affected</li> </ul> </li> </ul>



The gland needs to uptake every single iodine in the blood to make more thyroid hormone. => Increase uptake of iodine from blood.



**ALYAMI EBTISAM HUSS**

10 cm

Patient Name : ALYAMI EBTISAM HUSS  
 Patient ID : 843223  
 Exam Date : 03Jun2007  
 THYROID UPTAKE

843223

THYROID UPTAKE : 2.96 %

Area 29.8 (sqcm)  
 Mass 53.0 g

Adac Laboratories BV  
 Maarssen  
 The Netherlands

Study Date  
 Study Time

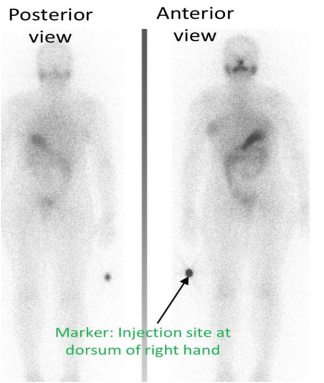
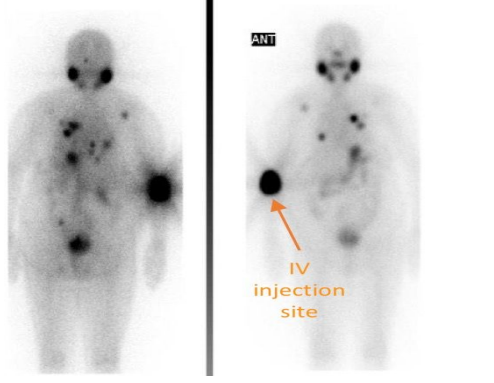
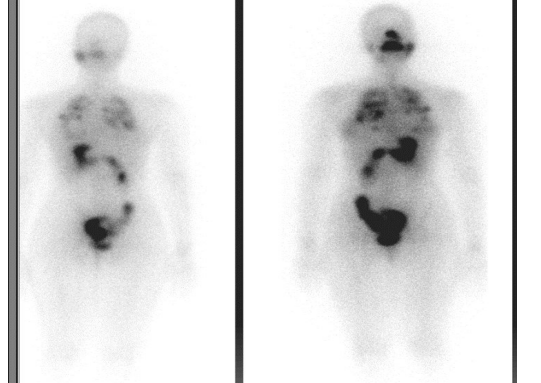
ANTERIOR

"Tc-99m Thyroid scan and uptake"  
 Thyroid uptake here in 2.96% which is normal.

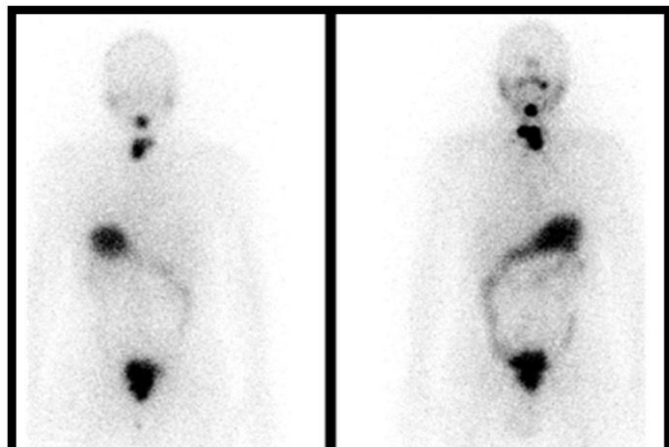
<sup>6</sup> If less then the gland will be hypoactive if more it will be hyperactive.

# ❖ THYROID METASTASES STUDY ★ (I-123 or I-131 as Sodium Iodide):

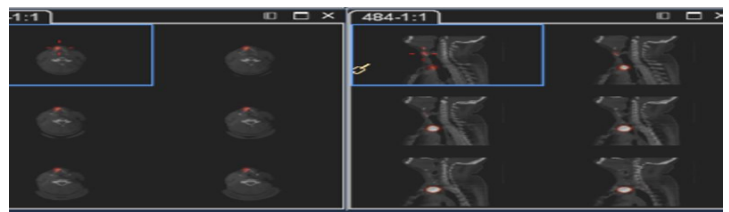
When I-123 is not available for example in rural areas I-131 can be used but in small doses."131 footnote"

<b>Indications:</b>	Detection and localization of persistent or recurrent functioning thyroid cancer.	
<b>Patient Preparation:</b>	<p><b>Stimulation of potentially functioning thyroid tissue:</b></p> <p>A. <b>Inject recombinant human thyrotropin on 2 consecutive days</b> and administer the radiopharmaceutical on the third day.</p> <p>B. <b>Withdraw thyroid replacement hormones:</b></p> <ul style="list-style-type: none"> <li>- Thyroxine (T-4) for at least 4 weeks.</li> <li>- Triiodothyronine (T-3) for at least 10 days.</li> </ul> <p><b>The patient must not have had i.v iodinated contrast material</b> (IVP, CT with contrast, myelogram, angiogram) for at least 3 weeks .</p> <ul style="list-style-type: none"> <li>- The patient should be NPO for at least 4 hours prior to radiopharmaceutical administration and for at least 1 hour afterwards.</li> </ul>	
<b>Radiopharmaceutical, Dose, &amp; Technique of Administration:</b>	<p><b>Radiopharmaceutical: Oral administration:</b></p> <ol style="list-style-type: none"> <li>1. I-123 as sodium iodide : 2 mCi.</li> <li>2. I-131 as sodium iodide : 2-10 mCi.</li> </ol> <p>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.</p>	
<b>Imaging used Gamma camera</b>	Whole body scan.	
 <p>Posterior view      Anterior view</p> <p>Marker: Injection site at dorsum of right hand</p> <p><b>Negative WBS</b> (post thyroidectomy)</p>	 <p>ANT</p> <p>IV injection site</p> <p><b>Bone Metastases</b> (Normally Iodine uptake in salivary glands, and metastatic several ribs and left humerus.</p>	 <p><b>Lung Metastases</b> Specially follicular type because it has hematogenous spread.</p>

## I-123 or I-131 Whole Body Scan(WBS) - "Planar Vs SPECT CT"



If There's multiple thyroid remnant in the neck in planar image, to know where exactly you have to do spect CT.



SPECT CT is very important to determine the exact location of the abnormality.



