



Thyroid and Parathyroid Imaging

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Outline

- Thyroid Nodules
- Thyroid Cancer
- Hyperparathyroidism

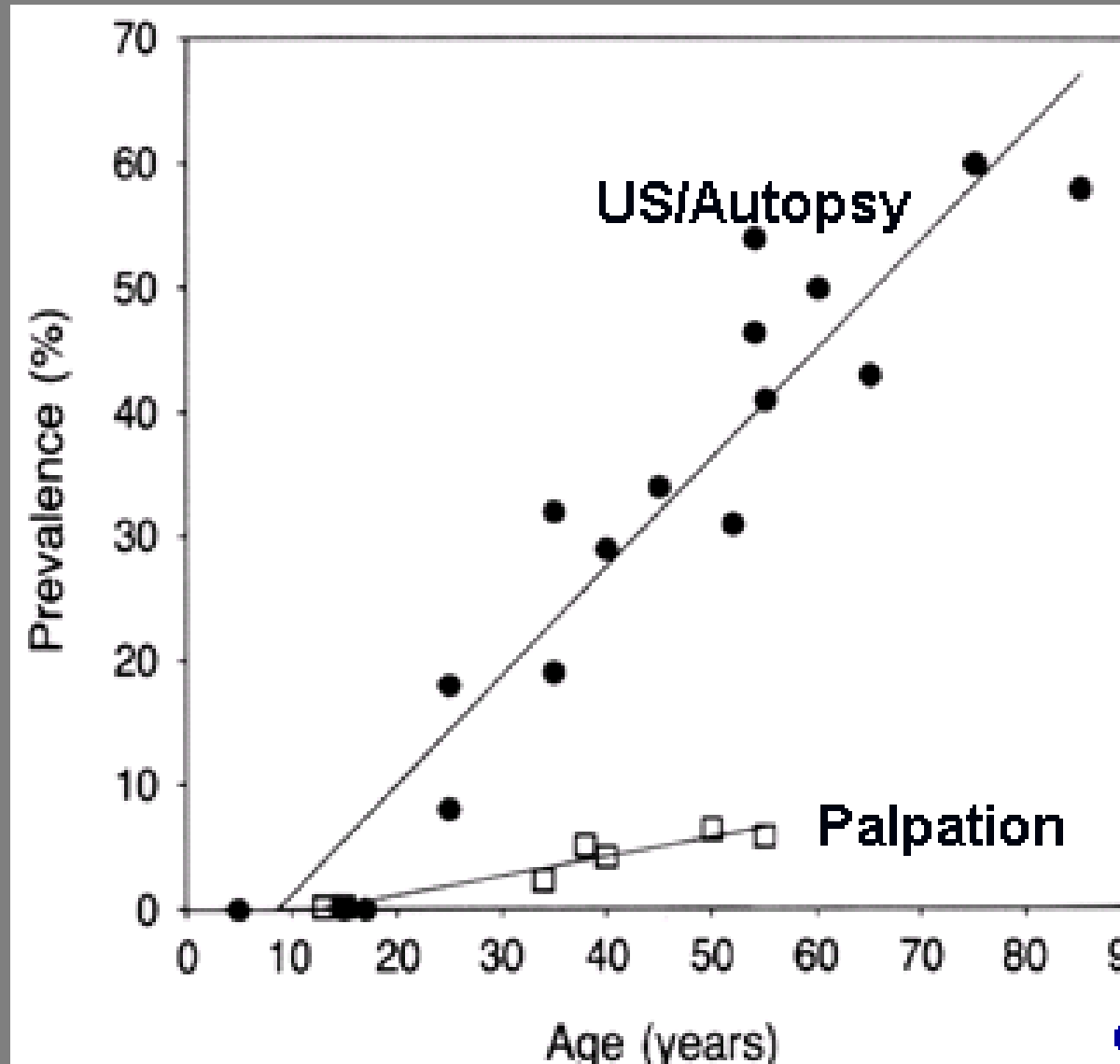


Thyroid Nodules

- Palpable thyroid nodule (TN) prevalence 5% in women, 1% in men
- US detected nodules in 19-67%
 - More in women and elderly
- 5-15% of TN cancerous
- 90% of cancers are differentiated (papillary and follicular)



Prevalence of TN





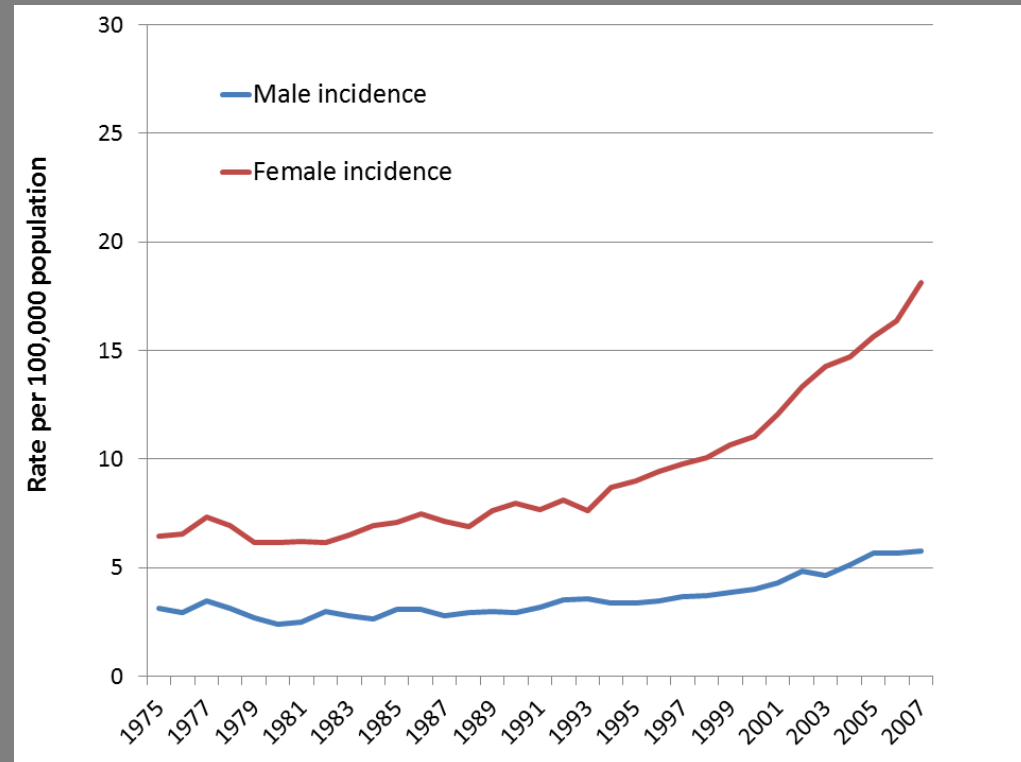
Thyroid Nodules Ddx

- Benign hyperplastic nodules ~70%
- Benign Adenoma ~10%
- Carcinoma ~5-10%
- Focal Thyroiditis ~1-5%
- Rare: intrathyroid parathyroid adenomas, metastases, true cysts...



