

# PARATHYROID IMAGING

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James Lee, MD  
Chief, Endocrine Surgery  
Co-Director NY Thyroid-Parathyroid Center  
Columbia University Medical Center



New York  
Parathyroid Center



COLUMBIA UNIVERSITY  
MEDICAL CENTER

*Discover. Educate. Care. Lead.*

**NO DISCLOSURES**

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# Overview

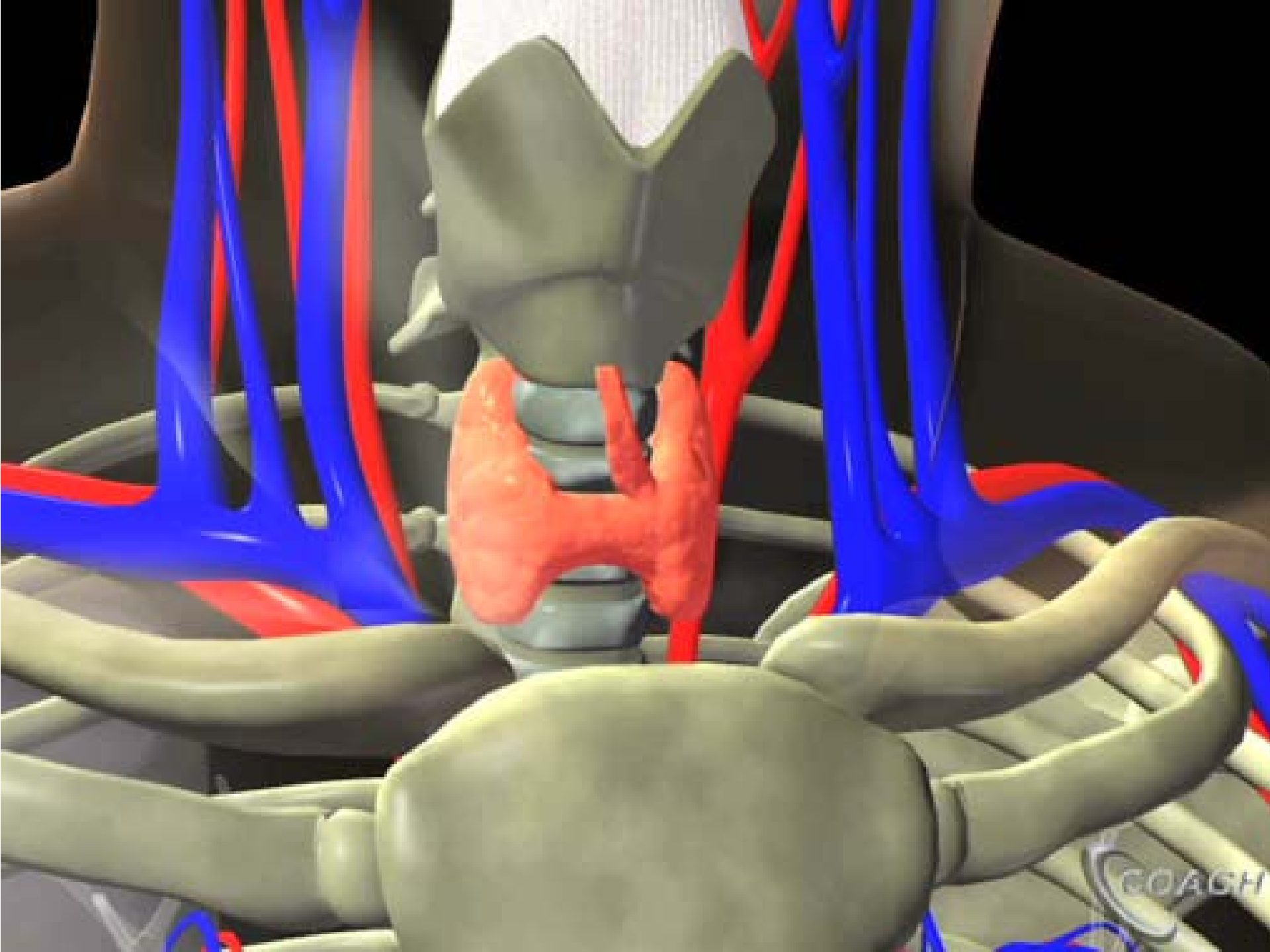
- The hallmarks of the ideal test
- Benefits and Limitations
  - MRI
  - USG
  - Sestamibi Scan
  - 4D CT
  - Parathyroid FNAB with PTH washout
  - Selective Venous Sampling
- Combined USG and MIBI
- Special Cases
  - Reoperative
  - Secondary Hyperparathyroidism
  - MEN 1

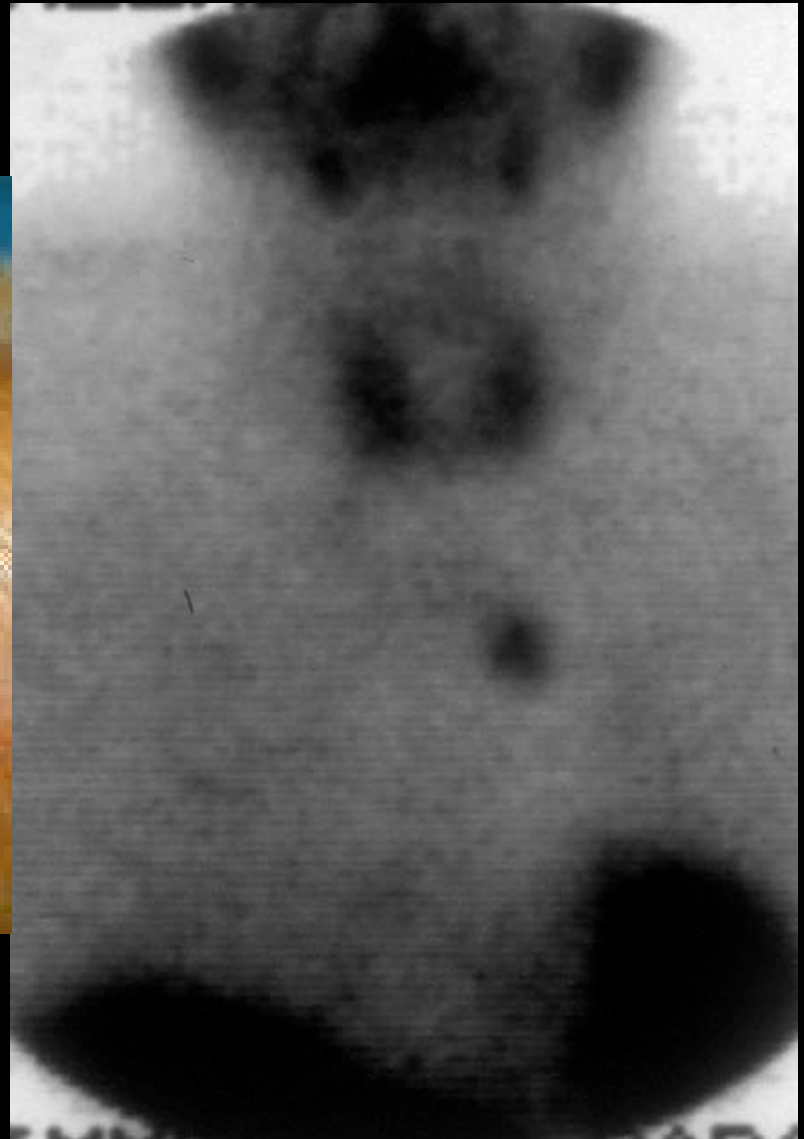
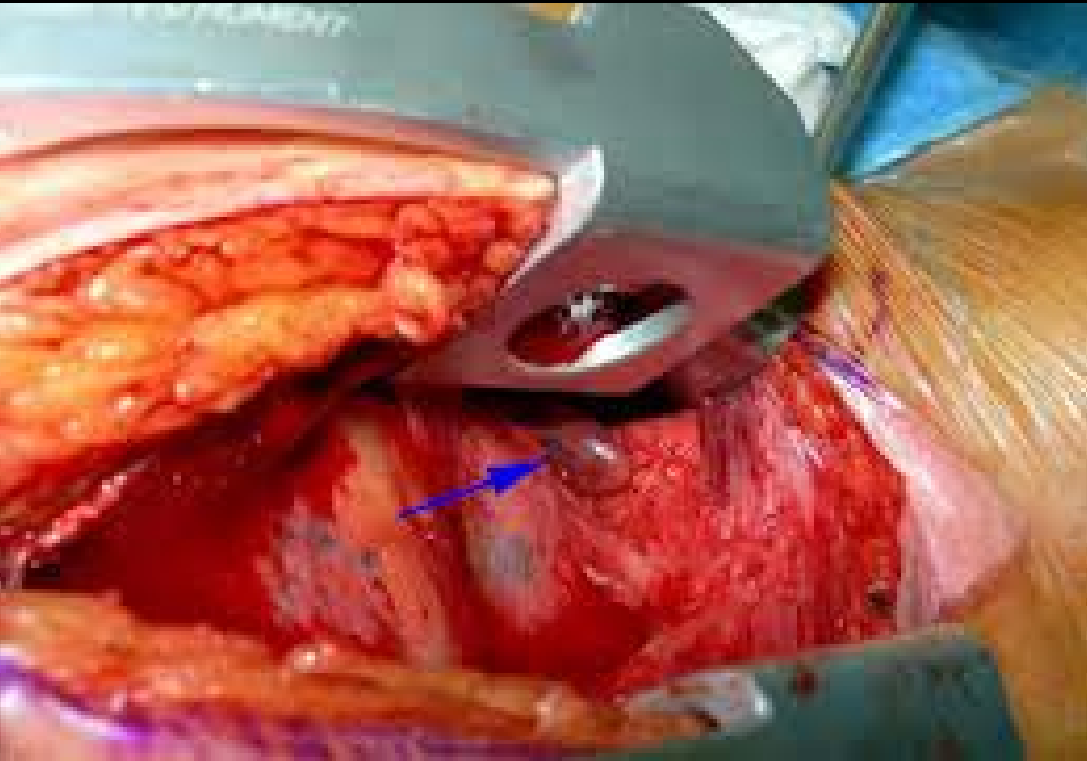
“The only localizing study indicated...is to  
localize an experienced parathyroid surgeon”

John Doppman, 1986



“The goal of localizing studies is to limit the amount of pain for the patient and surgeon”







# Hallmarks of the ideal test

- Localize culprit gland
  - Size vs Function
- Provide a “roadmap” of where to look
- Identify normal glands
- Identify associated thyroid disease
- Minimize radiation

# Interpreting results

- What is success (i.e. true positive)?
  - Localizes to gland vs quadrant of neck vs side?
- Positive predictive value
  - Likelihood that an identified adenoma will actually be there
- True negative can be as important as the true positive
- Surgeon review is more accurate than radiologist
  - Sensitivity of MIBI when read by
    - High volume Radiologist = 75-83%
    - Low volume Radiologist = 72%
    - Surgeon = 86-93%
  - ALWAYS LOOK AT THE IMAGES YOURSELF

<b>Technique</b>	<b>Sensitivity</b>	<b>PPV</b>	<b>Medicare Reimbursement</b>	<b>Exposure (mSv)</b>
Sestamibi	60-90%	90%	262	
Sestamibi-SPECT	80%	90%	550	6.7-7.8
SPECT-CT				
Ultrasound	70-80%	93%	125	0
4D CT	90%	93%	424	10
MRI	40-70%	67-80%	640	0
SVS	70-90%	90-100%	2300	1-20
MET-PET	80-90%	90%		
Parathyroid FNA	84%	100%		

Kuntsman, et al. JCEM 98(3):902-12

MRI

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# MRI

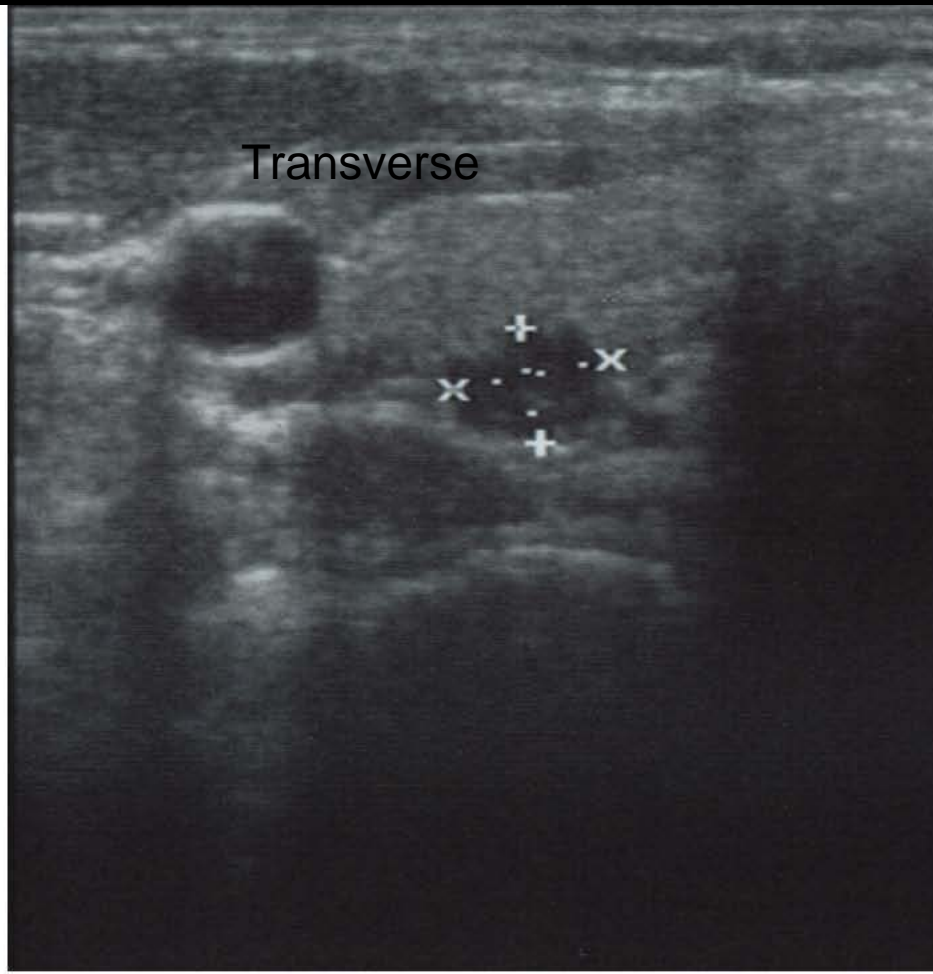
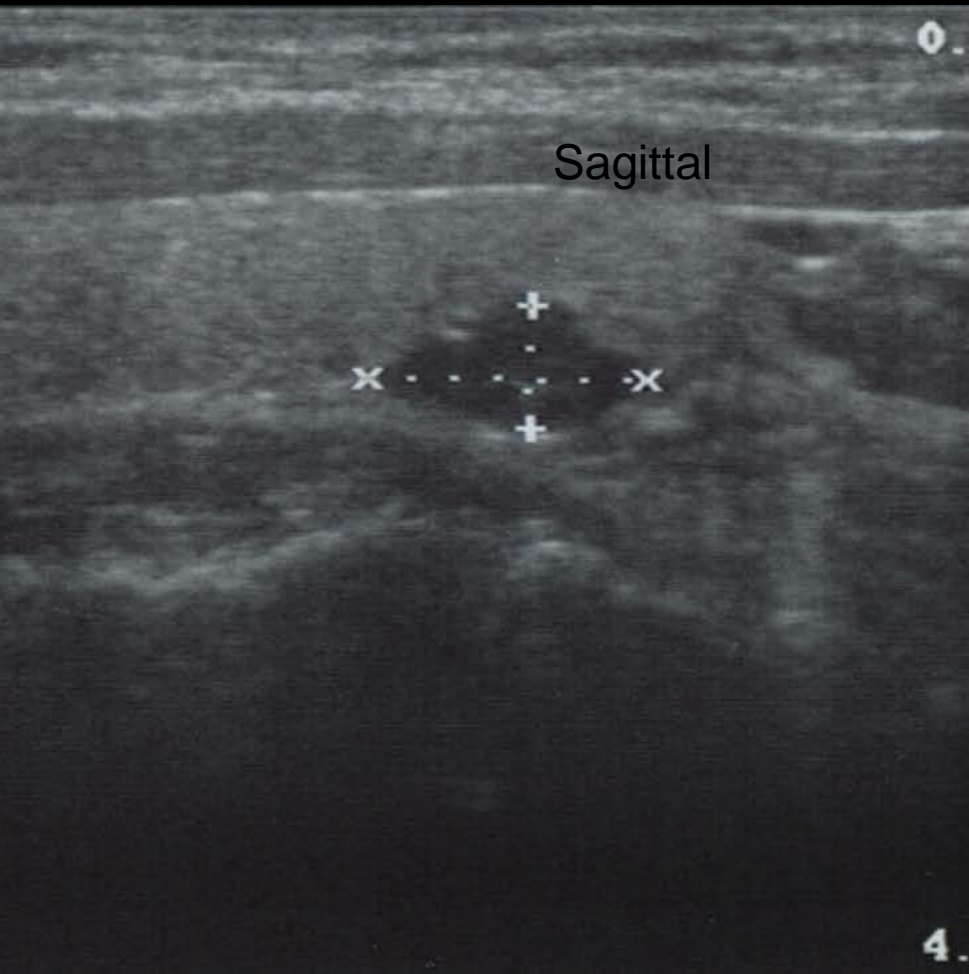
- Terrible test for parathyroid disease
- 59% sensitivity for glands in normal position and 79% for ectopic glands
  - False positives: thyroid nodules and lymph nodes
- Benefits: Typically reserved for re-operative cases or to confirm mediastinal adenomas
- Limitations: Expensive, poor sensitivity, patient compliance