This patient is post-operative which supposed there is no uptake of iodine in the neck (the thyroid is removed!). Which means these is **Local Recurrence** "The red thing is Remnant in thyroglossal cyst"

❖ **When is thyroid scanning helpful? Indications for Thyroid Scan: ★**

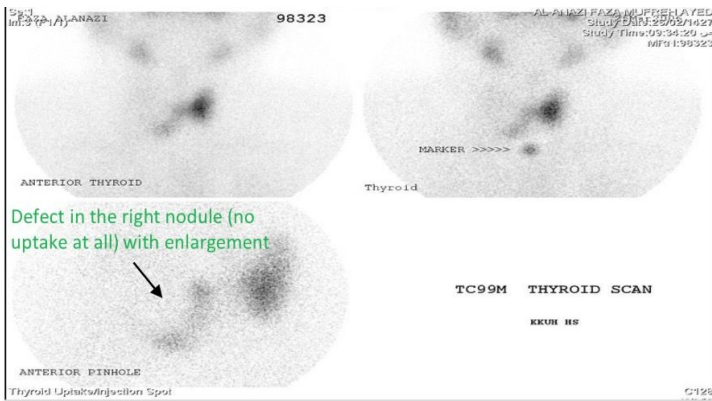
1. Evaluation of thyroid nodules: No. & type (hot vs cold nodule).
2. Evaluation of congenital hypothyroidism: Agenesis Vs. Dyshormonogenesis.

**Note:** TSH tests are routinely ordered for newborns as part of the screening program to evaluate how well the thyroid gland is working. If TSH is high we want to know if there is thyroid or not so we do thyroid scan (we don't use US because we can't see the base of the tongue in case of ectopic thyroid in the base as well it can not evaluate the function)

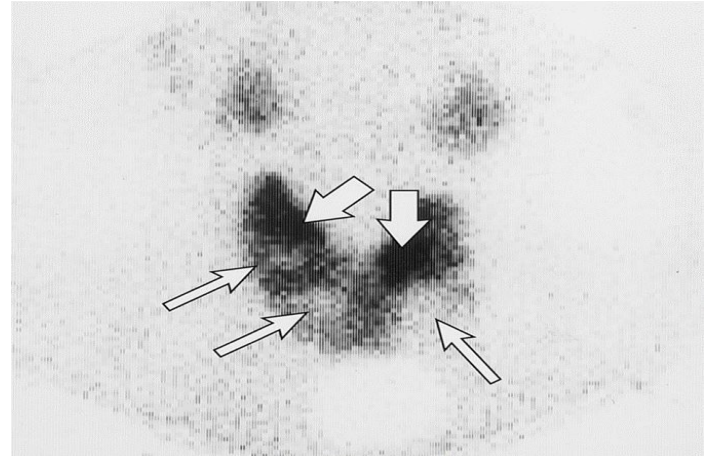
3. Evaluation of neck masses: ectopic thyroid, thyroglossal cyst.
4. Evaluation of thyrotoxicosis.

❖ **Evaluation of thyroid nodules (Single vs MNG):**

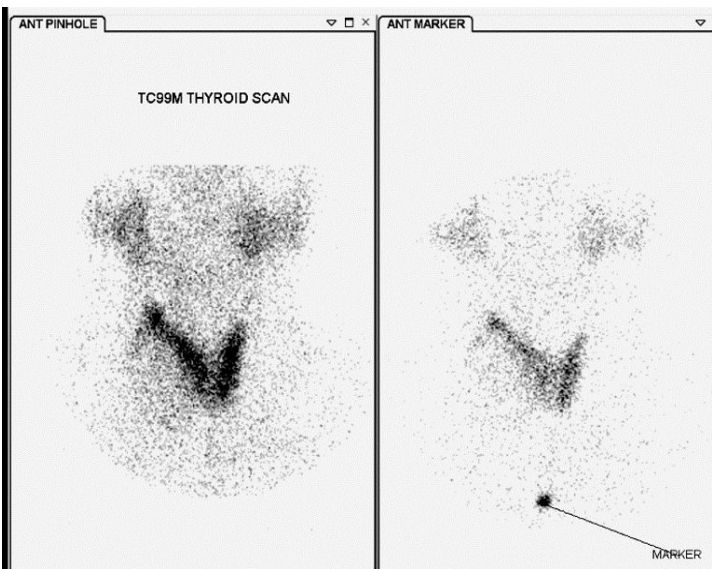
- The chance of malignancy is more in Solitary cold nodule than in MNG.
- As the number of nodules increase, the chance of malignancy decrease.



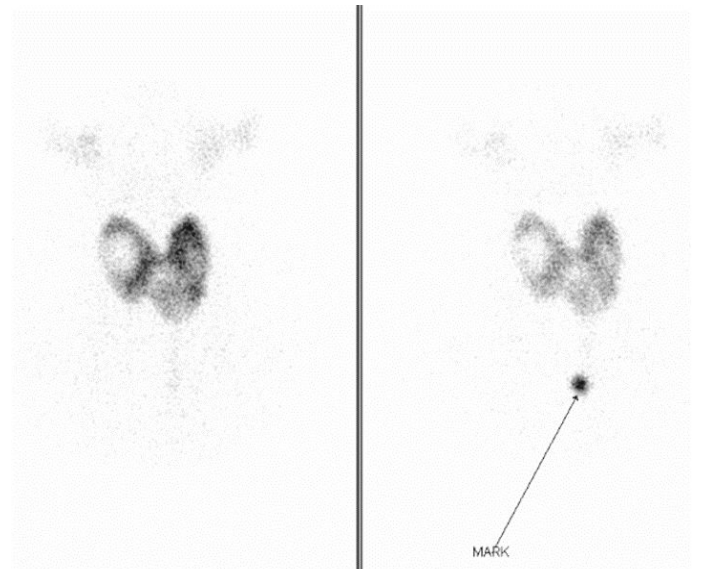
**Solitary cold nodule**  
(Single raised nodule)