Thyroid Cancer Incidence

-  Trend is continuing
- 62,980 new cases in 2014 estimated in US
- Increase almost entirely attributable to papillary thyroid cancer
- 50% of rising incidence is from lesions <1cm, 87% from lesions <2cm



NCCN Guidelines Version 2.2014
Thyroid Carcinoma – Nodule Evaluation**SONOGRAPHIC FEATURES****Threshold for FNA****Solid nodule**

- **With suspicious sonographic features^c** **≥ 1.0 cm**
- **Without suspicious sonographic features^d** **≥ 1.5 cm**

Mixed cystic-solid nodule

- **With suspicious sonographic features^c** **≥ 1.5-2.0 cm**
- **Without suspicious sonographic features^d** **≥ 2.0 cm**

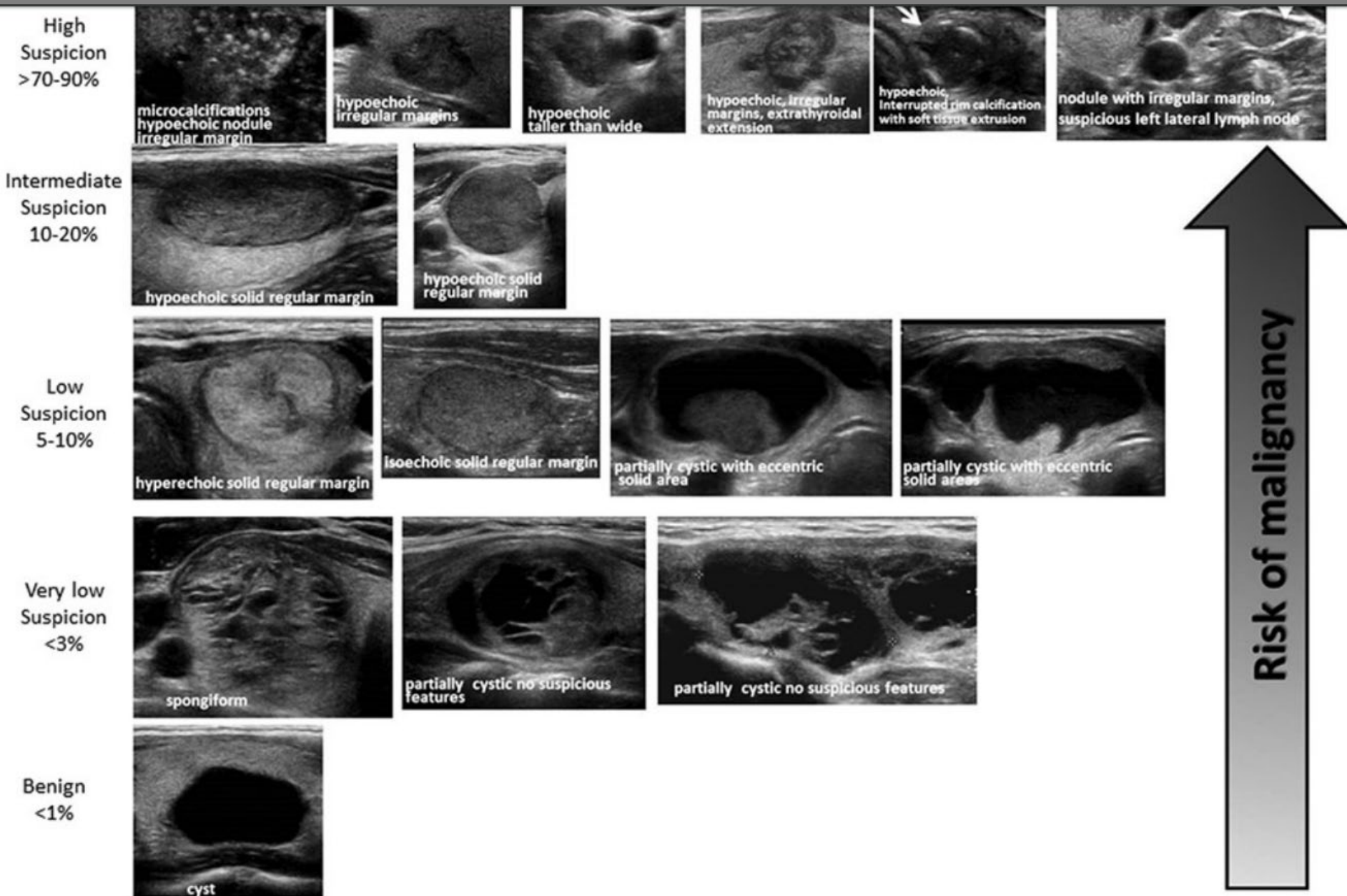
Spongiform nodule^e**≥ 2.0 cm****Simple cyst****Not indicated^g****Suspicious cervical lymph node^f****FNA node ± FNA associated thyroid nodule(s)**^cSuspicious sonographic features: Hypoechoic, microcalcifications, increased central vascularity, infiltrative margins, taller than wide in transverse plane.^dUltrasound features associated with low suspicion of malignancy include: isoechoic or hyperechoic solid nodules; mixed solid/cystic nodules without microcalcifications.

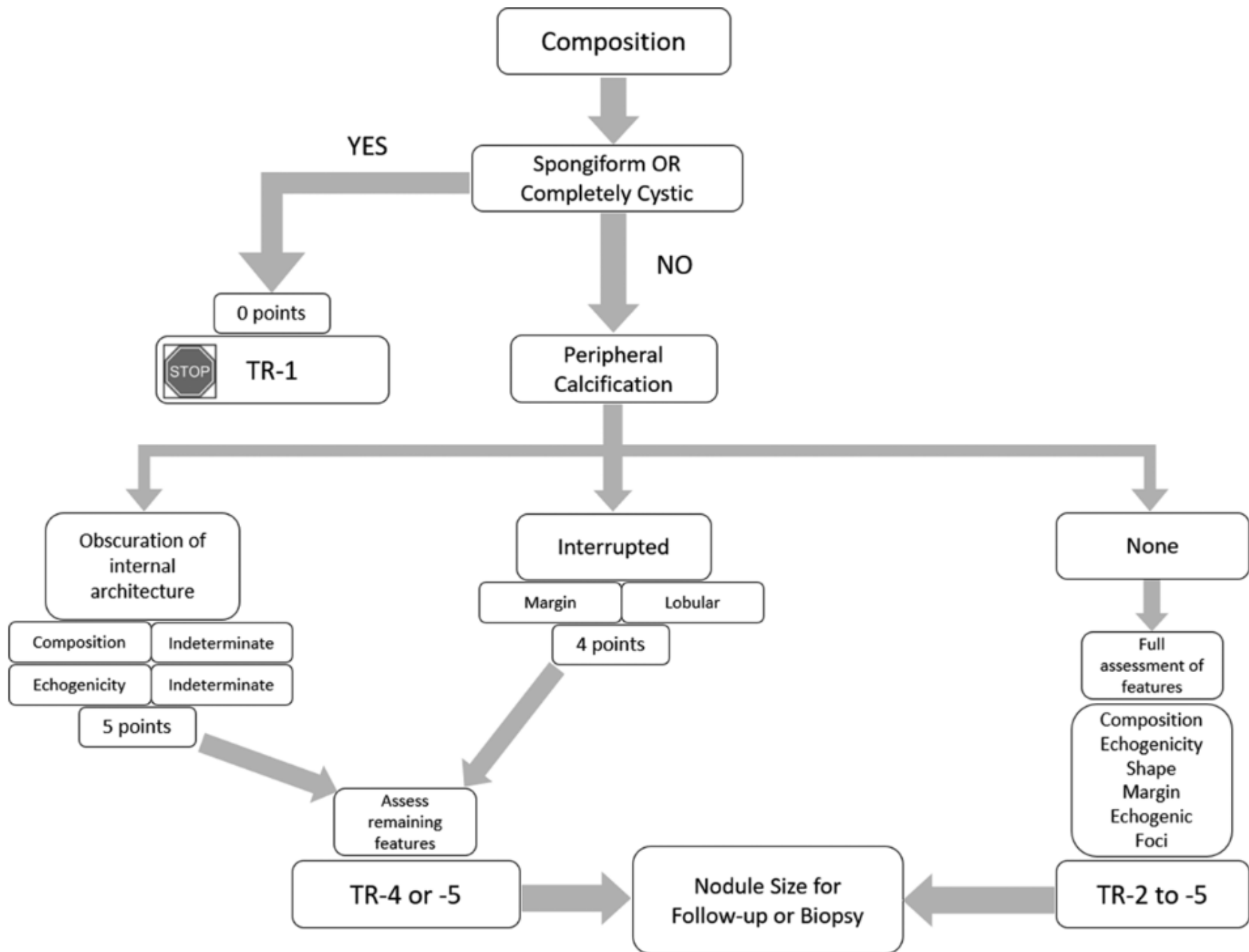
ACR TIRADS Classification

Nodule Characteristic	US Features with Point Values
Composition	Cystic = 0, spongiform = 0, mixed solid-cystic = 1, solid = 2, indeterminate = 2
Echogenicity	Anechoic = 0, isoechoic = 1, hyperechoic = 1, indeterminate = 1, hypoechoic = 2, very hypoechoic = 3
Shape	Wider than tall = 0, taller than wide = 3
Margin	Smooth = 0, ill defined = 0, irregular = 2, lobulated = 2, extrathyroidal extension = 3
Echogenic foci	None = 0, comet-tail artifact = 0, macrocalcifications = 1, peripheral or rim = 2, punctate = 3

Note.—Points are totaled by adding single selections from the composition, echogenicity, shape, and margin categories to selections from the echogenic foci category, which allows multiple selections.