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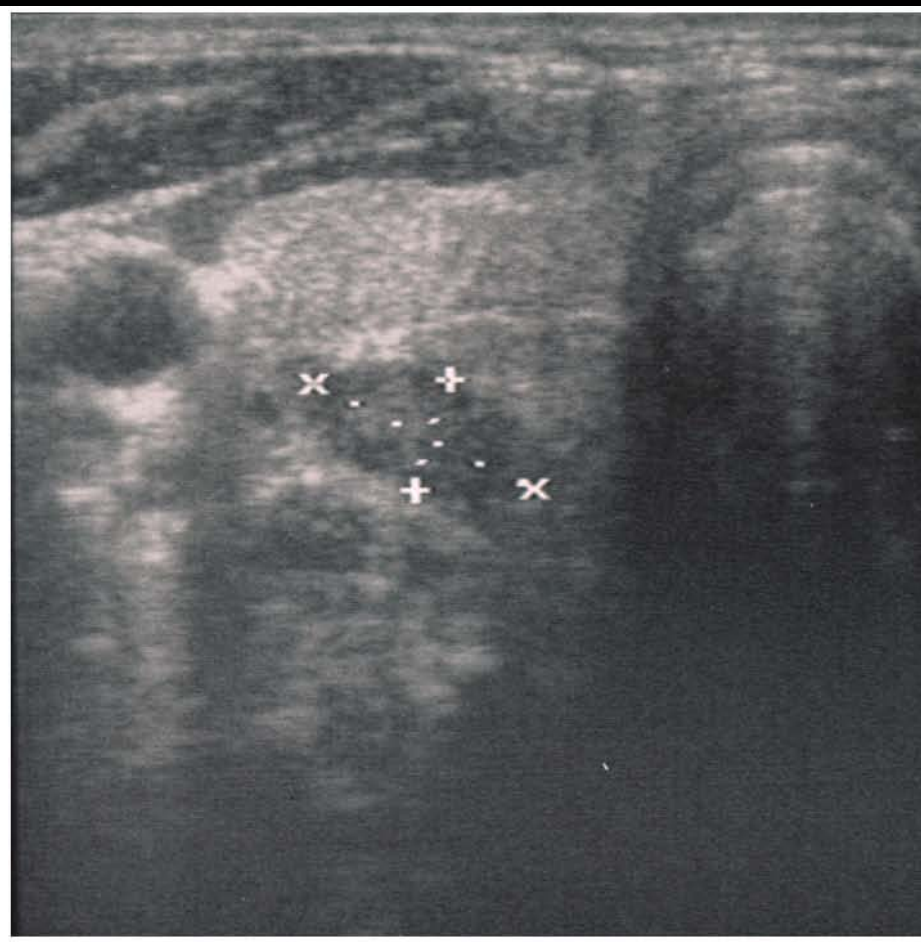
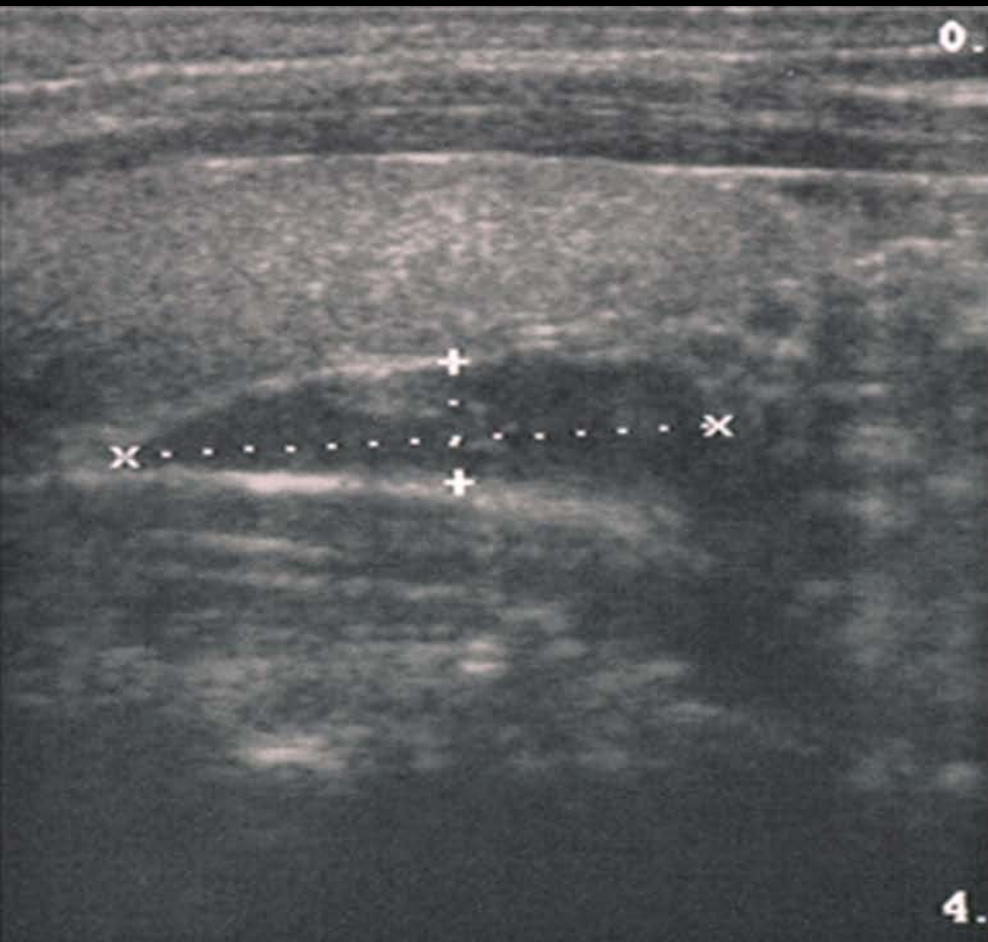
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USG

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# Ultrasound

- 70-80% sensitivity
  - False positive: thyroid nodules, lymph nodes
- Benefits:
  - Fast, office-based
  - No radiation
  - FNA-PTH sampling
  - Can delineate intrathyroidal glands
  - Best for looking at thyroid
- Limitations:
  - Operator dependent
  - Cannot penetrate bone/air
    - Not good for retroesophageal, retrosternal, retrotracheal, deep cervical
  - Can't see mediastinal glands
  - Usually miss small glands
  - Typically can't see normal glands

# Surgeon-performed USG

- Over 100 studies to date
  - Higher diagnostic rate
  - More useful description of locations
  - Increased accuracy

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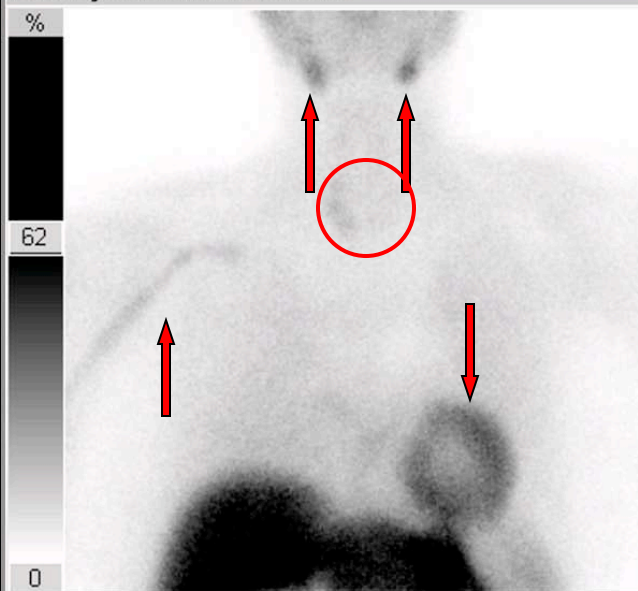
SESTAMIBI

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# Sestamibi

- Concentrates in mitochondria
  - Parathyroid, thyroid, salivary glands, heart
- Longer time to wash out of parathyroid than thyroid
  - Adenomas have higher percent of oxyphil cells
- Types:
  - Delayed
  - Dual Isotope
  - SPECT-CT

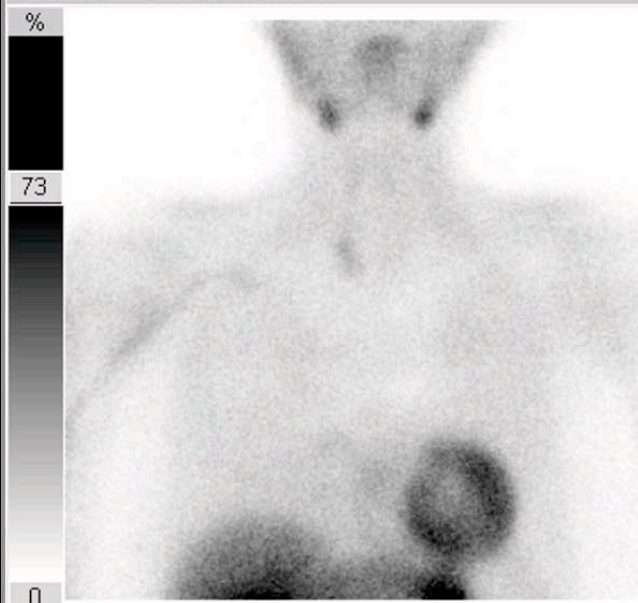
Parathyroid INITIAL 3/3/2009



R ANTERIOR L INITIAL

(B:0%,T:62%)