**Multinodular goiter**  
(Multiple cold (nox-toxic) nodules)



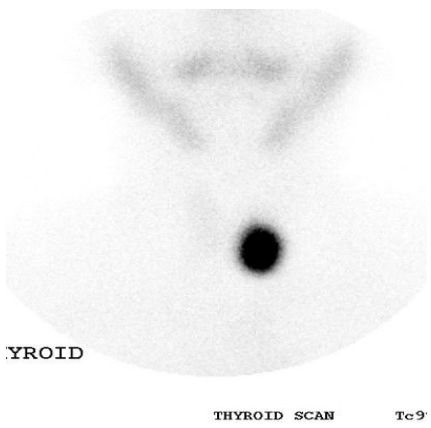
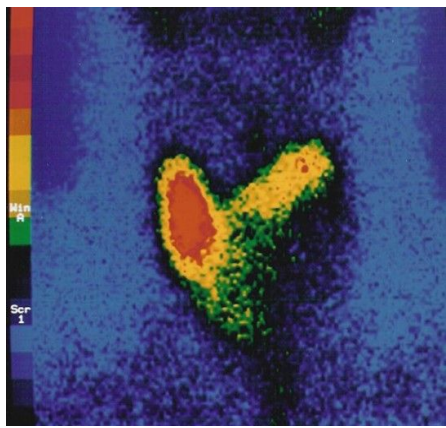
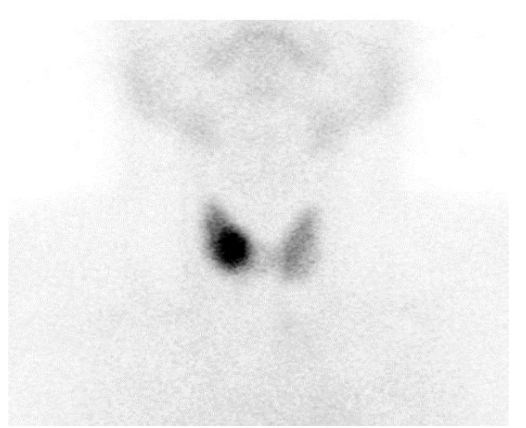
**Solitary cold nodule**



**Multinodular goiter "MNG"**

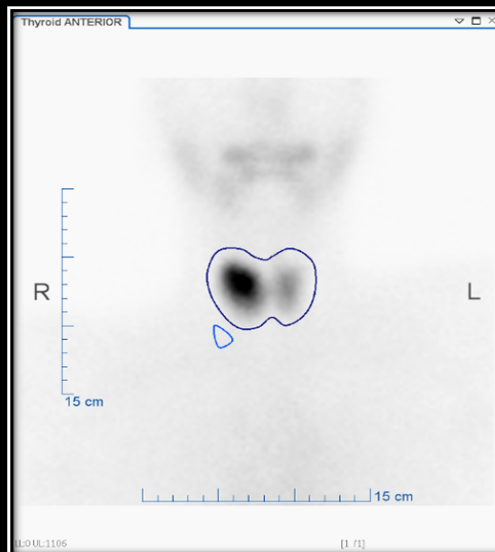


❖ Conti;...Evaluation of thyroid nodules (Hot vs Cold vs Warm):

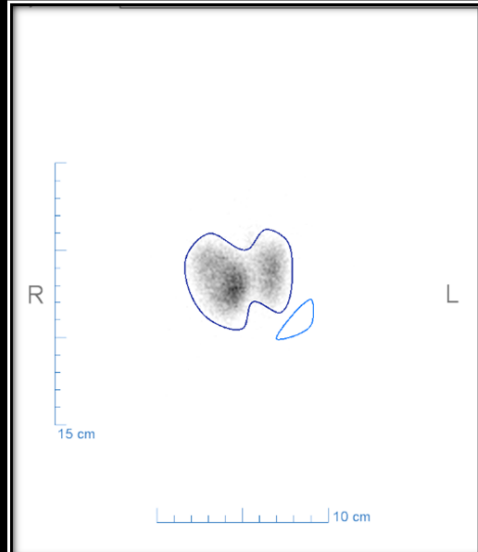
Hot	Cold ★	Warm
 <p>THYROID SCAN Tc 99m</p>		
<p><b>&lt;5% Malignant</b> (Autonomous toxic nodule) is a hot nodule that takes up all the tracer, suppressing the rest of the gland and independent on pituitary thyroid axis.</p>	<p><b>15(Female)-20(Male)% Malignant</b> No uptake at all in the affected gland.</p>	<p><b>Suspicious</b> There is uptake more than the rest of the gland without suppressing the gland. ("Further investigations and repeat iodine to determine if it's hot or cold")</p>

❖ Discordance Tc -I-123 Scan:

- The chance of malignancy of a discordant nodule about **20%**
- A warm nodule in Tc is worrying it can be cold when done by I123.

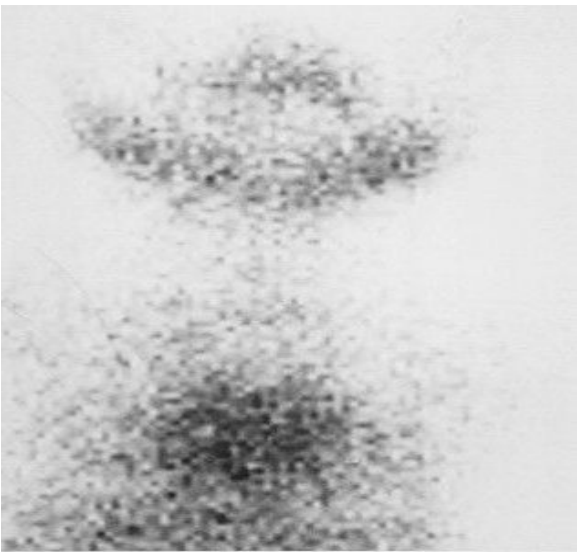
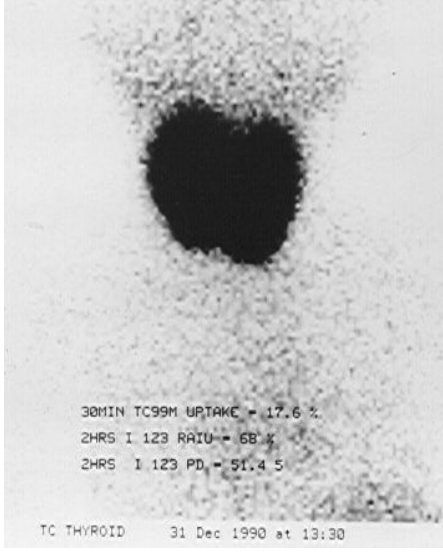
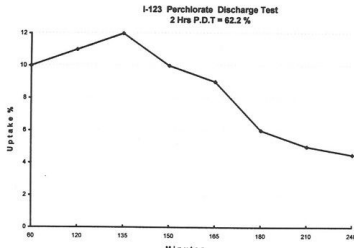