- TR1 0, (<2% risk)- benign, no FNA
- TR2 2, (2%)- not suspicious, no FNA
- TR3 3, (2.1-5%)- mildly suspicious, FNA if ≥ 2.5 cm, fu ≥ 1.5 cm at 1, 3, 5 y
- TR4 4-6, (5.1-20%)- moderately suspicious, FNA if ≥ 1.5 cm, fu ≥ 1 cm at 1, 2, 3, 5 y
- TR5 >6, (>20%)- highly suspicious, FNA if ≥ 1 cm, fu ≥ 0.5 cm yearly until 5 y





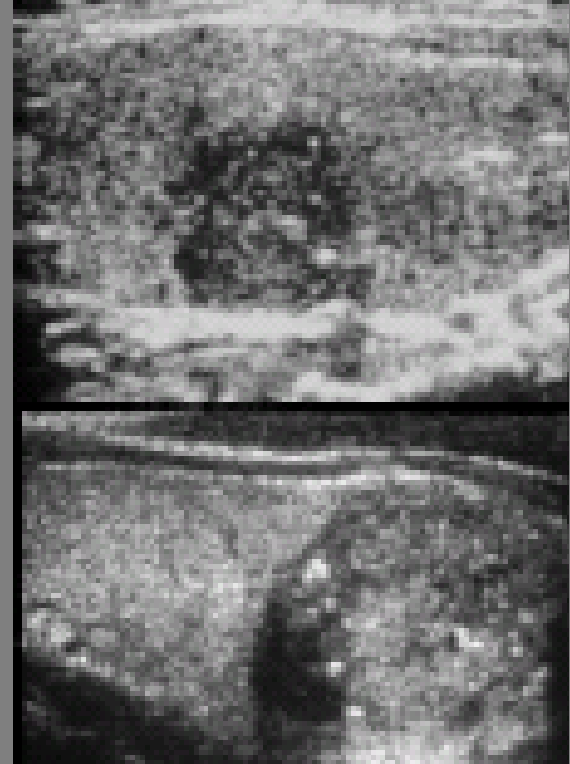


Clinical Features Suggesting Malignancy

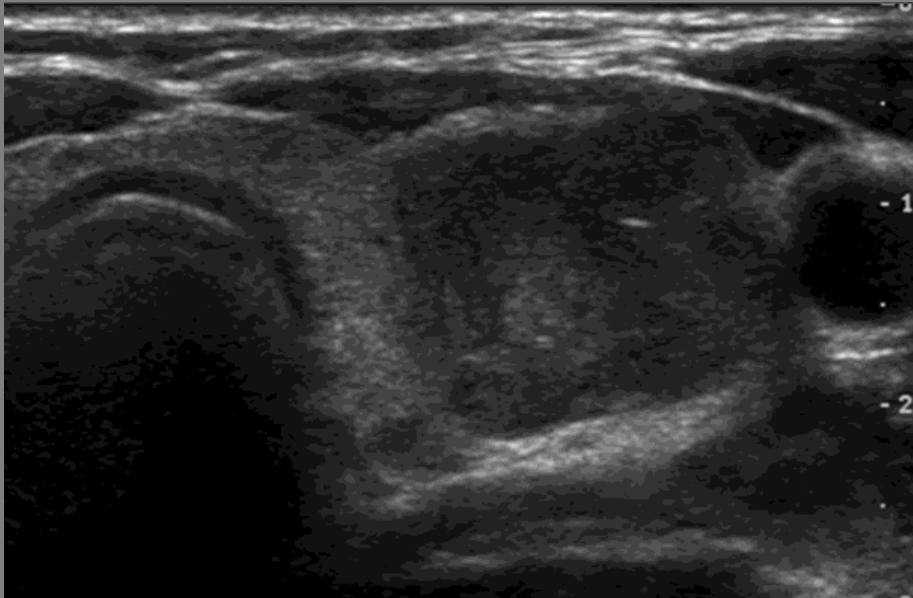
- History of childhood or adolescent head and neck or total body irradiation
- Family history of thyroid carcinoma
- Thyroid cancer syndrome (e.g., Cowden's syndrome, familial polyposis, Carney complex, multiple endocrine neoplasia [MEN] 2, Werner syndrome) in a first-degree relative
- Vocal cord paralysis
- Cervical adenopathy
- Fixed nodule

Microcalcifications

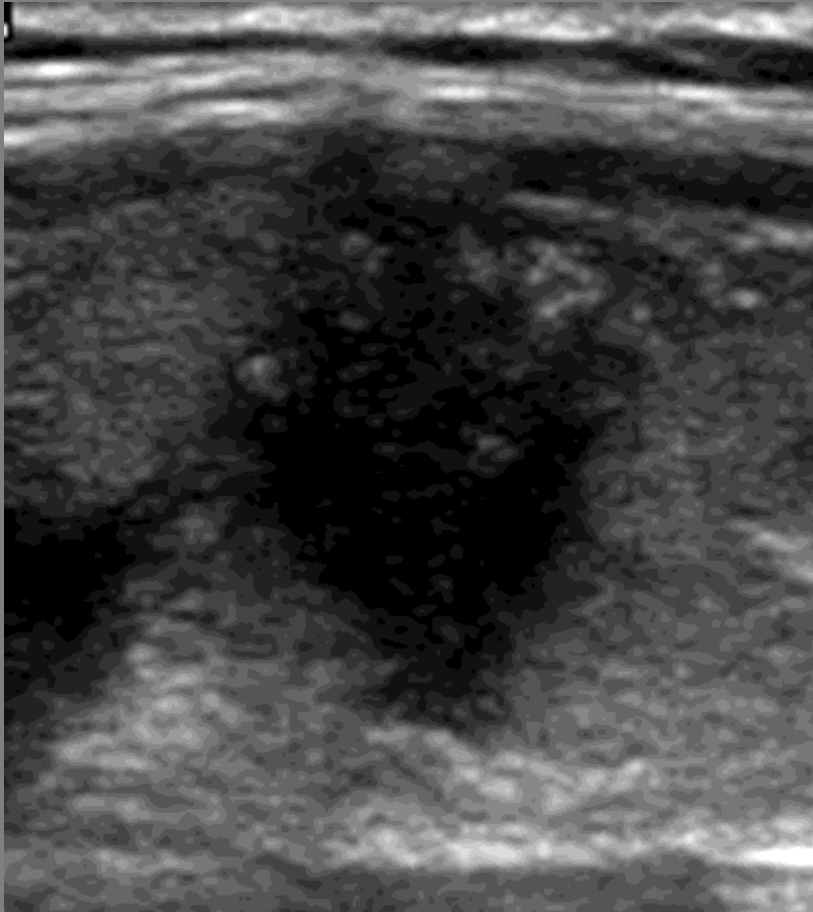
- Multiple punctate ($<1\text{mm}$) bright echoes without shadowing
- Most specific sign of papillary thyroid Ca.
- Not seen in Follicular Ca