Parathyroid Delay 3/3/2009



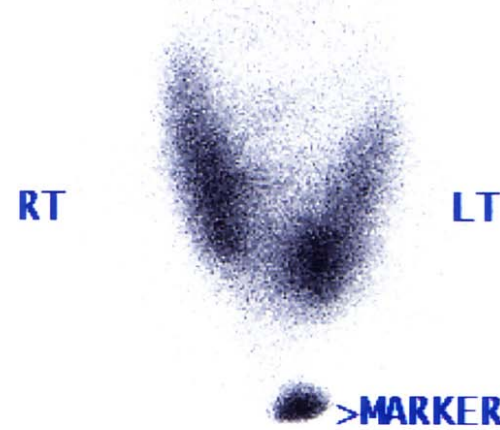
R ANTERIOR L Delay

FOV: not calibrated image  
1106V88H

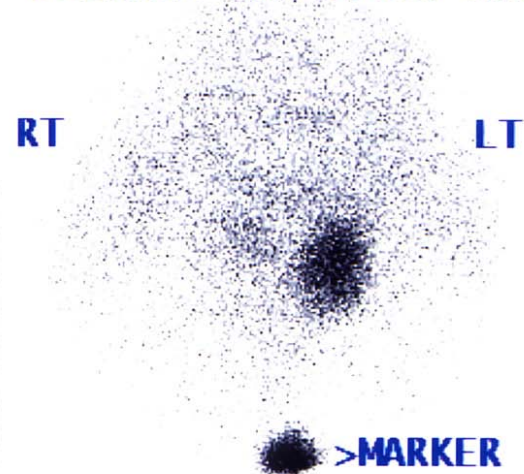
# Delayed Technique



**PINHOLE IMMEDIATE SCAN**



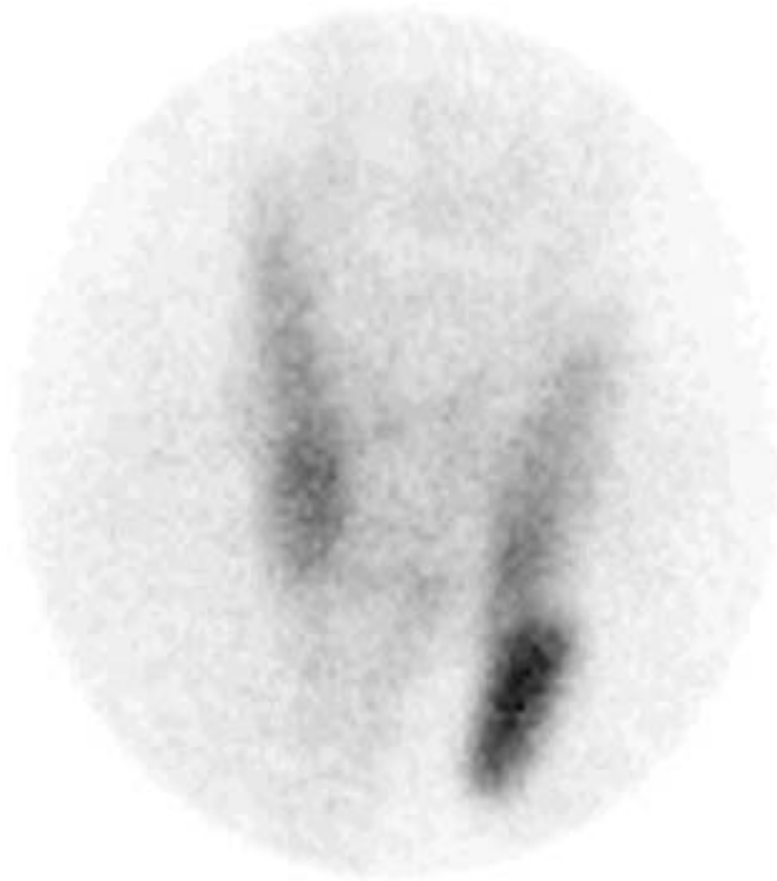
**PINHOLE 3HRS POST INJ**





# Dual-Isotope Technique

Early Sestamibi



# Dual isotope protocol

$^{123}\text{I}$

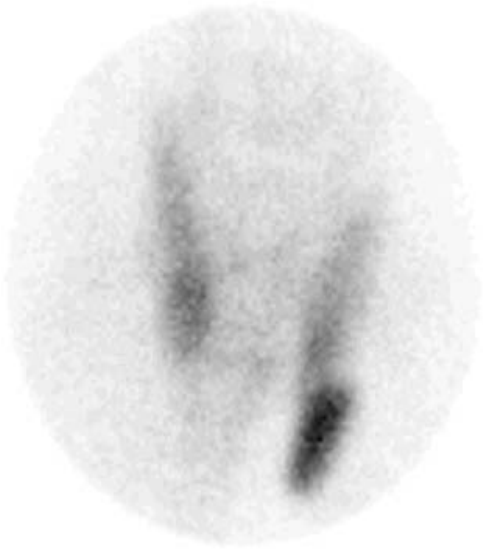


# Dual isotope subtraction protocol

**Early MIBI**

**$^{123}\text{I}$**

**(MIBI -  $^{123}\text{I}$ )**



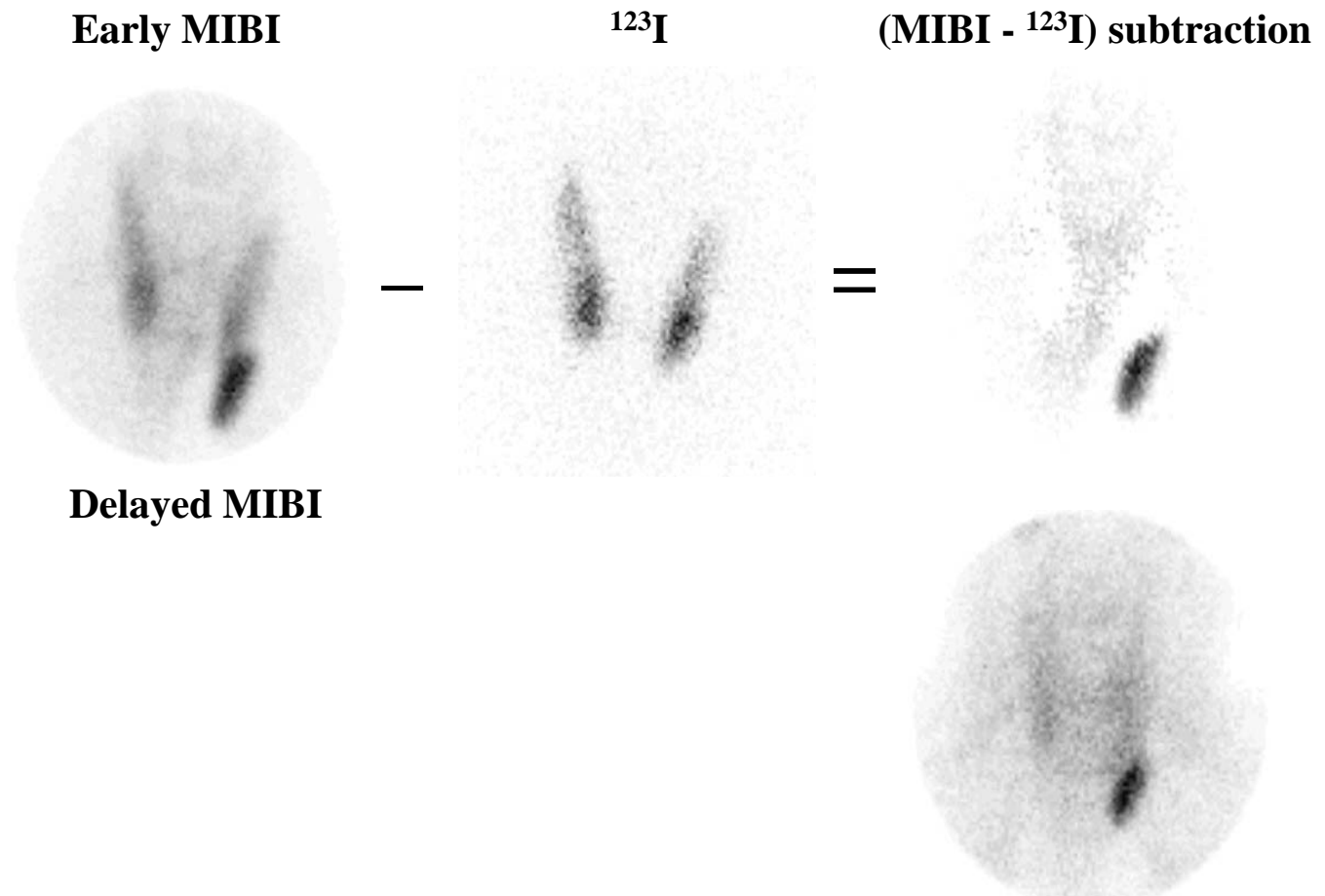
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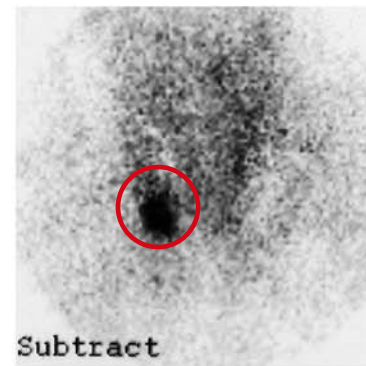
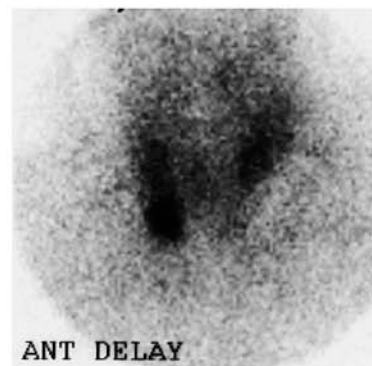
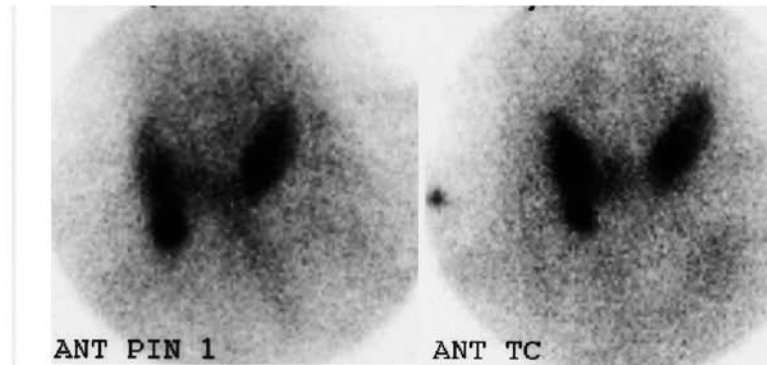
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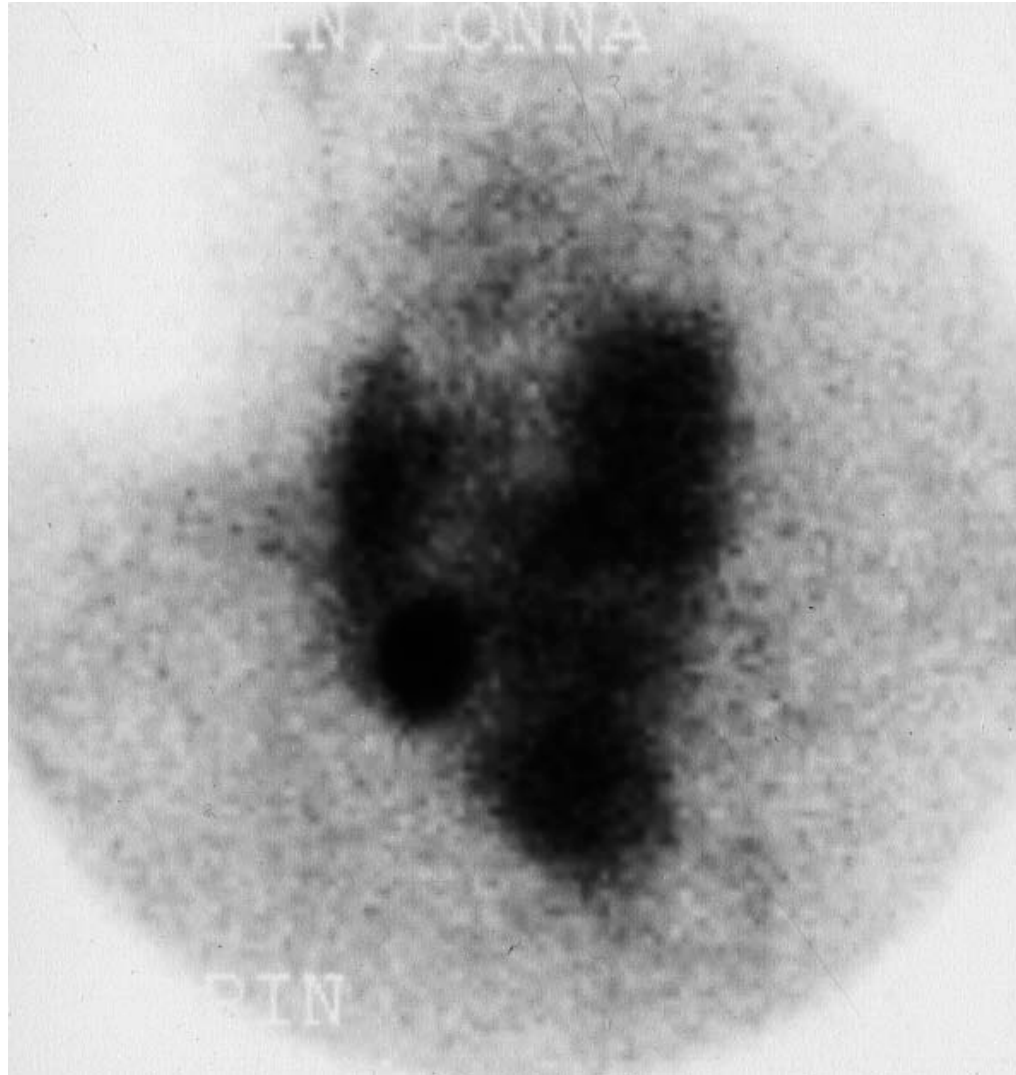
# Dual isotope subtraction protocol