Thyroid	
Counts	129362
Number of Pixels	573
Uptake (%)	2.56

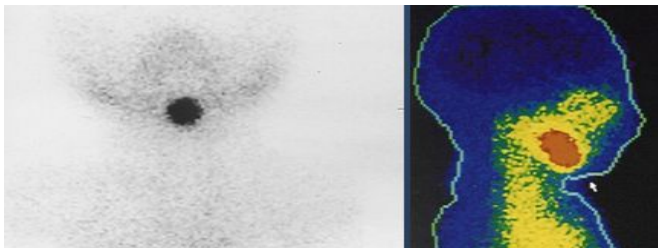



Thyroid	
Counts	32237
Number of Pixels	2358
Uptake (%)	16.81

## ❖ Evaluation of **congenital** hypothyroidism:

<b>Agensis<sup>7</sup></b> Treatment is thyroxine whole life	<b>Dyshormonogenesis<sup>8</sup></b>	<b>Perchlorate Discharge Test:<sup>9,10</sup></b>
		 <ul style="list-style-type: none"> <li>● 50 - 80 uCi I<sup>123</sup> orally.</li> <li>● 2 hrs RAIU</li> <li>● 400 mg Kclo4</li> <li>● RAIU/ 15 min for 2 hrs.</li> <li>● Positive test : &gt;= 15 fall of RAIU below 2 hrs. uptake.</li> </ul>

## ❖ Evaluation of **Neck masses:**

<b>Ectopic thyroid "Lingual thyroid"</b>	<b>Thyroglossal cyst</b>
	
<p>Lateral view is taken to confirm the diagnosis."don't surgically remove any lump under the tongue"</p>	<p>As the thyroid descend through the thyroglossal duct sometimes this duct remains producing a cyst.</p>

## ❖ 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. **Whatever the origin.**
- **Hyperthyroidism:** Overproduction of thyroid hormones by the thyroid gland (hyperactive gland)

<sup>7</sup> Thyroid dysgenesis or thyroid agenesis is a cause of congenital hypothyroidism where the thyroid is missing, ectopic, or severely underdeveloped.

<sup>8</sup> Thyroid dyshormonogenesis (or dyshormonogenetic goiter) is a rare condition due to genetic defects in the synthesis of thyroid hormones.

**Pic:**\*Uptake = 17.6% very high because of dyshormonogenesis (enzyme deficiency of the thyroid hormone synthesis which result in hypothyroidism) . There is high TSH and enlargement of the gland in attempt to produce hormones.

<sup>9</sup> A test used to show how well the thyroid gland in your child's neck takes up an iodine. To identify organification defects mostly "Peroxidase enzyme"

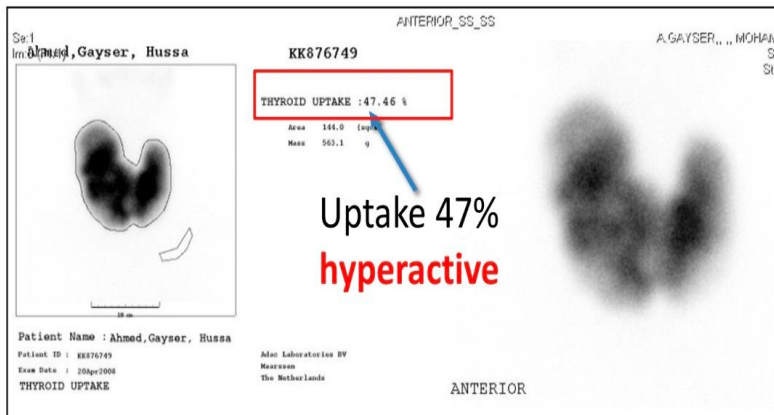
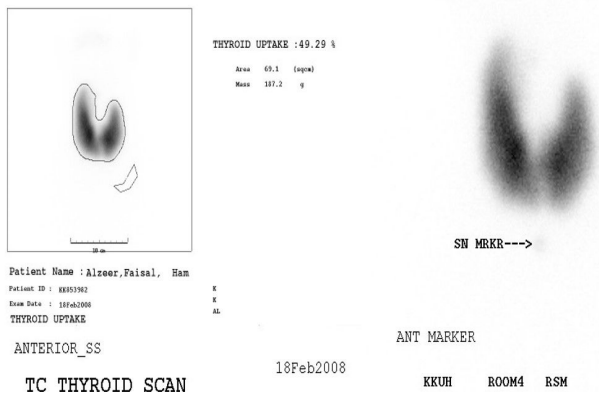
<sup>10</sup> **Used to confirm dyshormonogenesis.**

# ◆ Evaluation of Thyrotoxicosis **WITH** hyperthyroidism:

- 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 in Graves disease with very high uptake 49%**

**Graves' Disease on top of MNG the normal tissue between the nodules have graves. Nodular Graves Disease (**Marine-Lenhart syndrome**)**