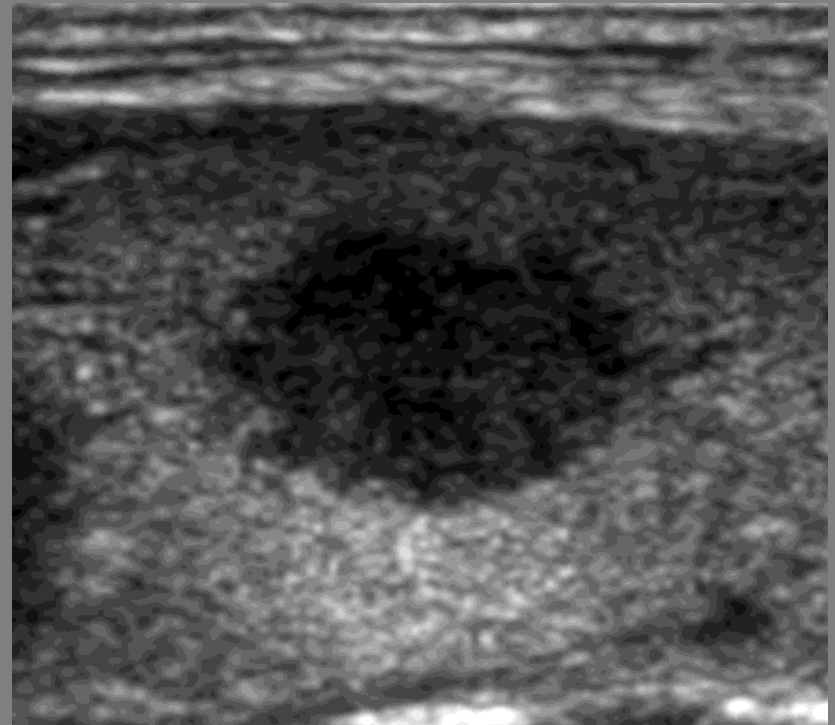
Microcalcifications



Malignant Nodules



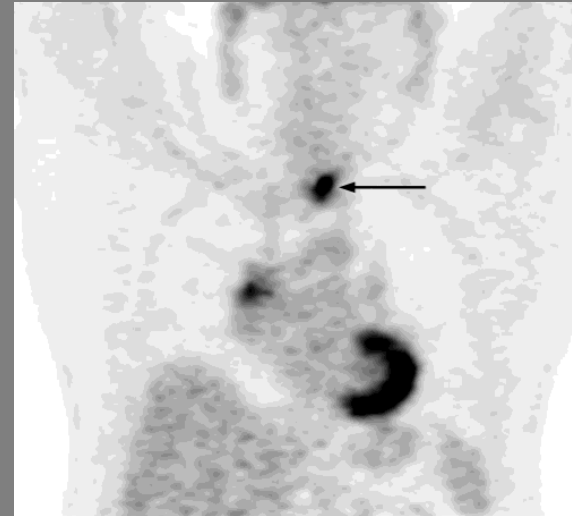
Taller than wide



Irregular margins

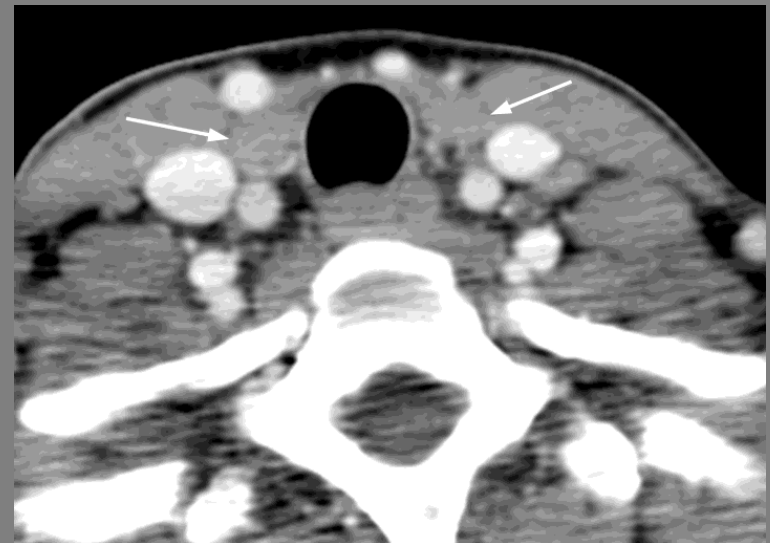
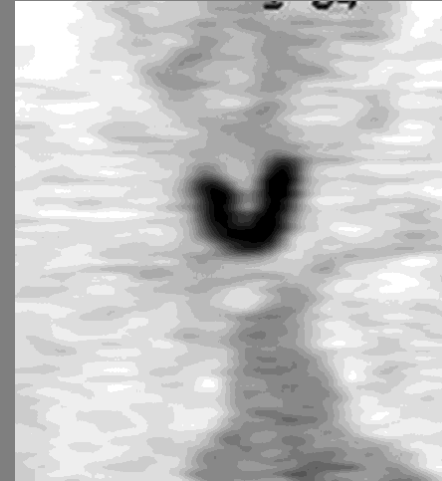
PET Incidentoloma

- 1–2% of people undergoing ^{18}F FDG-PET have FDG avid TN
- Risk of malignancy 33%



PET Diffuse Uptake

- Diffuse ^{18}F FDG uptake is likely related to underlying autoimmune thyroiditis



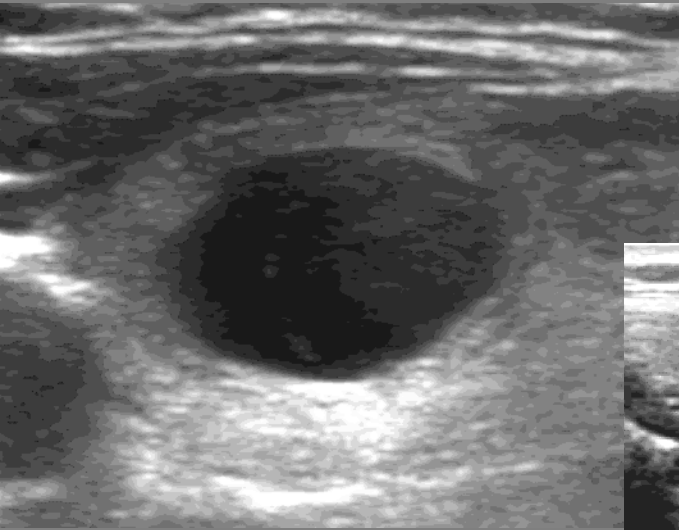


US Features that Predict Benign Nodule

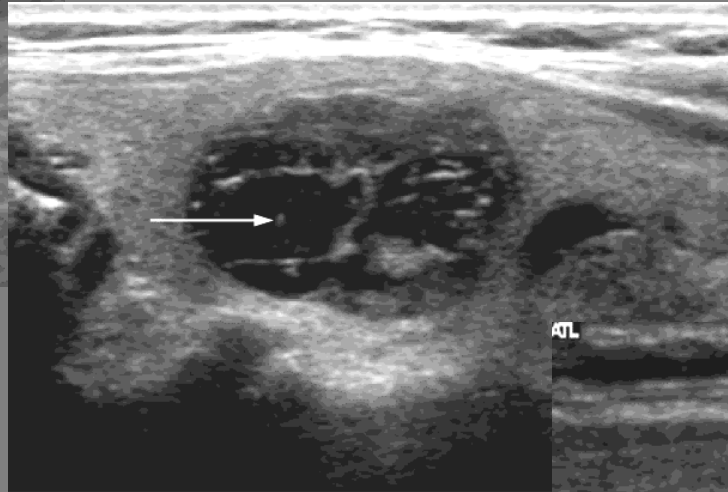
- Completely cystic nodule
- Spongiform nodules smaller than 2 cm



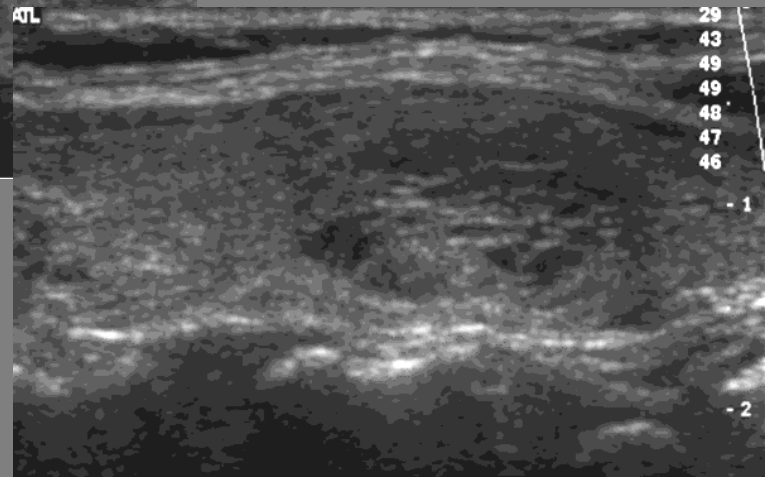
Benign Nodules



Cystic



Septated



Spongiform



Multinodular Goiter (MNG)

- Similar risk of malignancy (per patient) with solitary nodules
- When multiple nodules >1cm present FNA nodules with suspicious US features
- If none of nodules show suspicious features FNAC the largest lesion only and follow others with US
- If TSH is low perform scintigraphy and consider FNA for hypofunctioning nodules