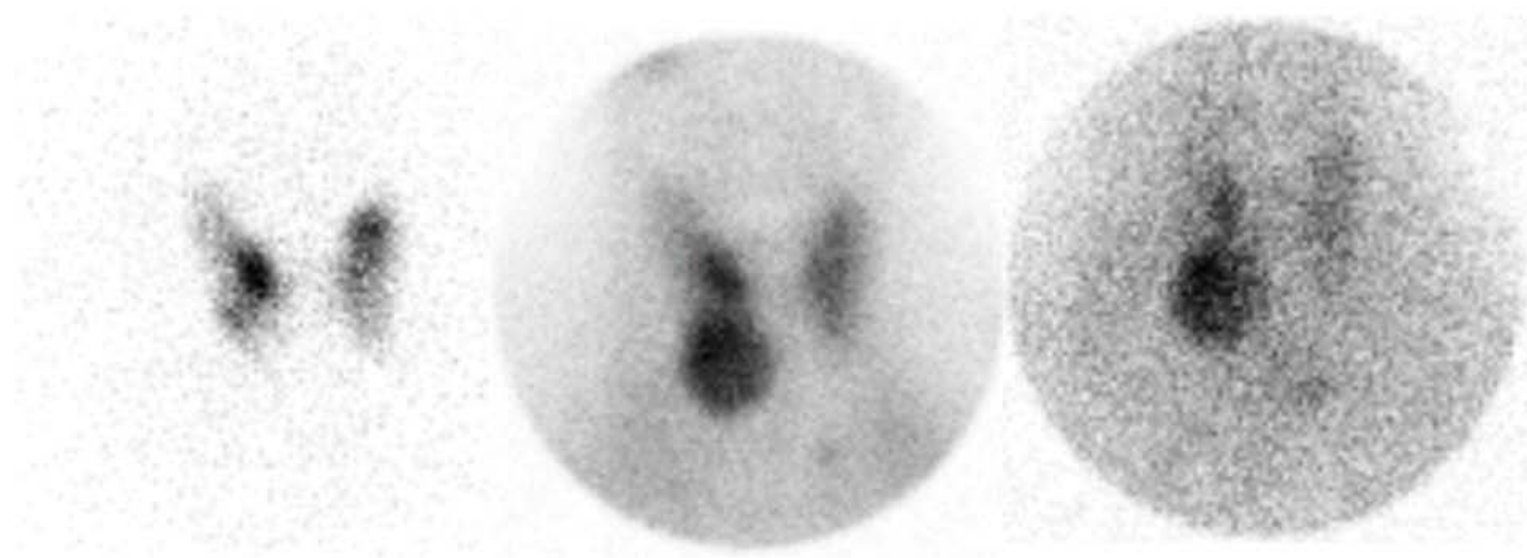
# Delayed and Subtraction



# False Positive



# Follicular and Hurthle Cell Neoplasms

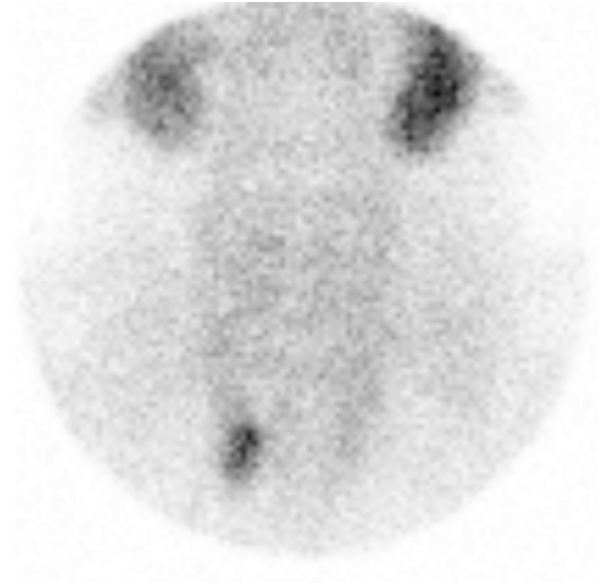
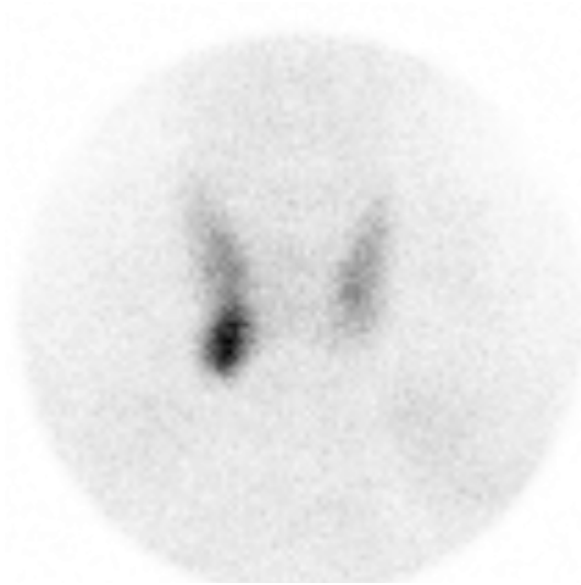
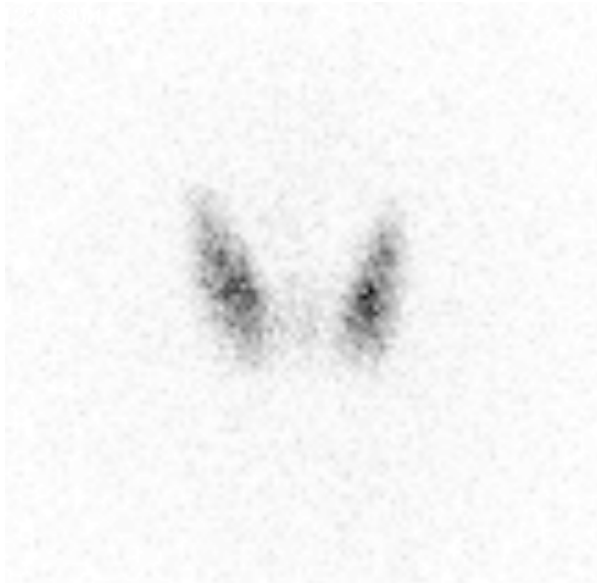


I-123

Early sestamibi

Delayed sestamibi

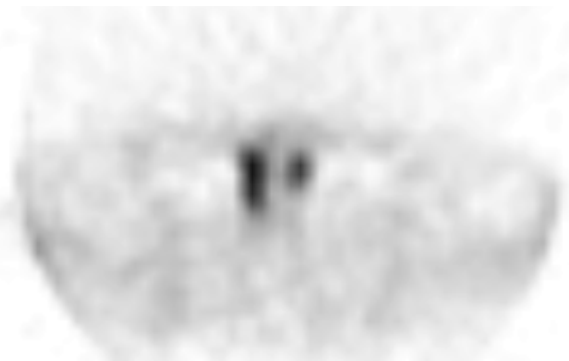
# Utility of SPECT



**Early MIBI**

**Delayed MIBI**





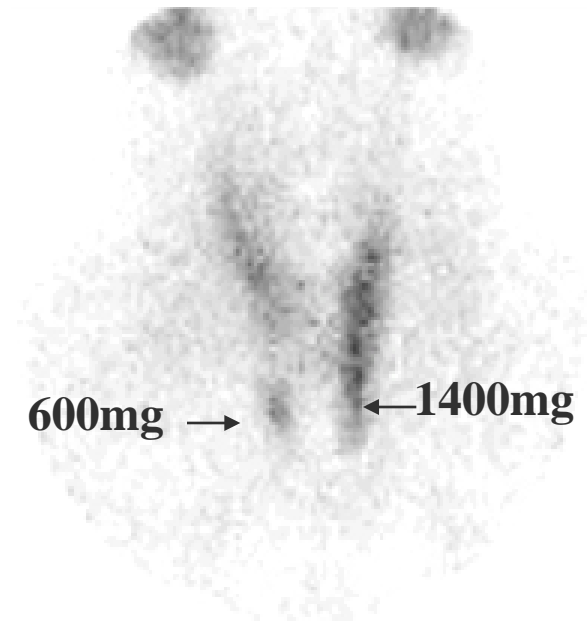
# Multi-gland Disease



RAI

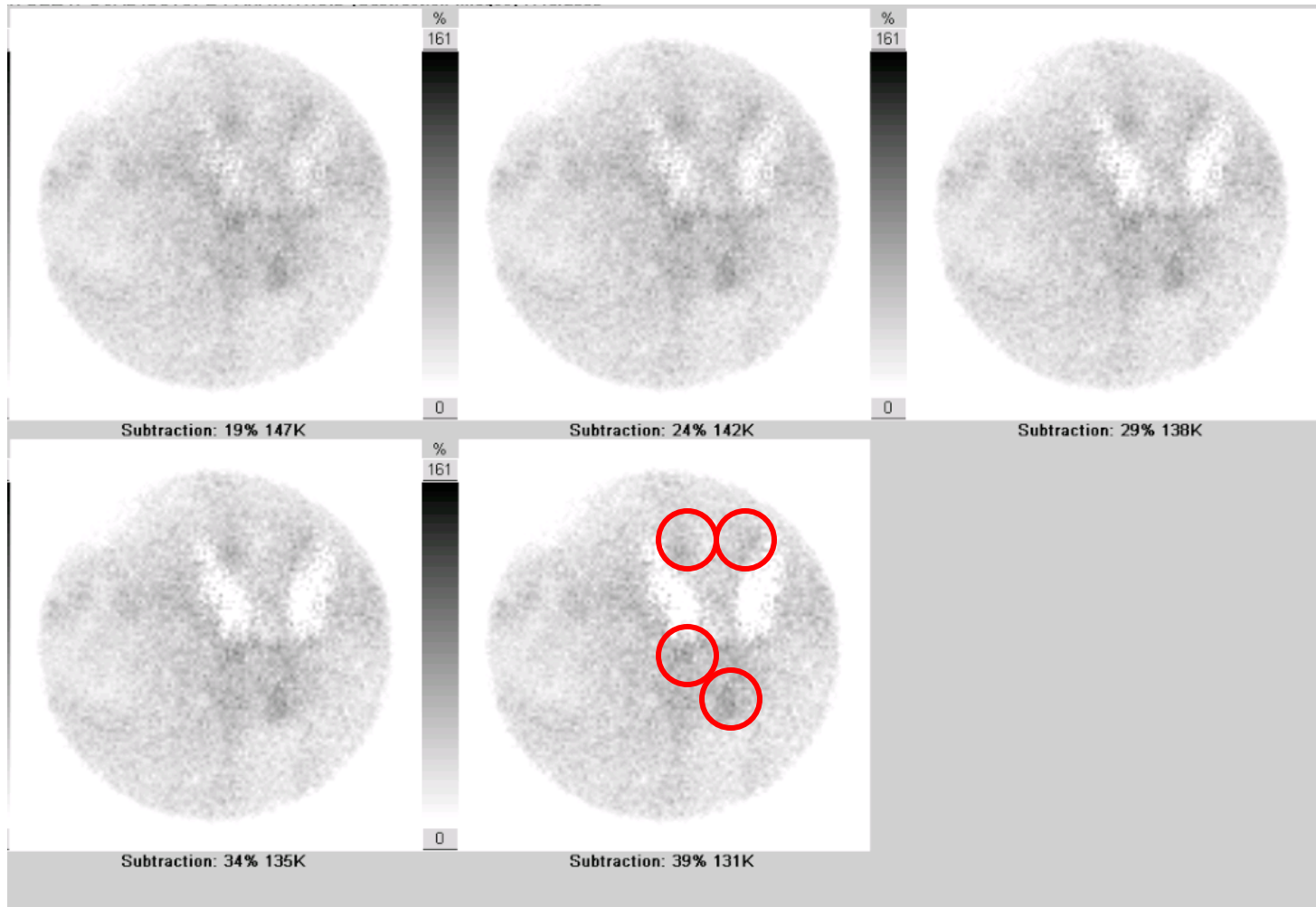


Sestamibi



600mg → ←1400mg

# 4 gland hyperplasia



# The negative MIBI

- Refer to a high volume center
  - High volume centers have better localization (82% vs 67%)
  - Negative MIBI will be positive if repeated at high volume center in many cases (up to 80%)
- Get a 4D CT

# Sestamibi

- 80-90% sensitivity for single adenomas depending on the technique and local expertise
- Must at least do delayed images
- Subtraction
  - Pro: 5-10% higher sensitivity
  - Con: may be affected by thyroid replacement/recent iodine loads
  - Thyroid nodule that is MIBI+/cold on RAI, has 47% PPV and 88% specificity for thyroid cancer
- SPECT is particularly useful in imaging ectopic adenomas (mediastinal or deep in neck)
- False negative: cystic adenomas, multigland disease

# Sestamibi (cont' d)

- Benefits:

- Good sensitivity
- Identifies ectopic glands (especially mediastinal and undescended)
- Functional test, not just anatomic
- Acceptable radiation

- Limitations:

- Only 35% accurate in multiple gland disease
- Quality is highly variable
- Small glands
- Does not provide precise anatomic detail
- Usually miss small glands

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# COMBINING USG/MIBI

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# Combining USG and MIBI

- Kebebew Score:
  - 1 point each for calcium >12, PTH > 2x ULN, positive MIBI, positive USG, concordant MIBI and USG

**Table 3. Sensitivity, Specificity, and Positive and Negative Predictive Values of the Scoring Model for Predicting Single-Gland Disease in 238 Patients With Primary Hyperparathyroidism**

Total Score*	Patients in Total Study Cohort, %	Sensitivity, %	Specificity, %	PPV, %	NPV, %
≥1	80	89	59	90	57
≥2	50	60	89	96	35
≥3	35	44	100	100	30
≥4	18	23	100	100	26
5	8	6	100	100	22

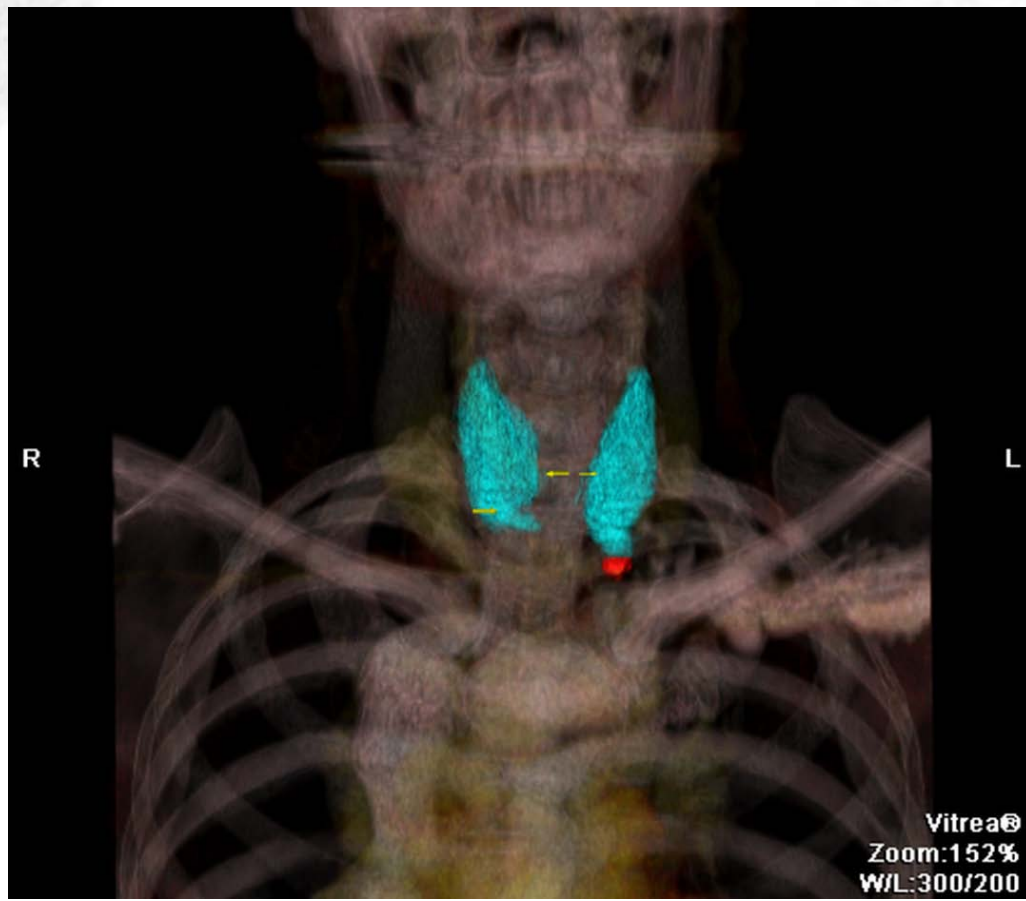
Abbreviations: NPV, negative predictive value; PPV, positive predictive value.

\*Total score for the 5 variables in the CaPTHUS model was determined by the following: (1) 1 point for a total serum calcium level of 3 mmol/L or greater [ $\geq 12$  mg/dL]; (2) 1 point for an intact parathyroid hormone level 2 or more times the upper limit of normal intact parathyroid hormone levels; (3) 1 point for positive sestamibi scan results showing 1 enlarged gland; (4) 1 point for positive neck ultrasound results showing 1 enlarged parathyroid gland; and (5) 1 point for concordant sestamibi and neck ultrasound results (identifying 1 enlarged gland on the same side of the neck).