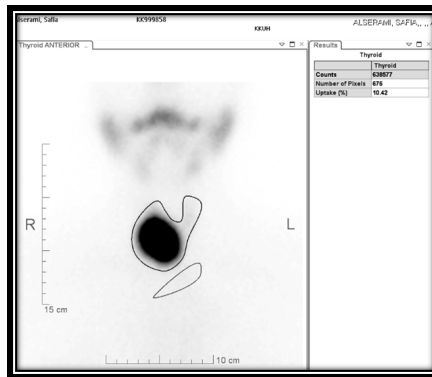
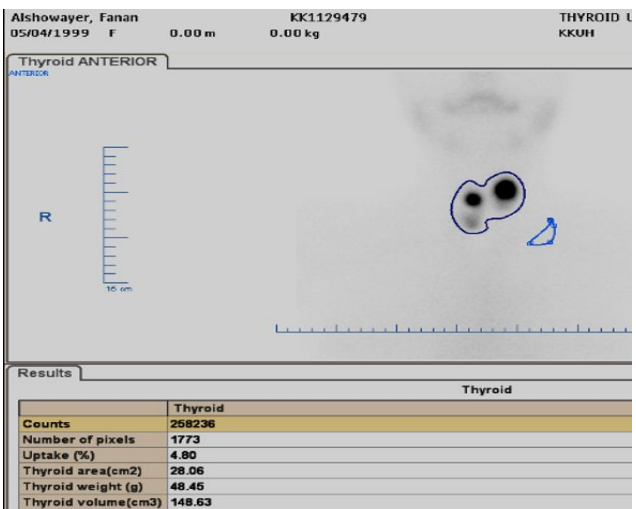
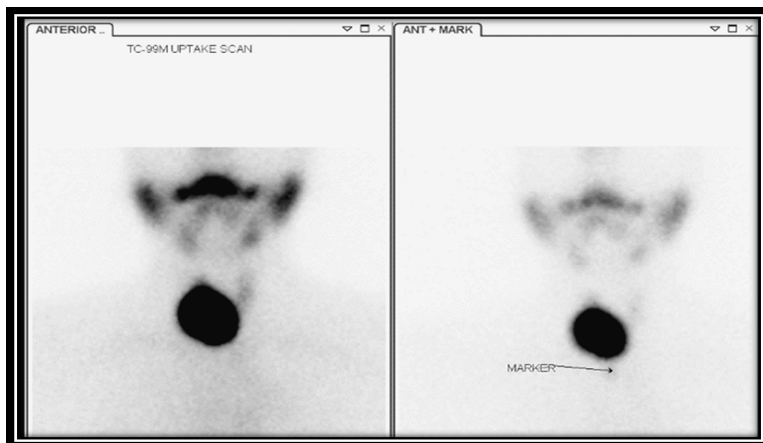
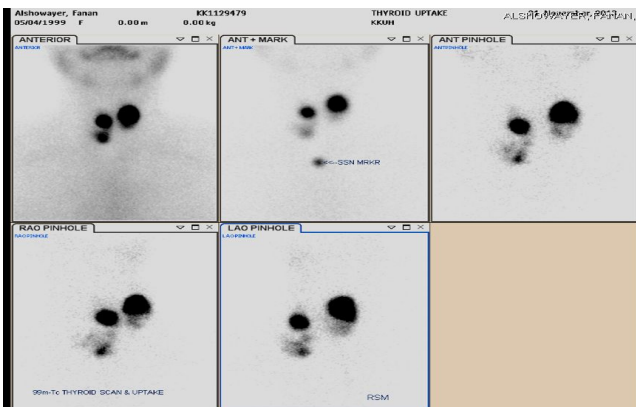


Management: Definitive treatment.

1. Antithyroid drugs, complication? agranulocytosis tell your patient "if feeling of sore throat come to the ER"
2. Surgery
3. Radioactive Iodine

**MNTG (Plummer's Disease)**

**Autonomous thyroid nodule "ATN"**



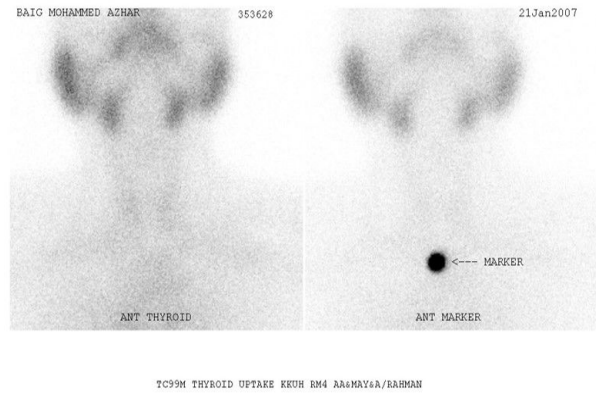
Very hot nodule. the rest of the gland are not seen.

- Autonomic: not dependence on TSH. It releases its hormone without the need of TSH. The best case for Iodine therapy.

## ❖ Evaluation of 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.
- **Thyroid extract** (e.g.Hamburger thyrotoxicosis- "Ground beef contaminated with thyroid tissue" لأن الجزار يسوي البرقر من لحم الرقية زمان والناس ياكلونه ويصير ثابرو توكيكوسيس).
- **Ectopic thyroid:** (Metastatic thyroid carcinoma, Struma ovarii)

### Subacute thyroiditis "SAT" You don't see the thyroid gland!



Here the treatment is mainly symptomatic relief.

## ❖ Radioactive Iodine Therapy:

Hyperthyroidism	Thyroid Cancer
<ul style="list-style-type: none"> <li>● <b>Isotope used: I-131</b></li> <li>● <b>Physical Properties: Solution</b>(be careful with elderly or kids risk of spilling) <b>or capsule.</b></li> <li>● <b>Main Side effect: Hypothyroidism.</b></li> <li>● <b>Dose:</b> <ul style="list-style-type: none"> <li>- <b>Calculated:</b> considering weight and uptake of the gland. (To delay the onset of hypothyroidism)</li> <li>- <b>Empirical: Graves (5-15mCi) ATN (15-20 mCi)</b></li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>● <b>Isotope used: I-131</b></li> <li>● <b>Physical Properties: Solution or capsule.</b> <ul style="list-style-type: none"> <li>- Thyroid remnant: 80-100 mCi</li> <li>- Lymph nodes mets: 100 mCi</li> <li>- Local Recurrence: 100 mCi</li> <li>- Lung mets: 150 mCi</li> <li>- Bone mets: 200 mCi</li> </ul> </li> </ul> <p style="text-align: right;">↑ Increase dose ↓</p> <p>You don't need to memorize these numbers EXCEPT the graves!!!</p>

## Parathyroid Scan

### ❖ Normal and Ectopic Parathyroid Glands:

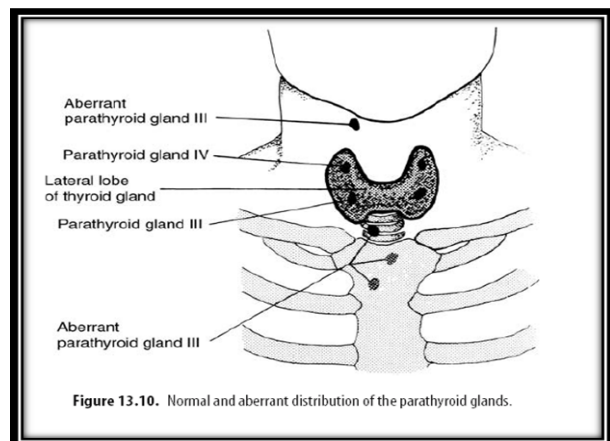
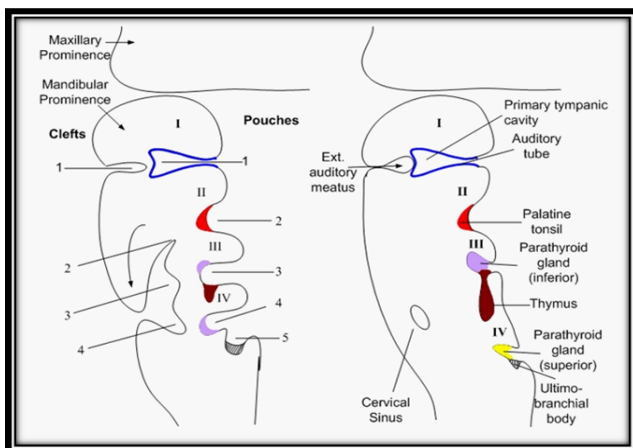