Reporting of FNAC Results per NCI Thyroid FNA State of the Science Conference: The Bethesda System



Result	Risk of Malignancy%	Risk of Malignancy % with NIFT-P	Action
I. Nondiagnostic	1-4	1-4	Repeat FNAC
II. Benign	<1	<1	Follow up US
III. Atypia/follicular lesion of undetermined significance AUS/FLUS	10-30	6-18	Repeat FNAC
IV. Follicular neoplasm/suspicious for follicular neoplasm FN/SFN	25-40	10-40	Lobectomy
V. Suspicious for malignancy	50-75	45-60	Near total thyroidectomy
VI. Malignant	97-99	94-96	Near total thyroidectomy

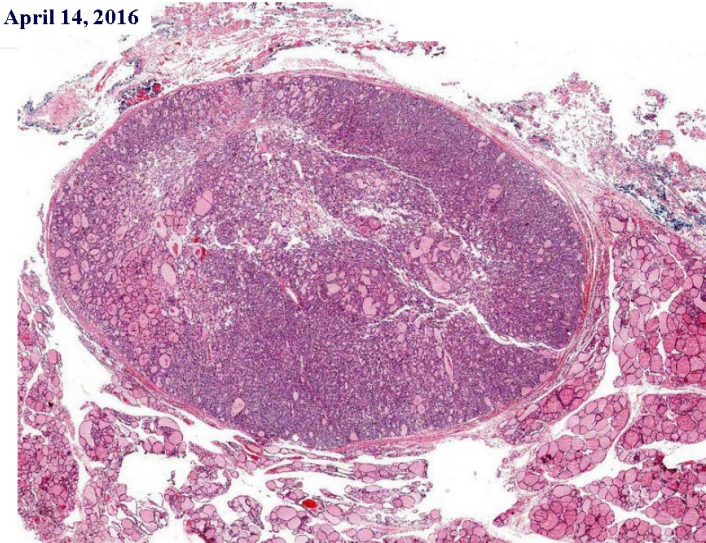


Noninvasive follicular tumor

HEALTH The New York Times

It's Not Cancer: Doctors Reclassify a Thyroid Tumor

By Gina Kolata April 14, 2016



Nikiforov et al.

JAMA Oncol. 2016;2(8):1023-1029.

**Nomenclature Revision for Encapsulated Follicular Variant
of Papillary Thyroid Carcinoma**

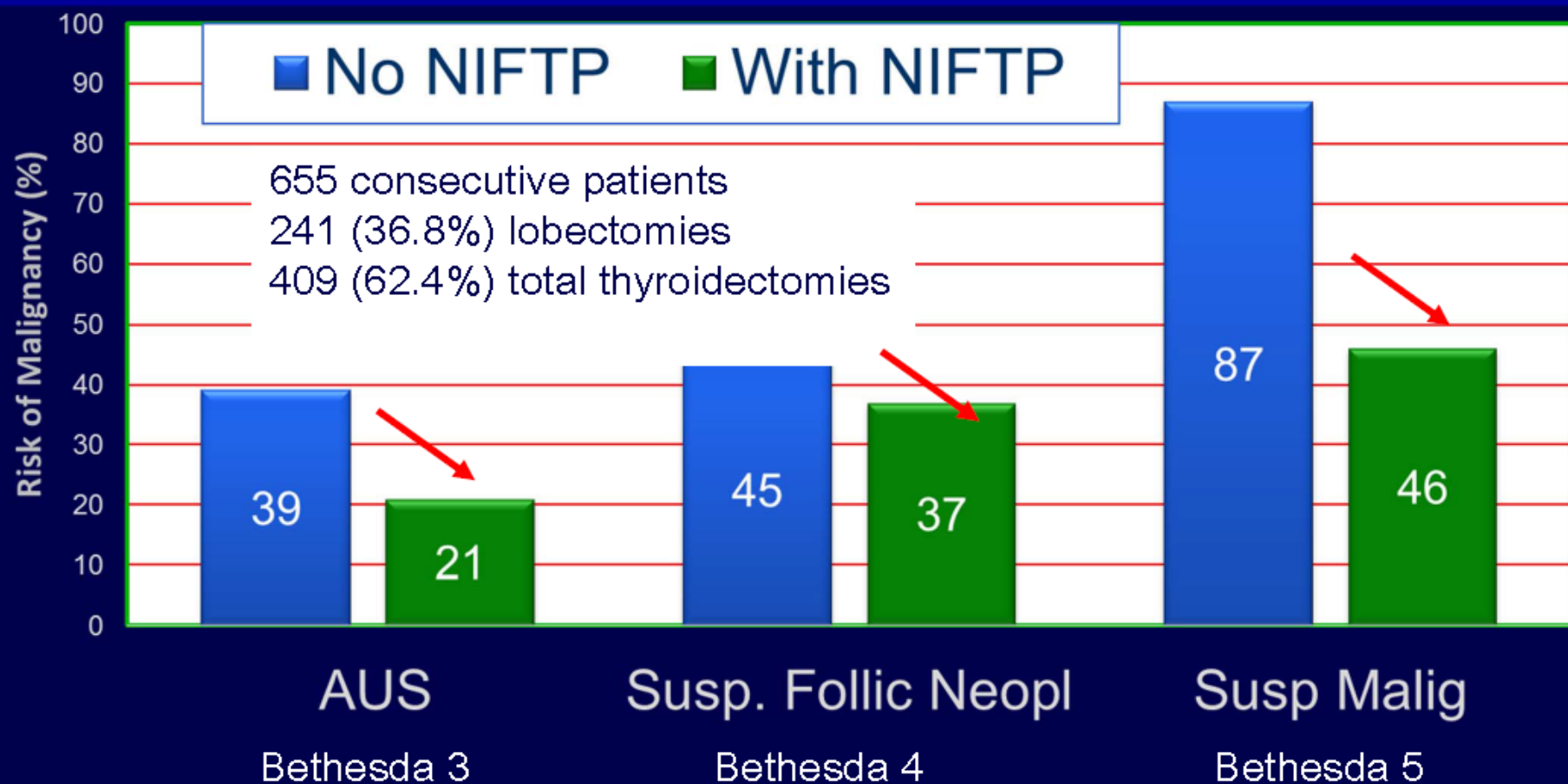
A Paradigm Shift to Reduce Overtreatment of Indolent Tumors

What is noninvasive follicular
thyroid neoplasm with papillary-like
nuclear features (NIFTP) and what
are the diagnostic implications?



Change in Risk of Malignancy with NIFTP as a Diagnosis

Strickland et al. Thyroid 2015





Nodule Growth

- Benign nodules may and often do grow
- One study found no difference in the rate of growth in benign and malignant nodules
- Lesion growth is indication for repeat biopsy
 - 20% diameter growth, 2 mm in 2 planes, or 50% increased volume