- Concordant MIBI and USG = 96% chance that is the only abnormal gland
  - Arici C, et al. Surgery 129(6): 720-9, 2011

# Positive MIBI/Negative USG

- 58% chance of PLUG (posterior located upper gland)
- USG cannot visualize past trachea
  - Harari et al. Ann Surg Oncol 18(6):17171-22, 2011



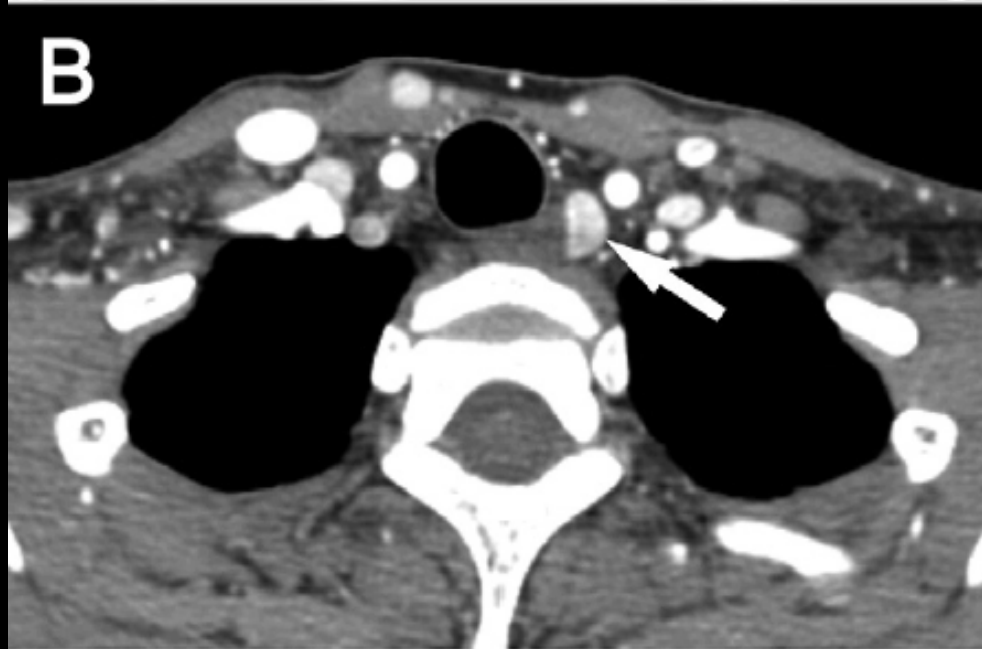
R

L

Vitrea®  
Zoom:152%  
W/L:300/200

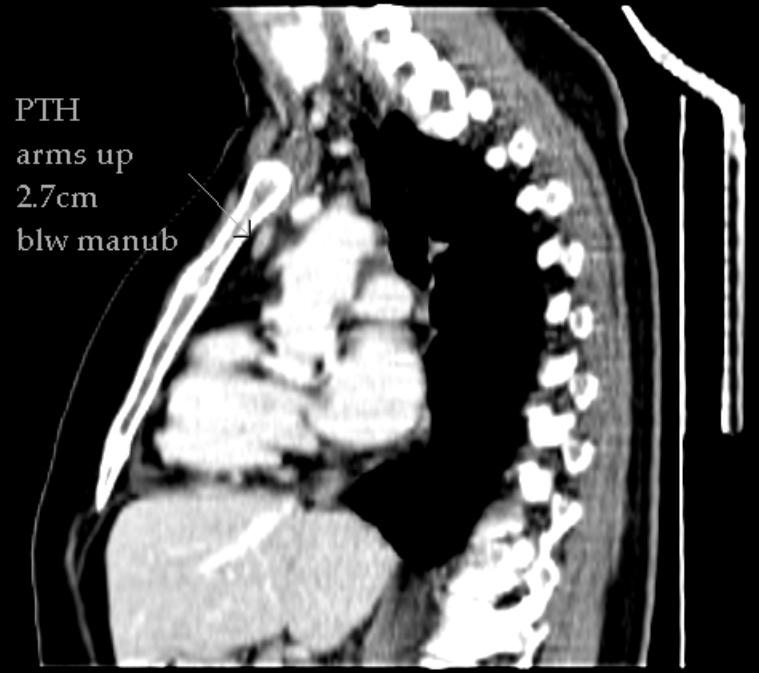
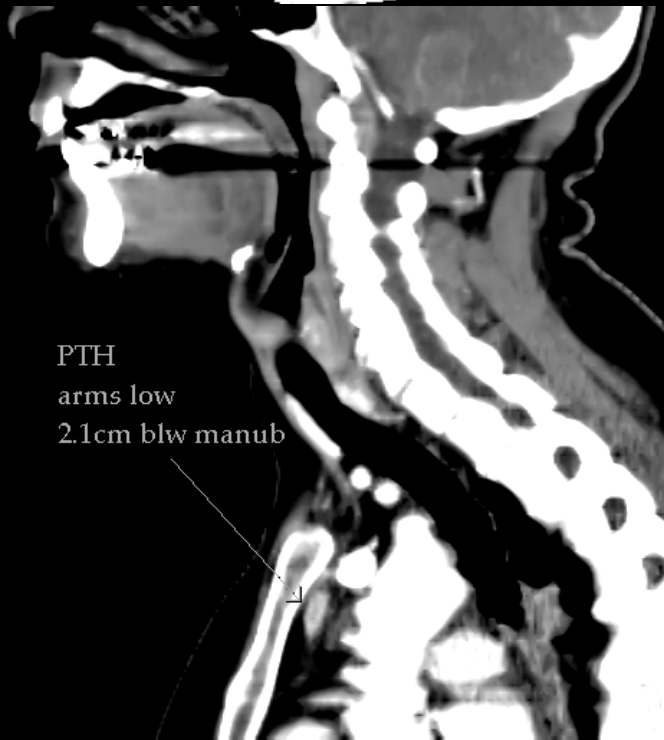
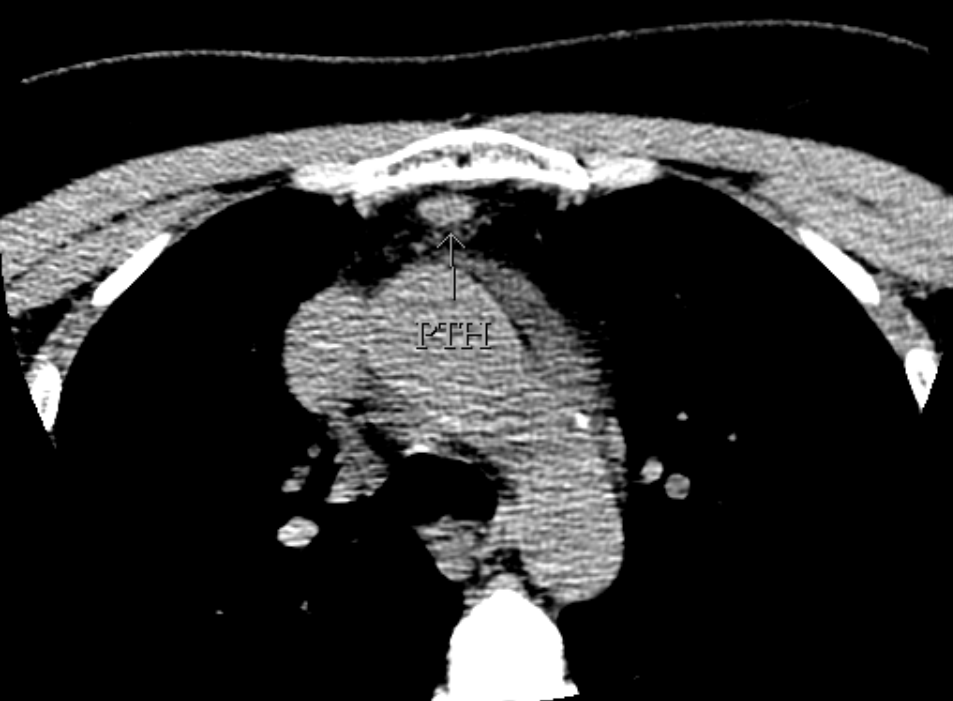
4D CT

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# 4D CT

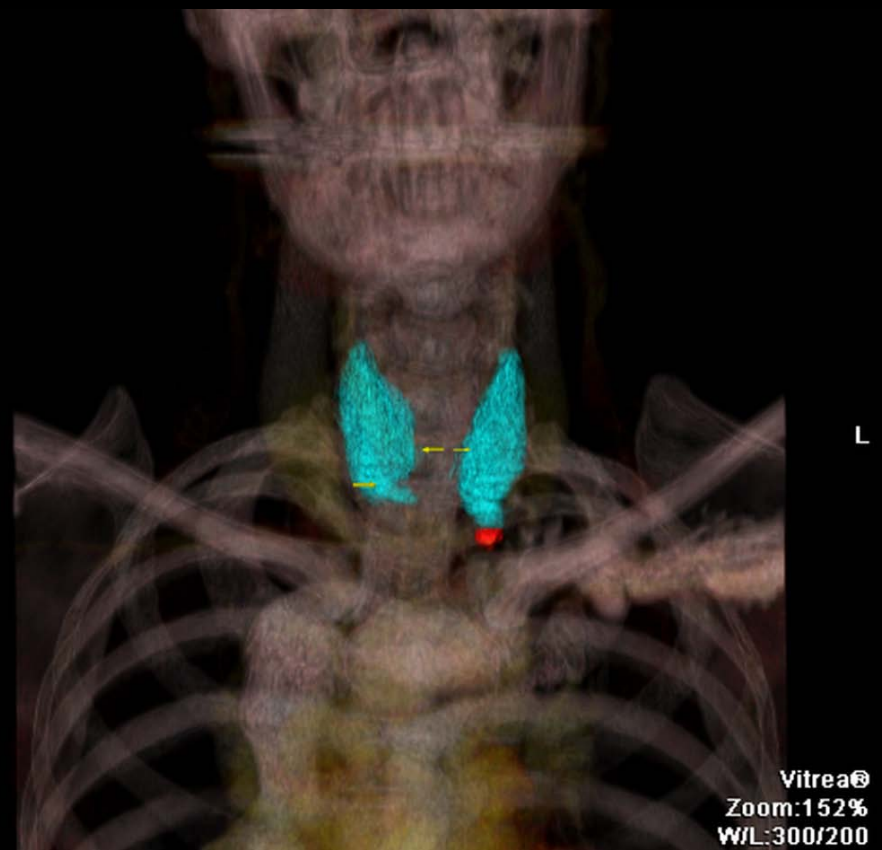
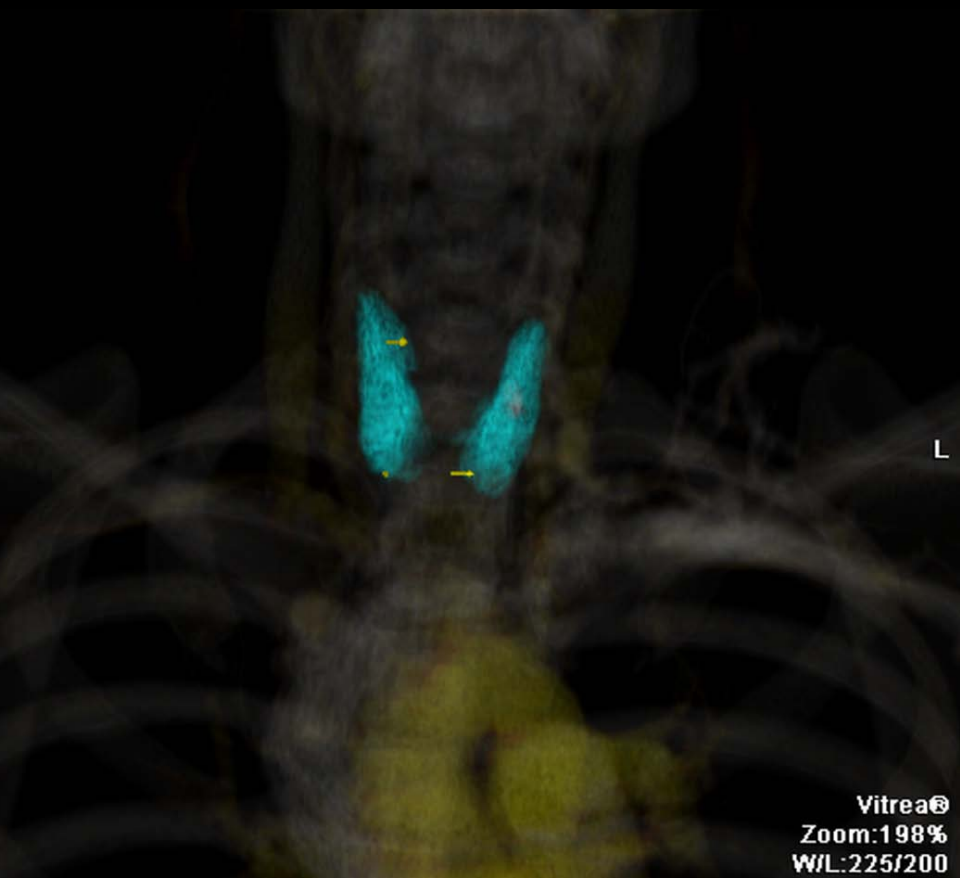
- Very thin cuts
- 4<sup>th</sup> dimension is time
  - i.e. contrast characteristics over time
  - Adenoma
    - <80HU on non-contrast
    - >130HU at 45s
    - Decrease by >20HU on delayed images
  - Lymph node
    - Start at soft tissue density, increase to peak<130 and increase further on delayed images
- Different protocols perform different # of scans
  - Non-contrast
  - Arterial phase (25s)
  - Washout 1 (30s)
  - Washout 2 (60-75s)



# Precise Information Provided by High Quality CT Scanning

- “A 0.4cm AP and 0.7m wide and nearly 1.8cm long (262ml) moderately hypervascular nodule, located at the posteriomedial aspect of the right mid-lower thyroid lobe, behind the neurovascular bundle, directly anterior to the right longus colli muscle, medial to the right common carotid artery and just to the right of the esophagus, is consistent with a low-lying right upper parathyroid adenoma with an estimated weight of 262mg”
- At surgery, the above was confirmed, wt 300mg.