Figure 13.10. Normal and aberrant distribution of the parathyroid glands.

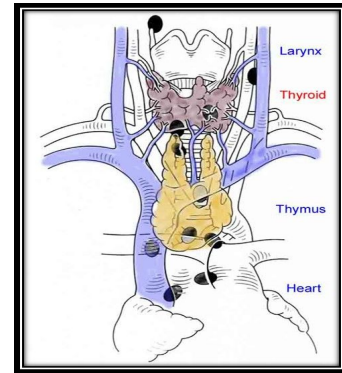
- **The third pair of pouches:** proliferates into the inferior parathyroid glands and the thymus.
- **The fourth pair of pouches:** proliferates into the superior parathyroid glands and the lateral angle of the thyroid gland.

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

## → 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.



### Ectopic parathyroid adenoma

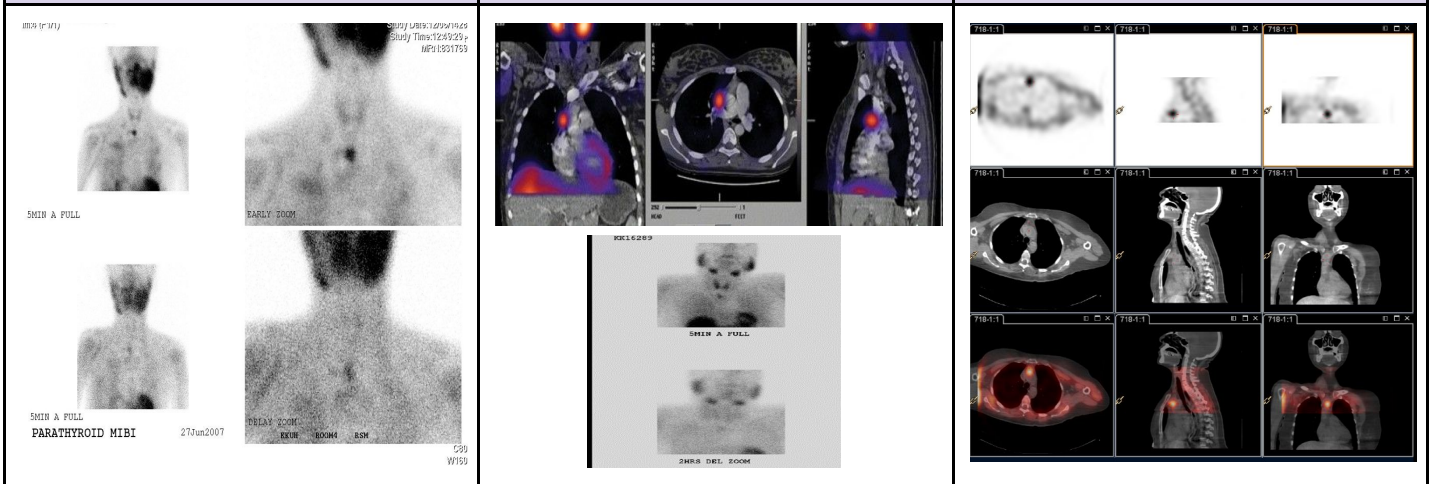
**Ectopic parathyroid: 16% of total adenomas**  
in upper mediastinum

#### PLANAR vs SPECT/CT

SPECT-CT images accurately localize the adenoma and guide the surgeon to the best surgical approach.

#### Antero-superior mediastinum

"here we can localize the adenoma close to the aortic arch"

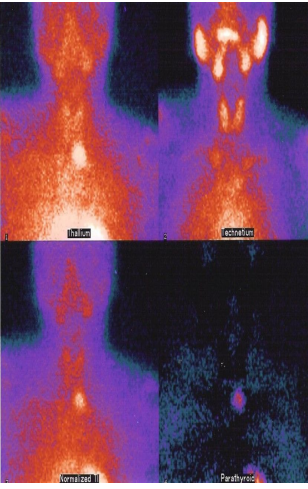
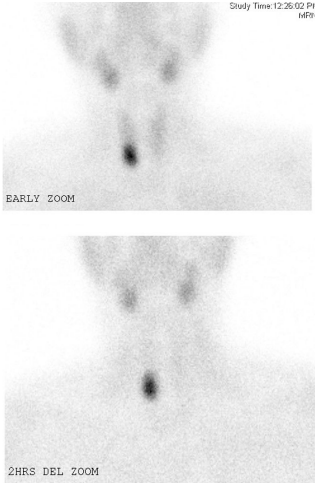
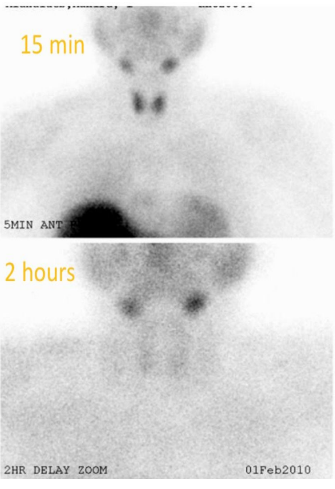
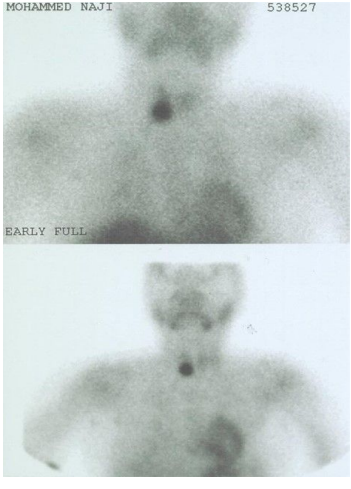