Histologic Types of TC

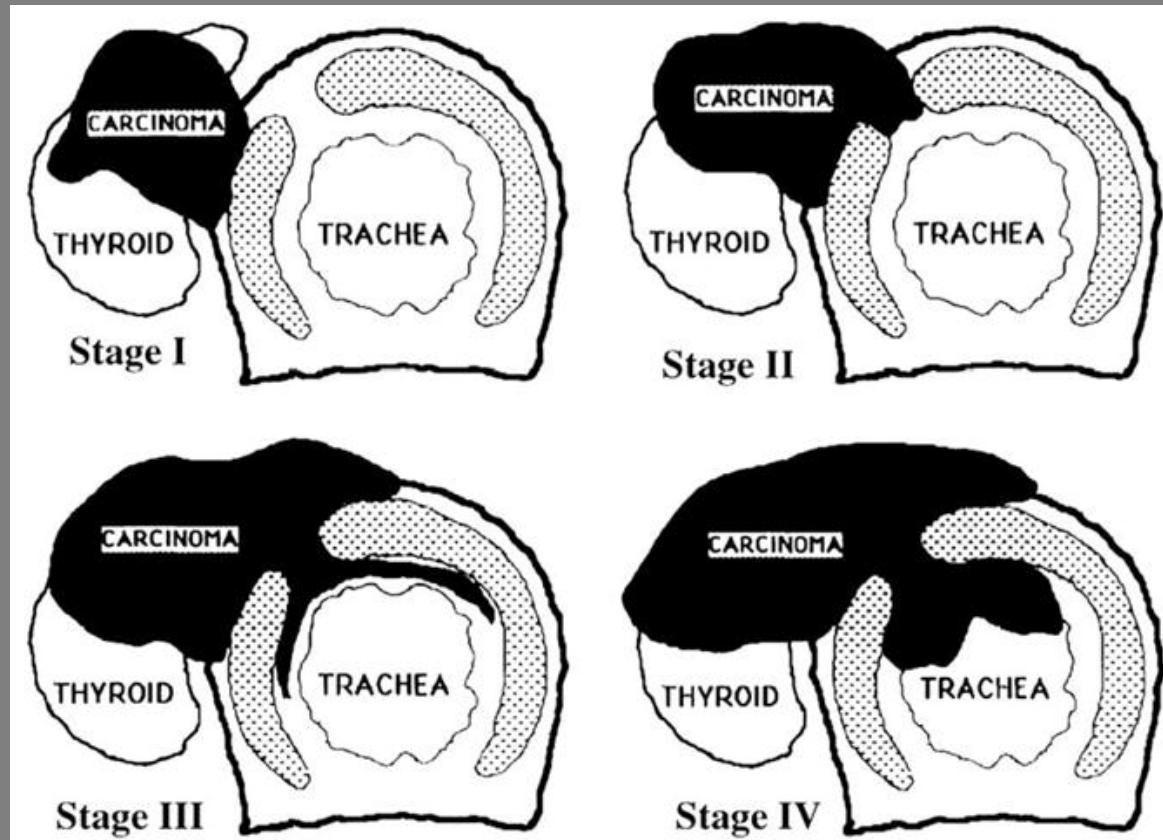
Type	Relative frequency	10-year Survival
Papillary	~80%	93%
Follicular	~10%	85%
Hurtle cell	~3%	76%
Medullary	~5%	75%
Anaplastic	>5%	14%
Lymphoma, metastasis, insular TC, squamous cell Ca		



Staging Thyroid Cancer

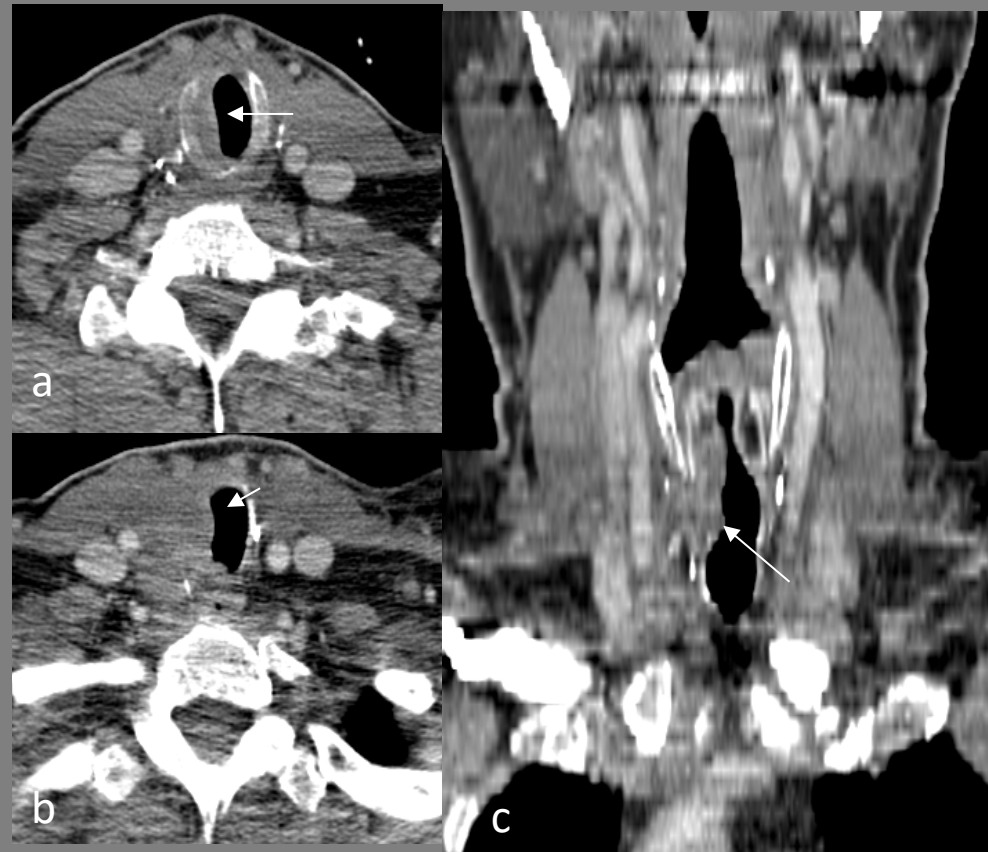
- Different staging schemes available
- Age, sex, histologic types taken into account
- Anaplastic variety is always stage IV, regardless of other features
- Factors affecting morbidity and survival: extrathyroid extension of tumor with involvement of esophagus and/or trachea, recurrent laryngeal nerve
- Prevertebral fascia involvement and carotid or other mediastinal major vessel involvement renders tumor unresectable

Shin Staging System for Tracheal Invasion by TC



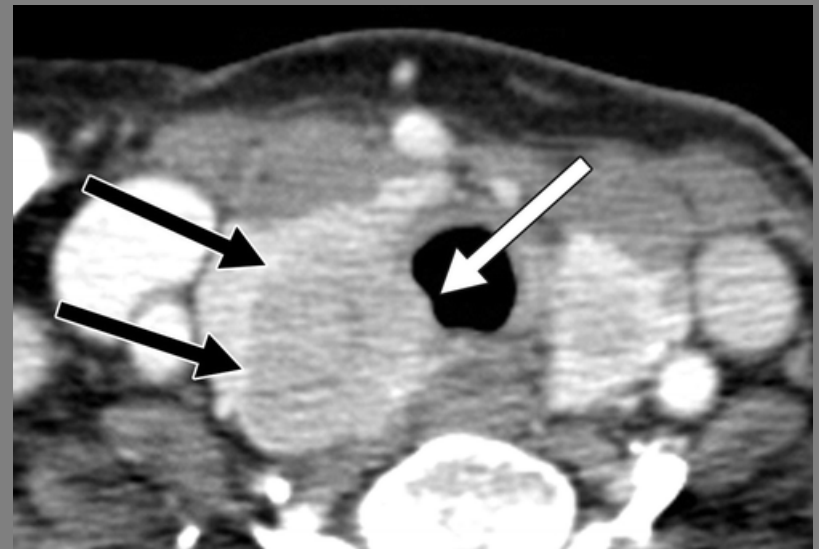
TC Extrathyroid Extension: Tracheal Involvement

- Requires resection and repair
- Up to 4 tracheal rings can be removed
- Intraluminal extension of tumor and $>180^\circ$ circumferential involvement have high PPV for tracheal involvement
- ~80% accuracy



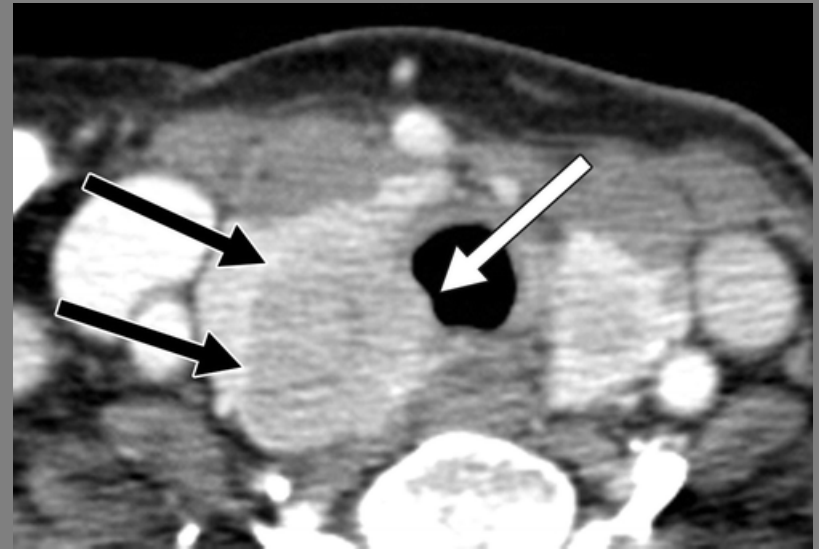
TC Extrathyroid Extension: Esophageal Involvement