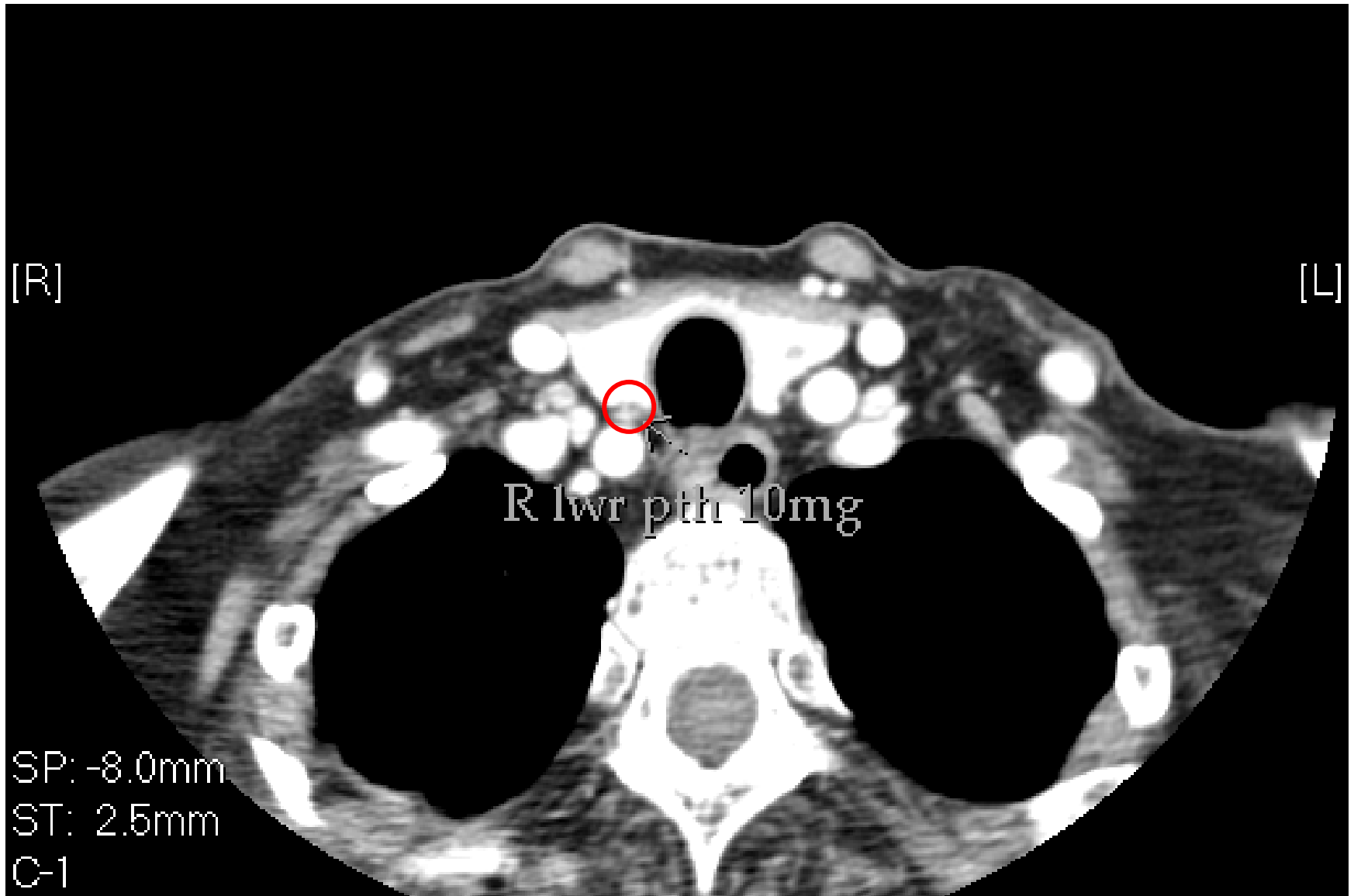




# Highly accurate in setting of negative MIBI

- 85% sensitive, 94% specific in lateralizing
- 66% sensitive, 89% specific in predicting exact location
  - Harari A, et al. Surgery 144(6):970-6, 2008

# Visualization of Normal Parathyroid



# 4D CT

- 90% sensitivity, 93-95% PPV
  - False positive: lymph nodes
- Benefits:
  - Precise anatomic localization
  - Some functional information
  - Can visualize normal parathyroid gland
  - 100% specificity for multigland disease
- Limitations:
  - Needs a dedicated radiologist
  - Radiation

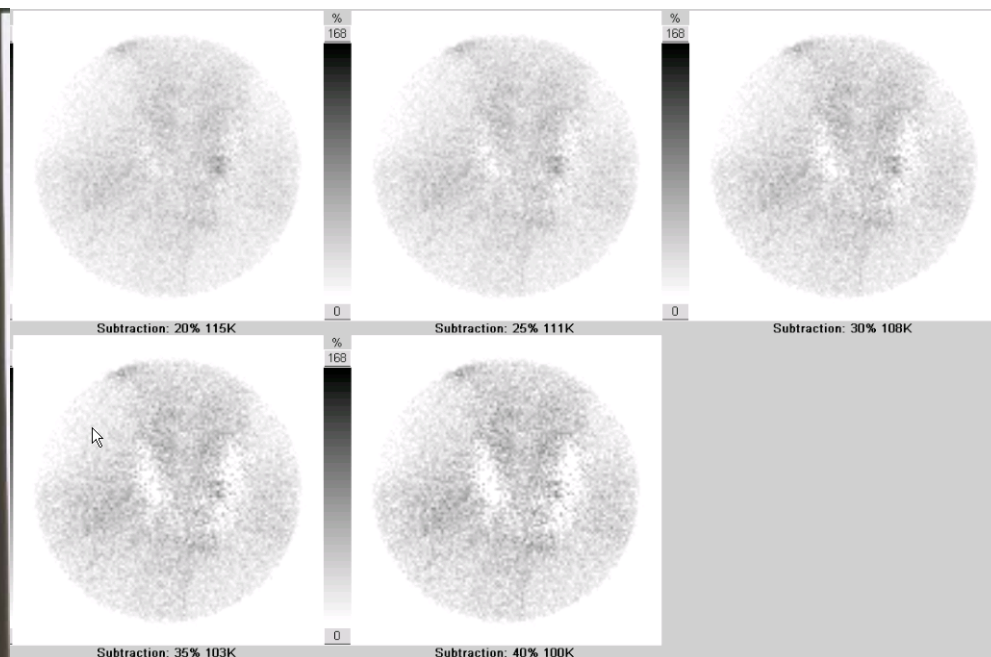
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# PARATHYROID FNAB

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# Intrathyroidal gland





# FNAB and PTH Washout

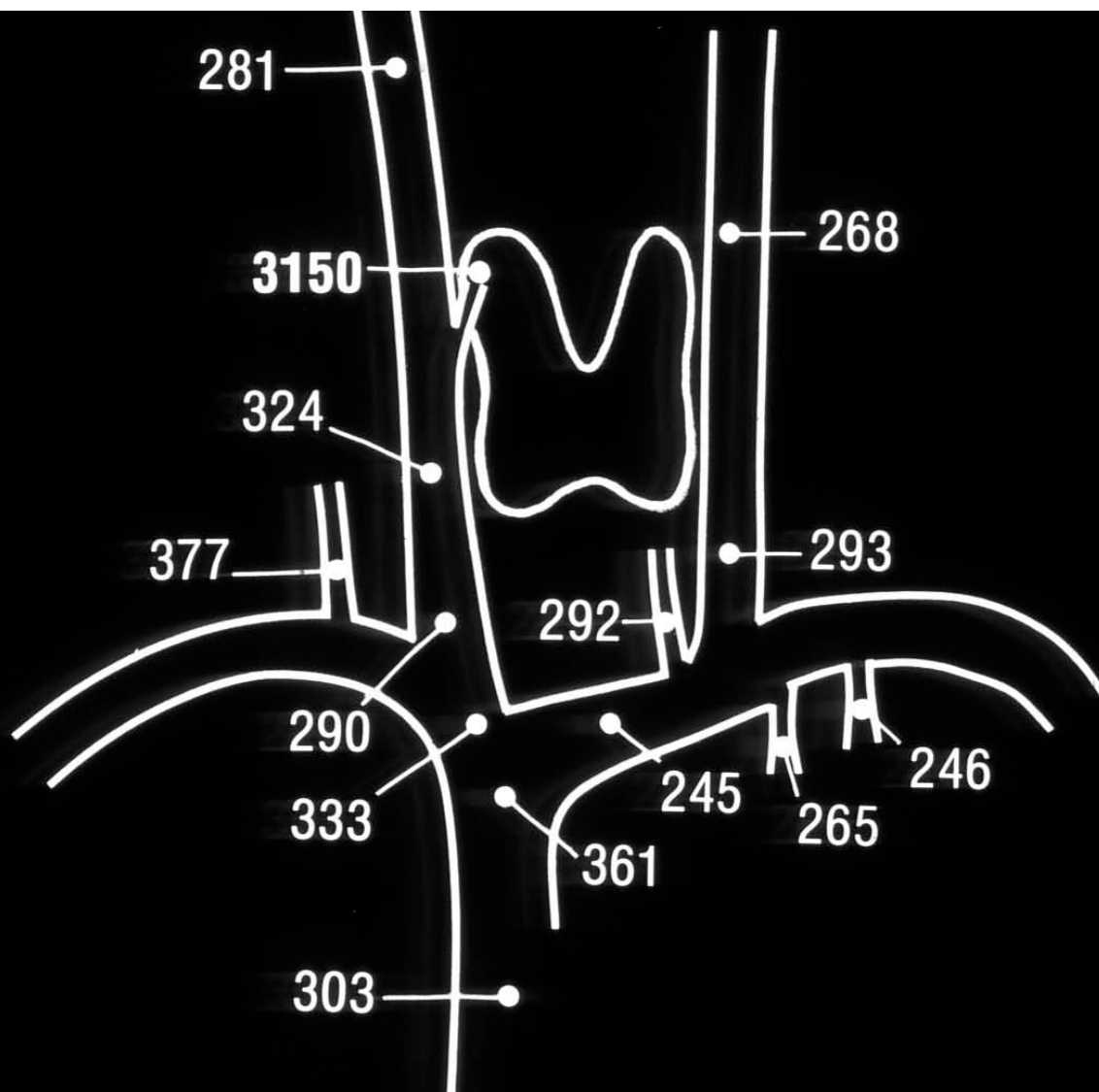
- Cytology may resemble follicular lesion
- Must do PTH washout
- Benefits:
  - Excellent PPV
  - Functional data
  - Can distinguish between parathyroid and thyroid
- Limitations:
  - May make surgery more difficult

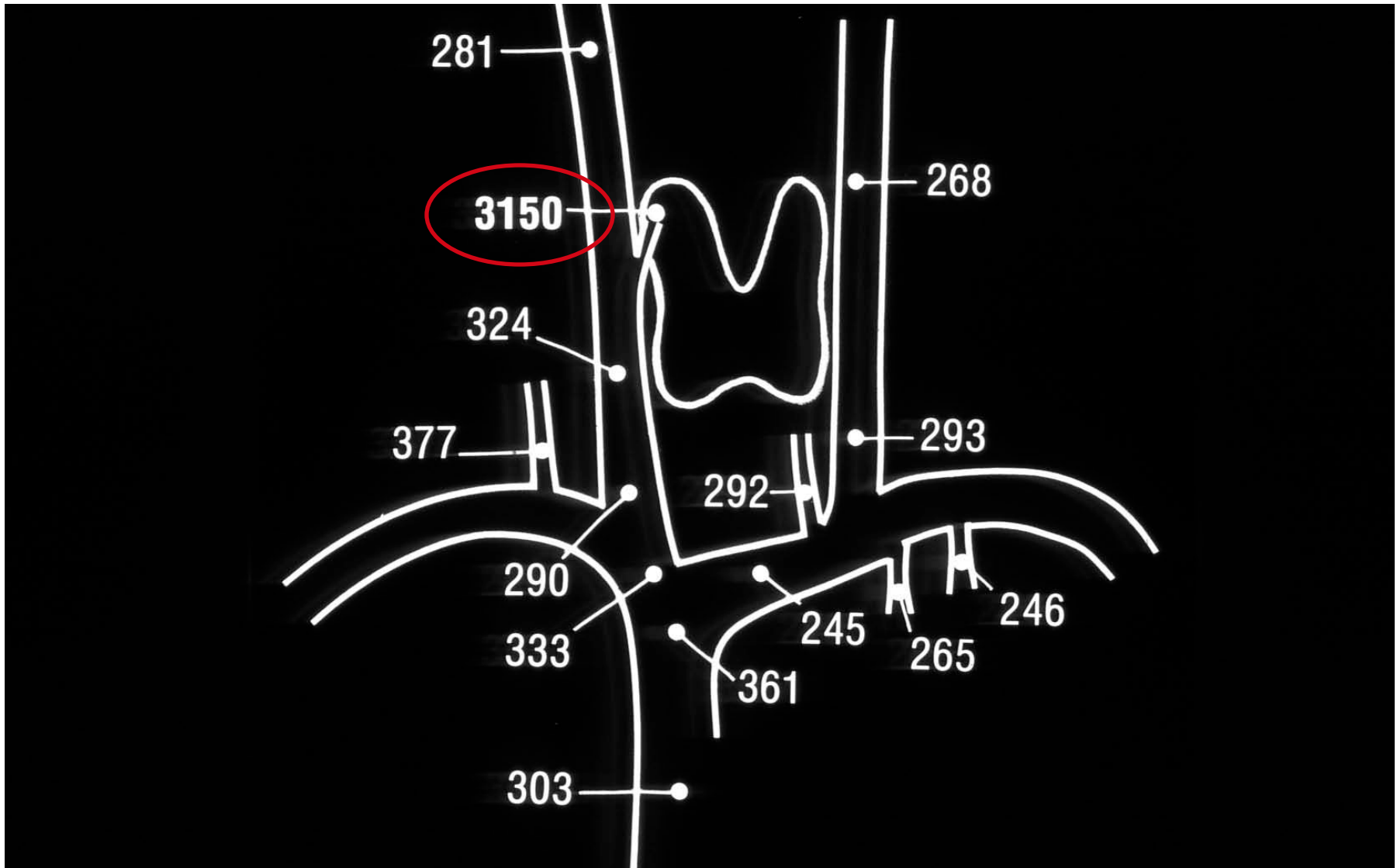
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# SELECTIVE VENOUS SAMPLING

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# Selective Venous Sampling

- Sensitivity 70-80%
- Benefits:
  - Functional data
  - Good for mediastinal and cervical adenomas
  - May identify multigland disease
- Limitations:
  - Invasive (risks of embolization, bleeding, hematoma, etc)
  - Radiation
  - Cannot use in renal failure patients
  - Does not provide precise anatomic detail
  - Requires a high degree of expertise

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# RE-OPERATIVE CASES

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# Re-operative Cases

- Confirm the diagnosis
  - Rule out BFHH with 24 hour urine
- Goal is a minimally invasive operation
- Localize with at least 2 modalities
- 4D CT highly accurate
  - Sensitivity 88% vs 54% with MIBI
  - Accuracy ~82%
- Consider FNAB with PTH washout

# SECONDARY HYPERPARATHYROIDISM

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# Secondary Hyperparathyroidism

- 15% have supernumerary glands
- Often in thyrothymic ligament
- Rule out mediastinal disease

MEN 1

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# MEN 1

- 4 gland exploration is near-mandatory
- Imaging may make the exploration easier
- Rule out mediastinal disease/thymic carcinoma

# Take home points

- Good parathyroid imaging can make life easier for everyone
- 4D CT is the most accurate localizing test
- In re-operative cases
  - Localize with 2 modalities
  - Consider FNAB, selective venous sampling if other modalities fail

# THANK YOU

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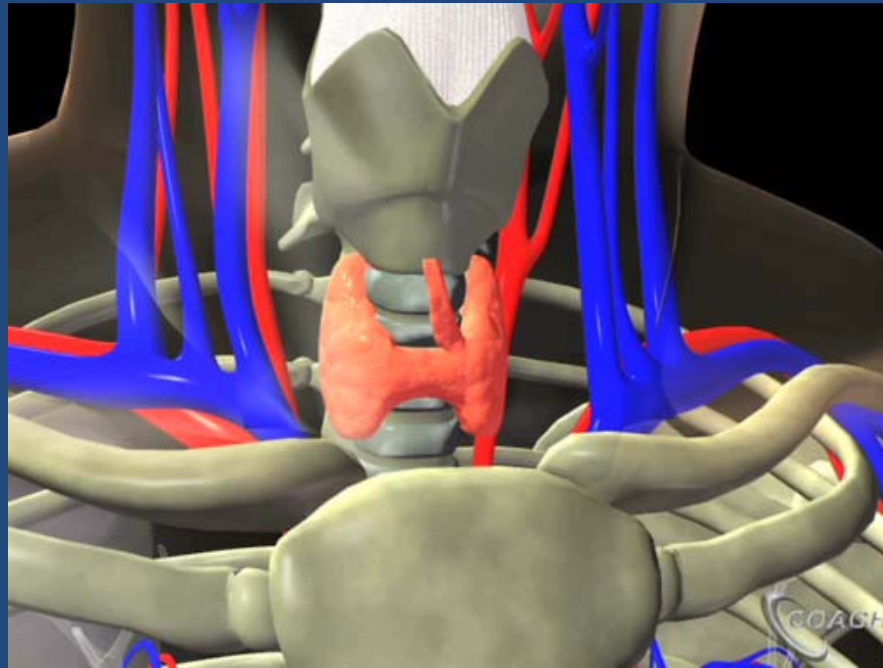