## ❖ Parathyroid Scan Techniques: ★

- **TL-201 \_ Tc-99m subtraction:** Several protocols have been developed for routine subtraction of thyroid tissue from parathyroid tissue.
- **Tc-99m Sestamibi (Dual Phase) Used currently for parathyroid imaging (Gold standard):** The Parathyroid Study depicts hypertrophied parathyroid tissue, probably because of uptake of Tc-99m-sestamibi in the mitochondria of hyperactive cells.
- **Tc-99m Tetrofosmin (Dual Phase)**

## ❖ Parathyroid imaging/scan:

Radiopharmaceutical	99mTc / 201Tl Subtraction	99mTc sestamibi
<b>Activity administered</b>	<ul style="list-style-type: none"> <li>- 80 MBq (2 mCi) 201Tl</li> <li>- 370 MBq (10 mCi) 99mTc</li> </ul>	<ul style="list-style-type: none"> <li>- 925 MBq (25 mCi)</li> </ul>
<b>Images acquired</b>	<ul style="list-style-type: none"> <li>- Inject Tl .rst and acquire 15-min 100 000 count view of neck and mediastinum.</li> <li>- Then acquire similar Tc images <b>without moving patient.</b></li> <li>- Subtract Tc data from Tl after normalization to equal count densities.</li> </ul>	<ul style="list-style-type: none"> <li>- Anterior (and oblique) views at 15 min and at 2-3h; SPECT as needed.</li> </ul>

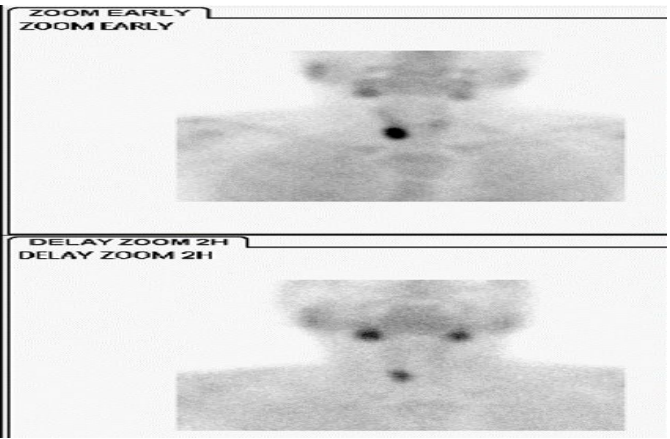
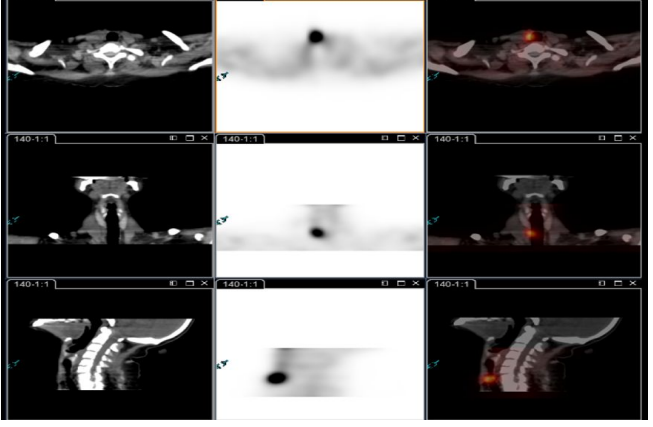
TL-201 _ Tc-99m subtraction	Tc-99m Sestamibi (Dual Phase)	Tc-99m Tetrofosmin (Dual Phase) - Dual phase MIBI Scan	
			
<p>1. We give thallium--it goes thyroid and parathyroid.  2. Then give only technetium-- it goes only to thyroid.  3. Subtract the images to visualize the parathyroid gland.</p>	<p>1. inject the sestamibi -- it will go to the thyroid and <b>abnormal</b> parathyroid. (Early phase)  2. After 2 hours we take another image. The remnants will represent the abnormal parathyroid. (Late phase)</p>	<p><b>Normal</b> parathyroid glands are small and not visualized.</p>	<p><b>Abnormal</b> parathyroid glands could be visualized.  "Right lower parathyroid adenoma"</p>

❖ **Tc-99m-Sestamibi: ★**

<b>Indications:</b>	Detect and localize parathyroid adenomas.
<b>Patient Preparation:</b>	None.
<b>Radiopharmaceutical, Dose, &amp; Technique of Administration:</b>	<ul style="list-style-type: none"> <li>● <b>Radiopharmaceutical:</b> 25 mCi Tc-99m-sestamibi i.v.</li> <li>● <b>Patient position:</b> Supine with head and neck extended and immobilized.</li> <li>● <b>Gamma camera Imaging field:</b> <ul style="list-style-type: none"> <li>- Neck.</li> <li>- Upper two thirds of the mediastinum.</li> </ul> </li> </ul>

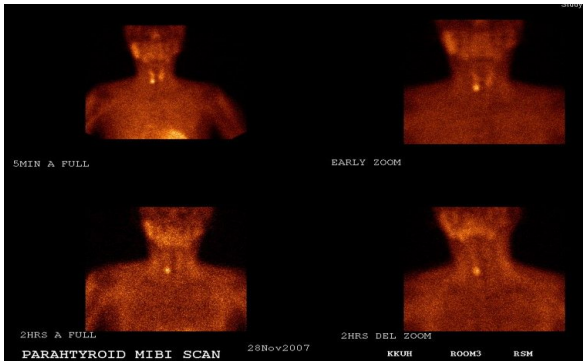
Acquire images at 15 minutes and 2-3 hours post injection.  
SPECT/SPECT CT images improves localization.