- Requires resection and repair
- Encasement $> 270^{\circ}$
- Focal T2 hyperintensity in wall
- ~80% Accuracy

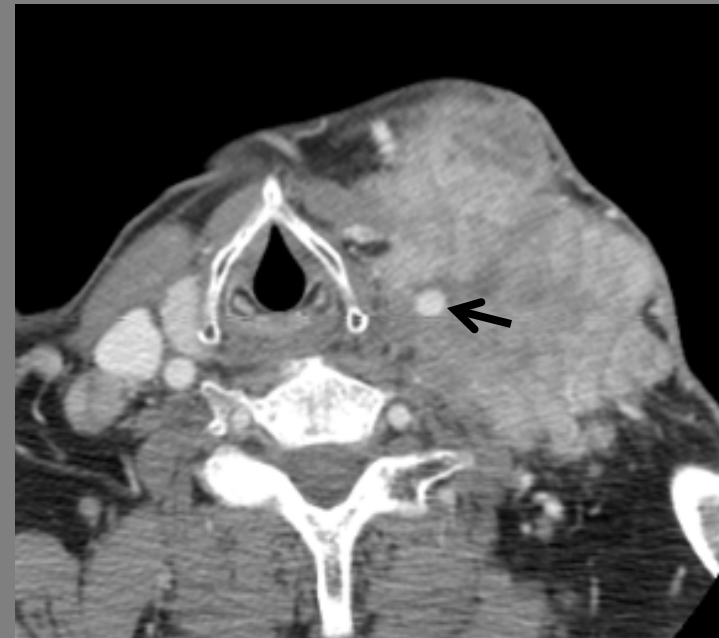
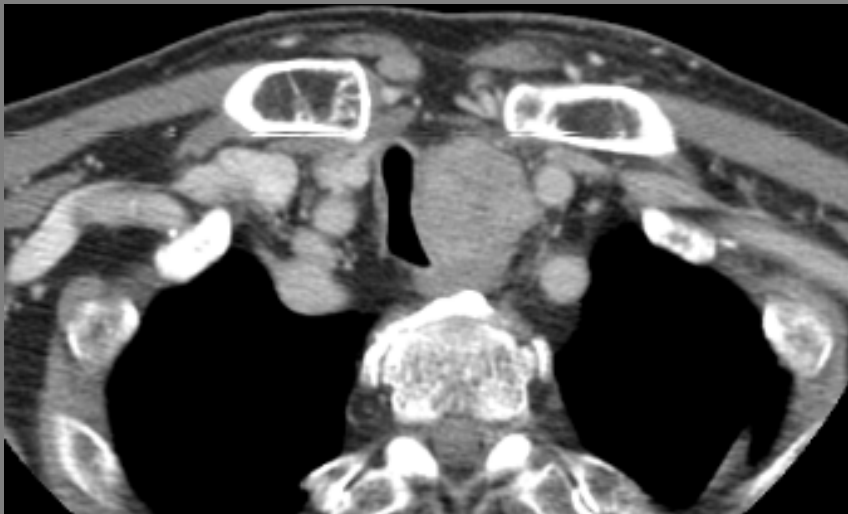
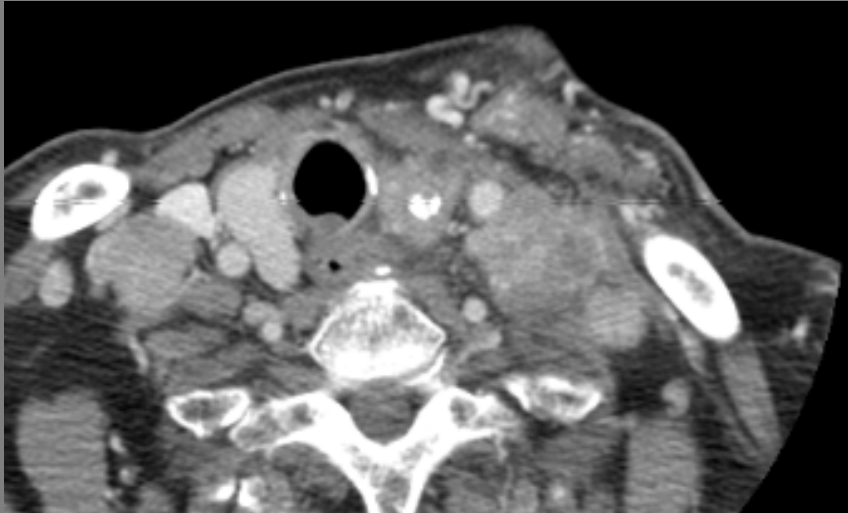


TC Extrathyroid Extension: RLN Involvement

- Vocal cord paralysis
- Effacement of tracheoesophageal groove
- ~80% accuracy

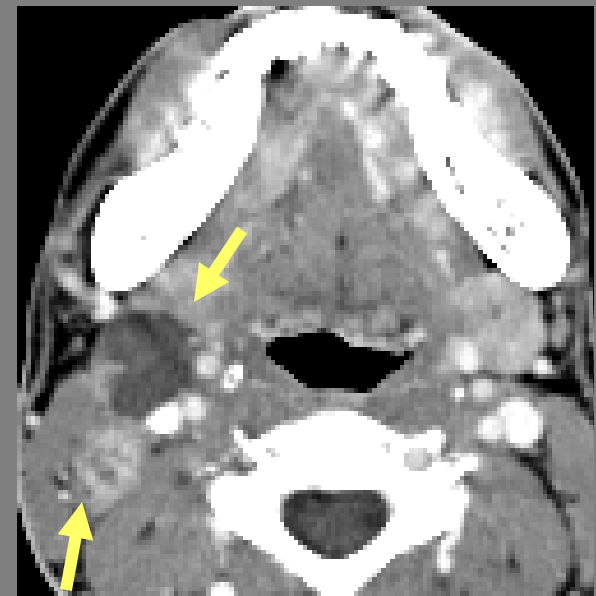


TC Extrathyroid Extension: Carotid Encasement

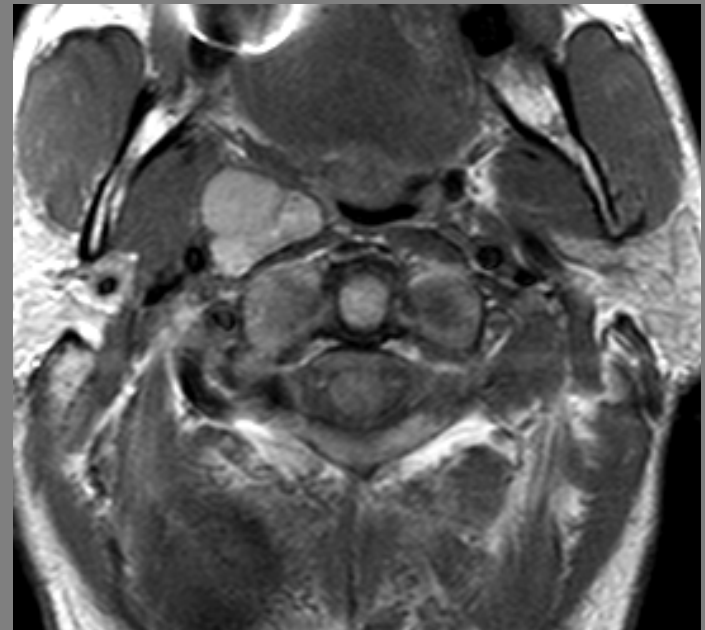
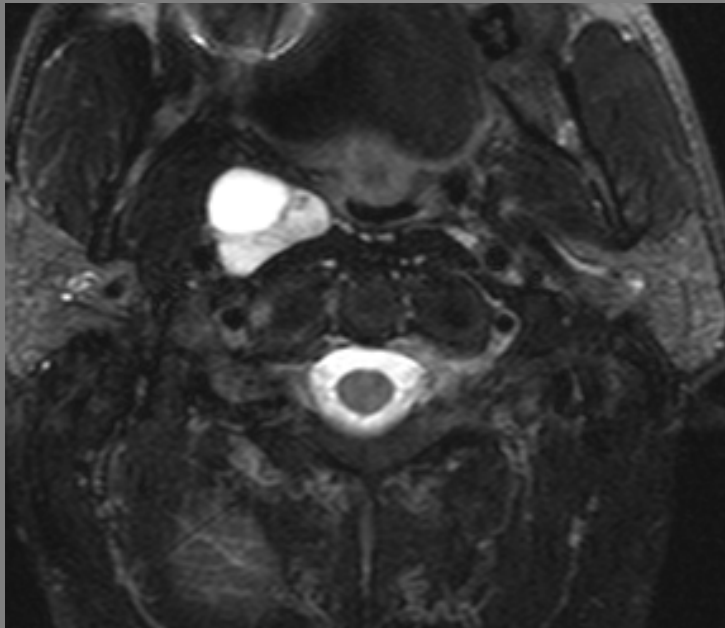