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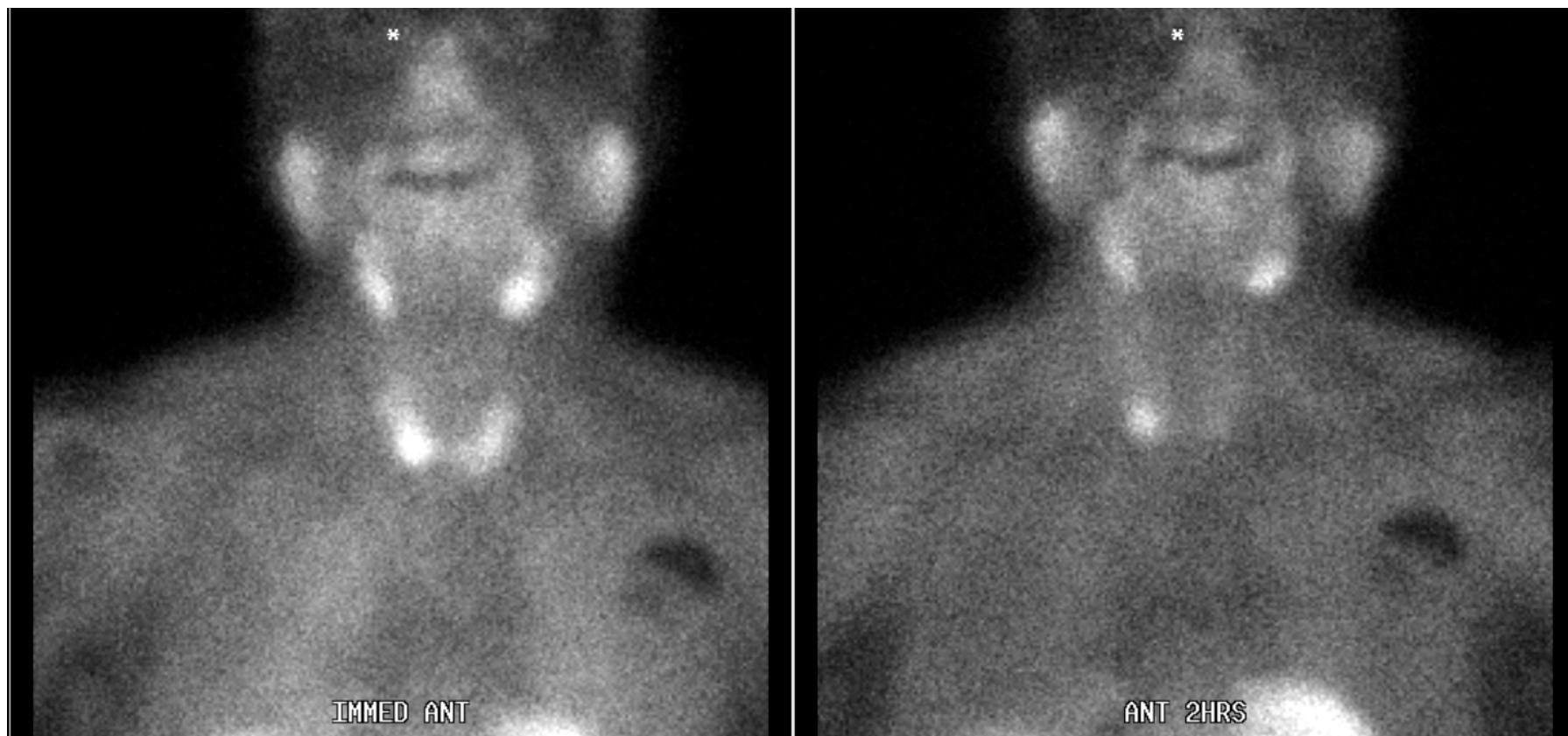


# ECTOPIC LOCATIONS

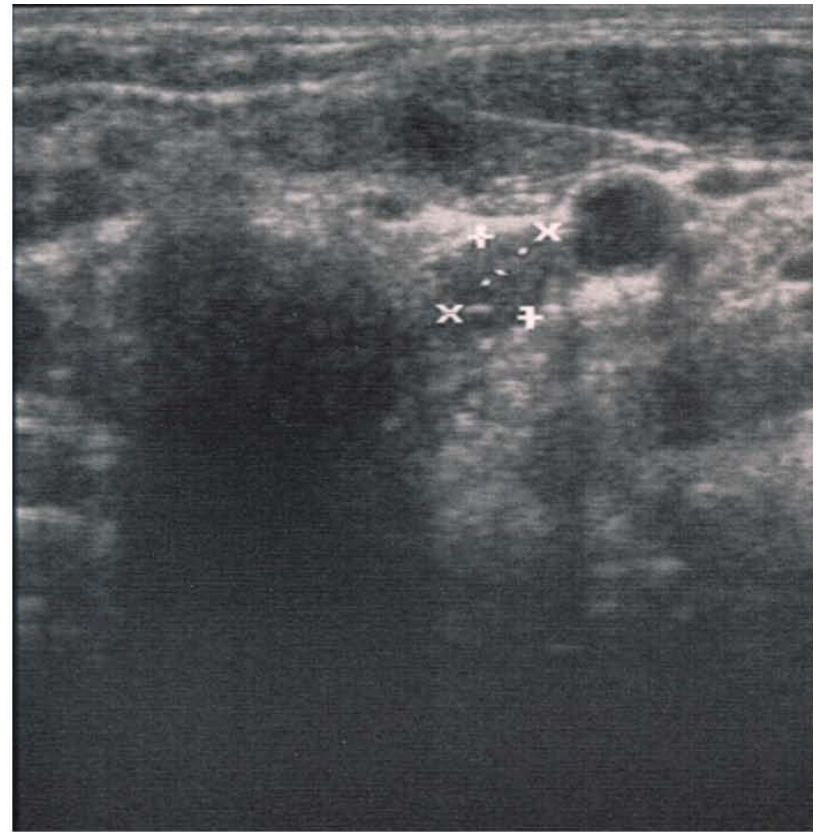
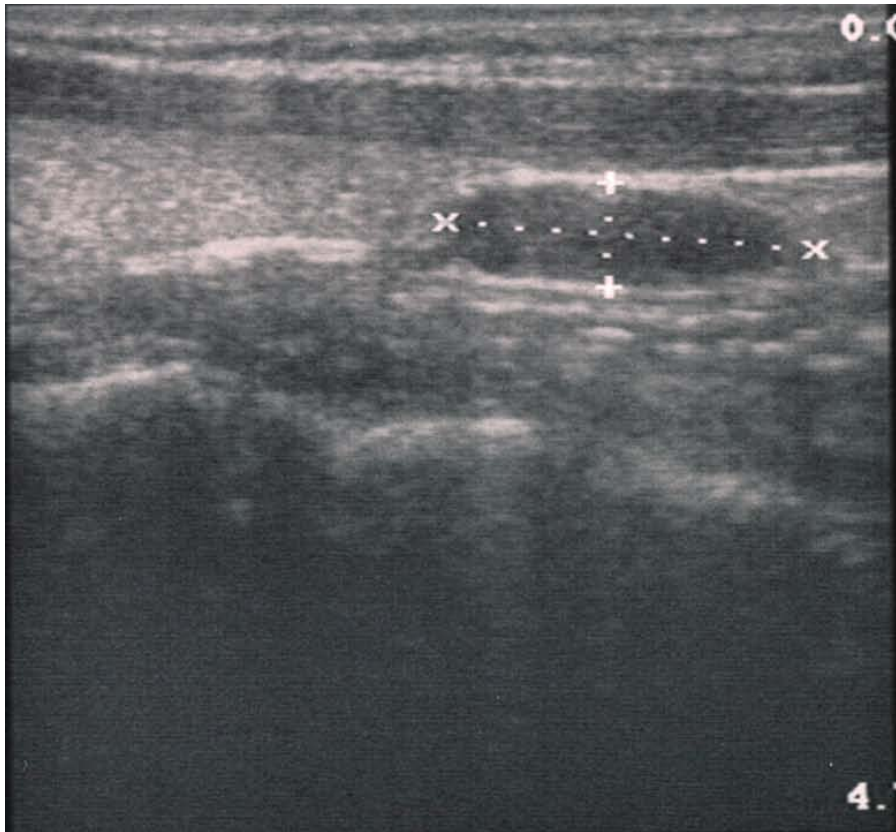
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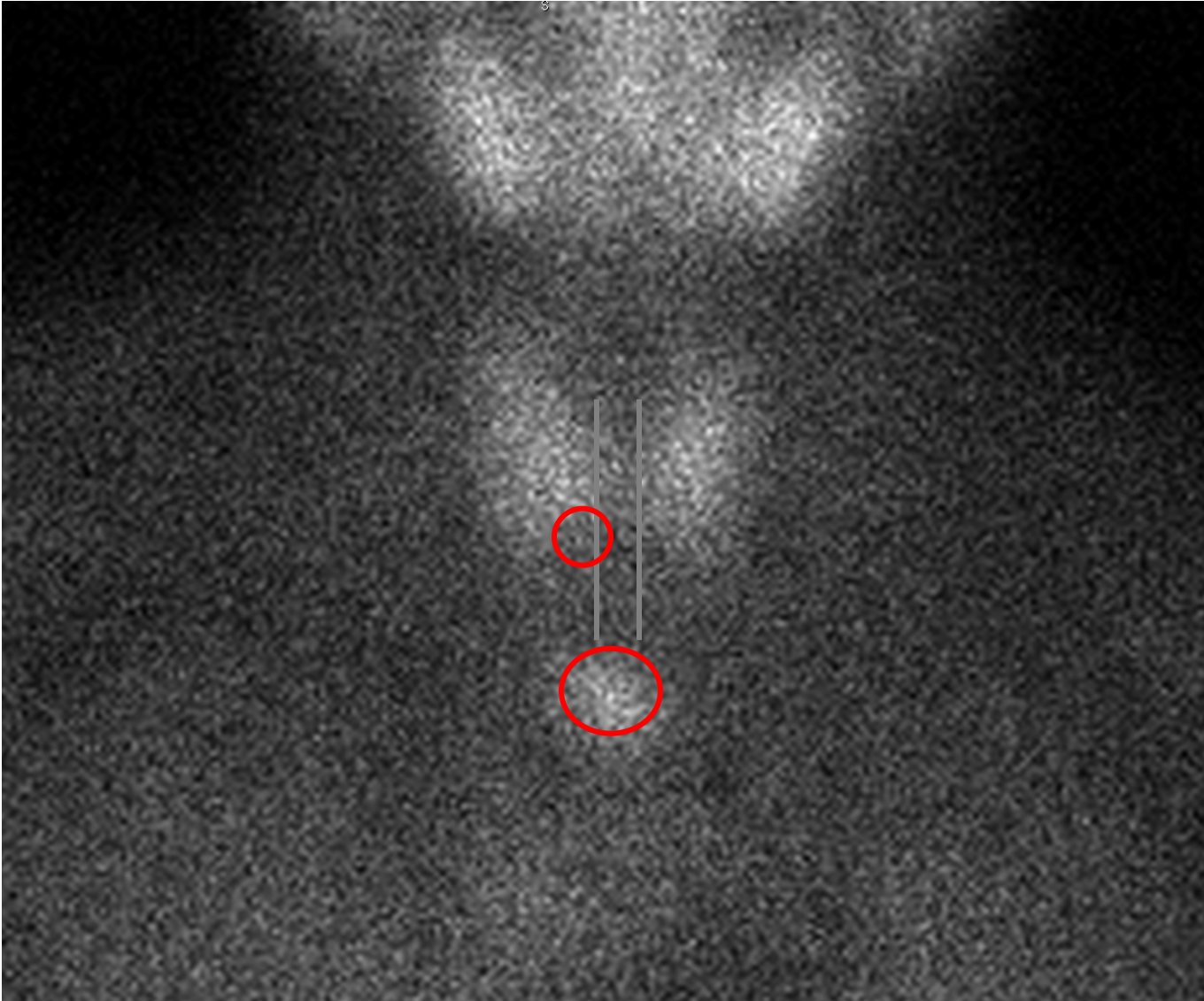
# Typical lower- sestamibi