**Sestamibi Dual Phase (Planar vs SPECT CT)**

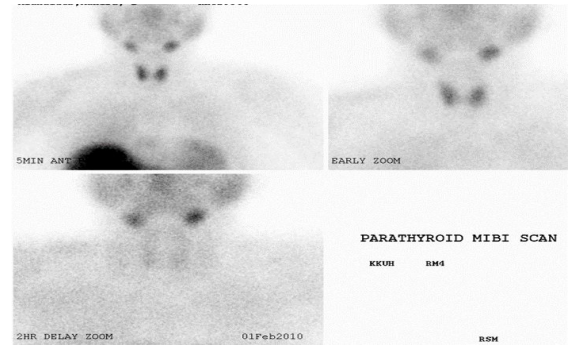
	
	<p>"here we can localize the adenoma lateral to the trachea"</p>

## 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:

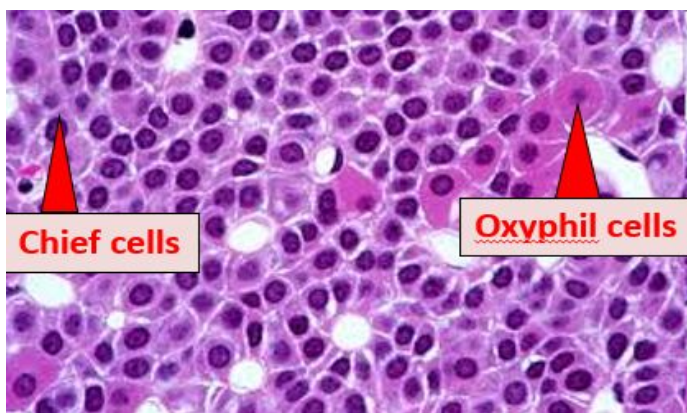
#### A. Biochemical properties of the tracer:

**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.

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

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

## Parathyroid Cells



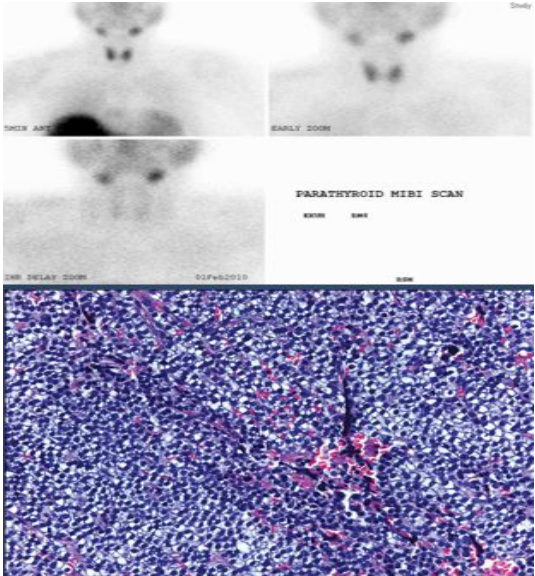
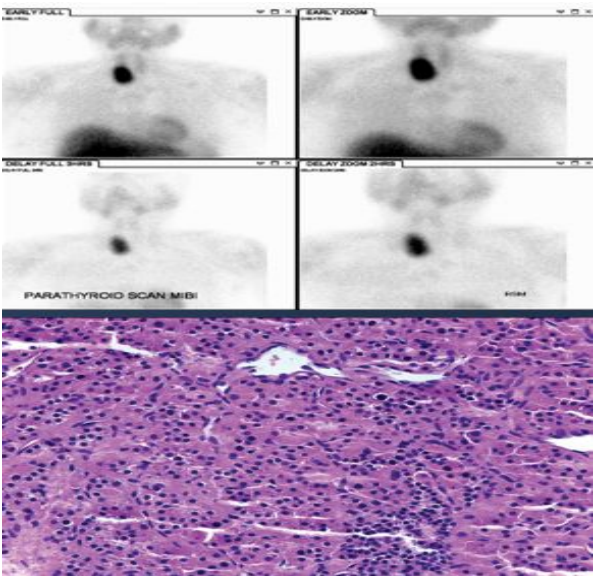
Normal parathyroid glands comprise 2 cell types<sup>11</sup>:

- 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.**

<sup>11</sup> **Note:** 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**)

## ❖ Cell type and Scan result:

Parathyroid adenoma composed entirely of <b>glycogen-rich chief cells.</b>	Parathyroid adenoma composed mainly of <b>mitochondrial-rich oxyphil cells.</b>
	

## ❖ 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: (Not imp)

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.

### ★ Don't forget! (432) ★

- ❑ 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.**
- ❑ **Indication of thyroid nuclear imaging include:**
  - A. *Evaluation of thyroid nodules.*
  - B. *Evaluation of congenital hypothyroidism: Agenesis Vs. Dyshormonogenesis.*
  - C. *Evaluation of neck masses: ectopic thyroid, thyroglossal cyst.*
  - D. *Evaluation of thyrotoxicosis.*
- ❑ Perchlorate discharge test is used **to confirm dyshormonogenesis**.
- ❑ **RAIU is used also to evaluate:**
  - A. *Thyroiditis : subacute and chronic thyroiditis.*
  - B. *Thyroid Cancer : Remnants uptake in preparation for therapy. (after surgery how much remnants is left, to prepare for I 131 therapy).*
- ❑ **Lactating mothers should stop breastfeeding according to the following:**
  - A. **Completely after I 131 therapy**
  - B. **3 weeks after diagnostic I 131**
  - C. **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.

## EXTRA: True ✓ or false X

### Regarding the thyroid and parathyroid glands:

1. The pyramidal lobe extends superiorly from the left lobe.
2. The left lobe is usually larger than the right.
3. The follicular nature of the thyroid is resolved by high frequency ultrasonographic examination.
4.  $^{99m}\text{Tc}$  pertechnetate imaging provides functional data on the thyroid gland.
5. The thyroid derives its blood supply from the external and internal carotid systems.
6. The thyroid gland originates at the apex of the foramen caecum on the developing tongue.

### Answers:

1. **False** – extends from the isthmus in the midline in 40% of subjects.
2. **False** – the opposite is true. The right lobe is more vascular than the left and tends to enlarge more in diffuse disorders.
3. **False** – the thyroid appears relatively homogeneous in texture and relatively hyperechoic to the superficial sternocleidomastoid muscles.
4. **False** –  $^{99m}\text{Tc}$  is not metabolized in the thyroid. However,  $^{123}\text{I}$  is both trapped and organified, and functional data can be obtained.  $^{99m}\text{Tc}$  provides morphological information and will reveal the presence of ectopic thyroid tissue.
5. **False** – the paired superior thyroid and inferior thyroid arteries are from the external carotid and thyrocervical trunk (subclavian artery) respectively. The thyroidea ima is an occasional branch of the brachiocephalic trunk on the aortic arch, which supplies the inferior portion of the right lower lobe.
6. **True.**