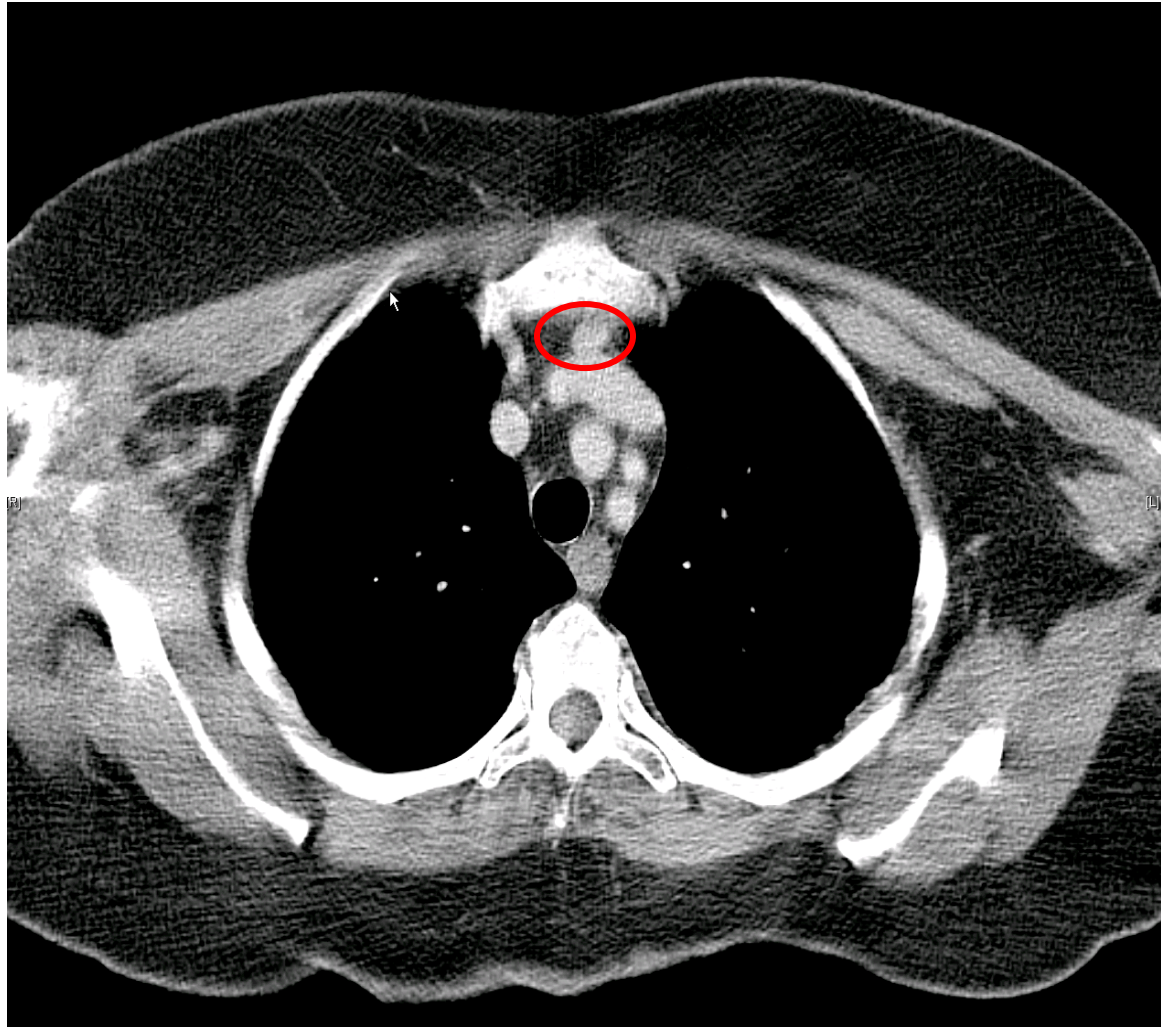


# Lower gland in thyrothymic ligament- USG

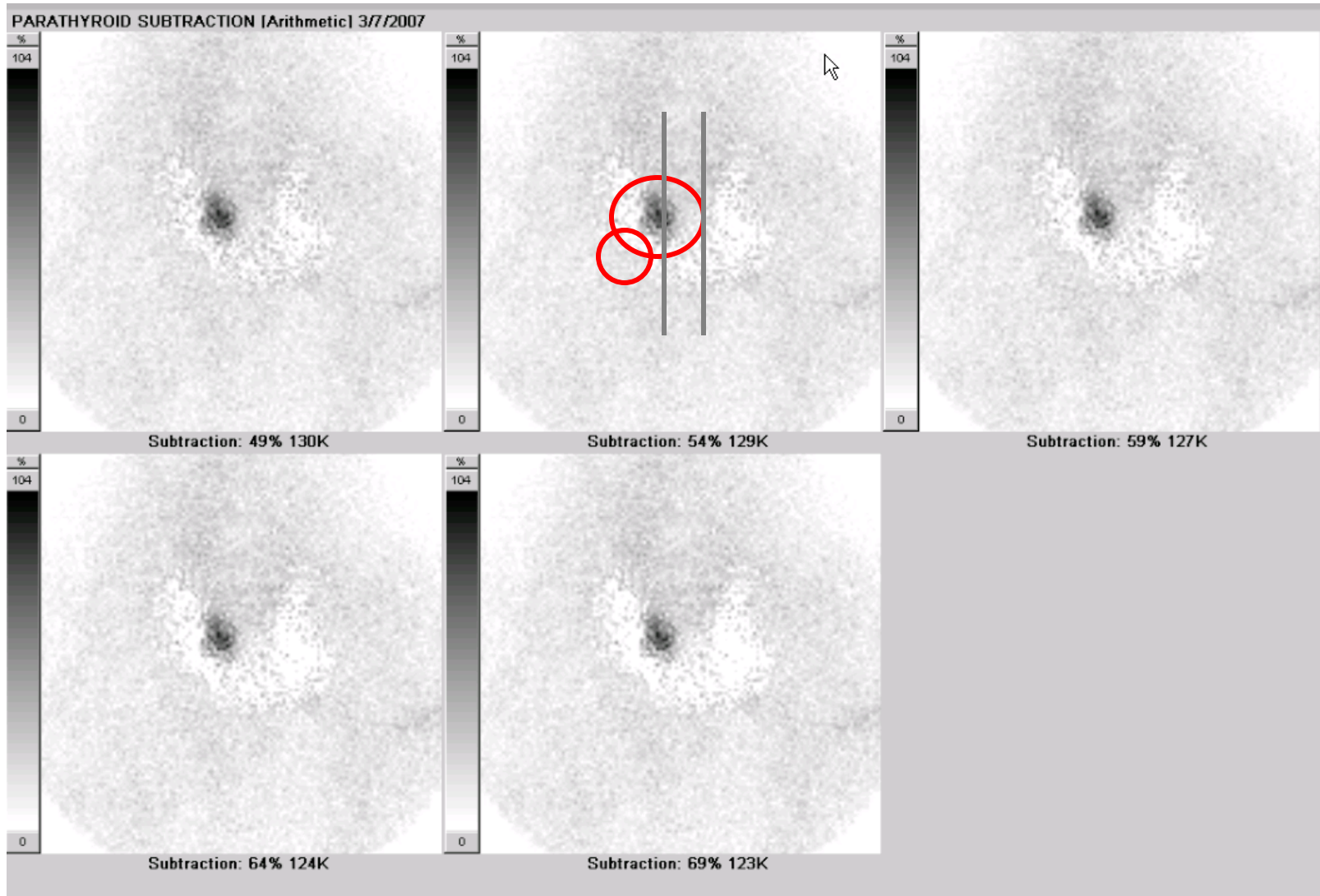


# Lower gland in thyrothymic ligament-sestamibi

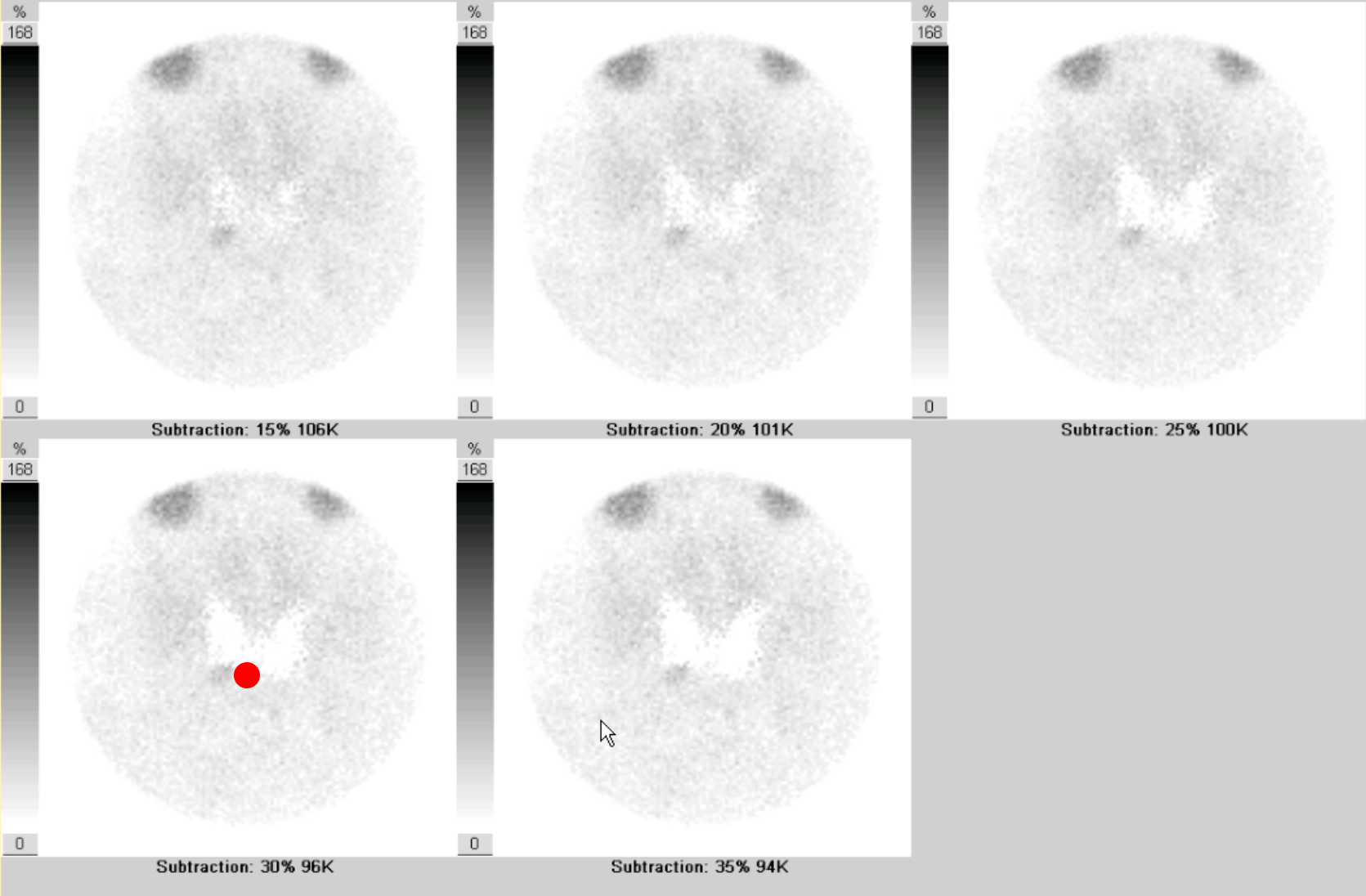




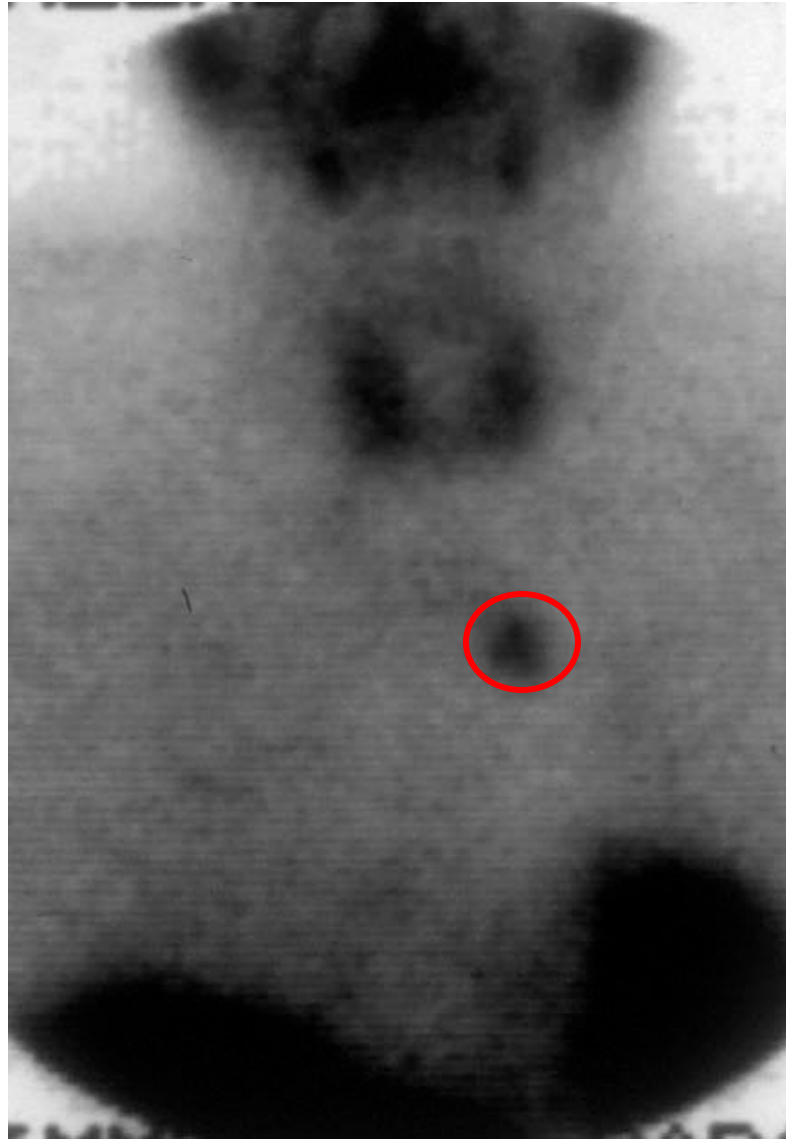
# PLUG- MIBI



DUAL ISOTOPE PARATHYROID- 3 HRS DELAYED [Subtraction Images] 4/21/2009



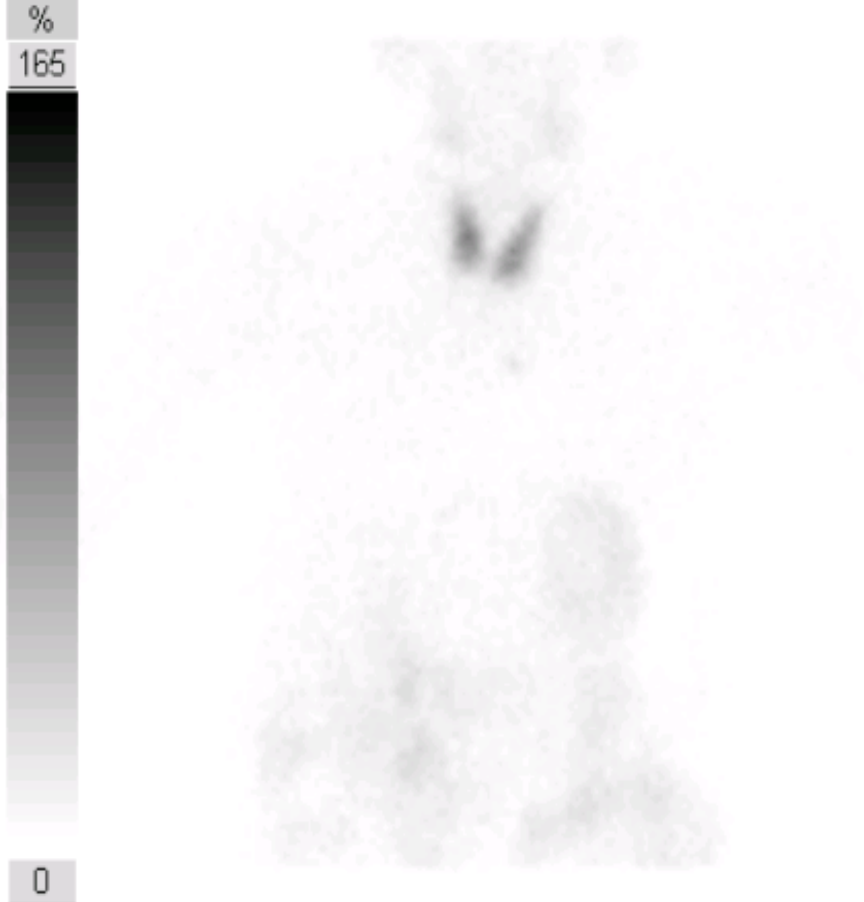
# Mediastinum



2HRS CHEST DEL PARATHYROID 3/24/2010



ANT CHEST Duration:601sec 99m Technetium



ANT CHEST Duration:601sec 123-Iodine