Thyroid Cancer: Nodal Metastasis

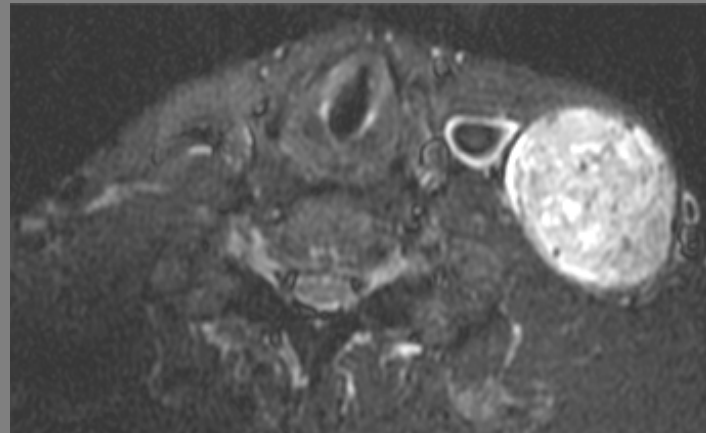
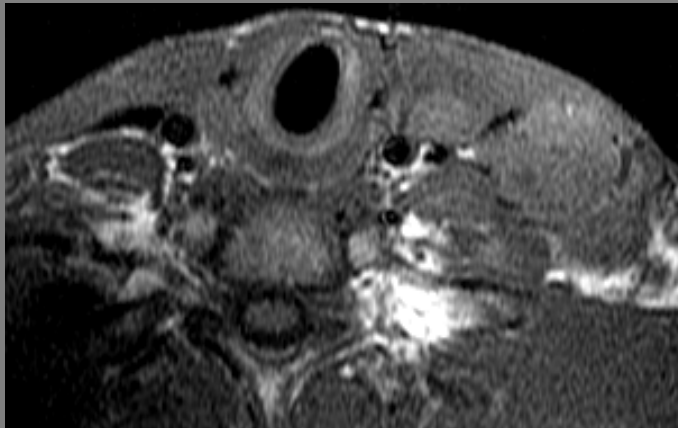
- Calcification
- Intranodal hemorrhage
- Cystic nodes
- Increased vascularity
- Small nodes in central neck compartment



Retropharyngeal Adenopathy



Hypervascular Nodal Metastasis





Hyperparathyroidism

- Primary hyperparathyroidism
 - Adenoma, hyperplasia, carcinoma
 - Ca^{++} , P 
- Secondary hyperparathyroidism
 - Kidney failure, calcium, vit. D deficiency
 - Ca^{++} , P 



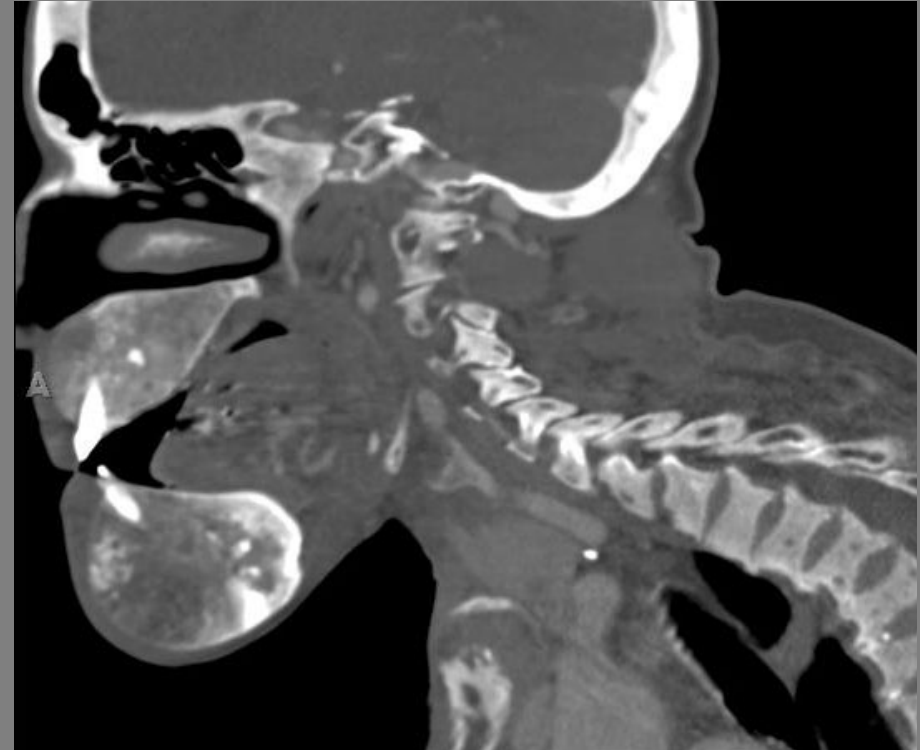
Primary HyperPTH Etiology

	Frequency	Sensitivity	
1X adenoma	88.90%	88.44%	Tc-MIBI
		78.55%	US
2X adenoma	4.14%	29.95%	Tc-MIBI
		16.20%	US
Hyperplasia	5.74%	44.46%	Tc-MIBI
		34.86%	US
Carcinoma	0.74%		Tc-MIBI
			US

Ruda JM, Hollenbeak CS, Stack BC Jr. A systematic review of the diagnosis and treatment of primary hyperparathyroidism from 1995 to 2003. Otolaryngol Head Neck Surg 2005;132(3):359–372

Symptoms

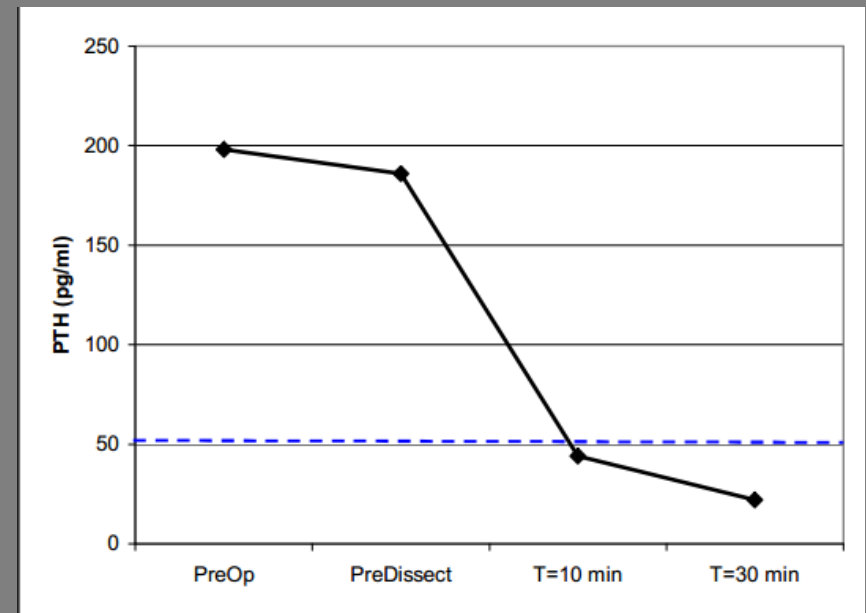
- Bone and joint pain
- Osteoporosis
- Kidney stones
- Excessive urination
- Abdominal pain
- Tiring easily, weakness
- Depression, forgetfulness
- Frequent complaints of illness with no apparent cause
- Nausea, vomiting or loss of appetite



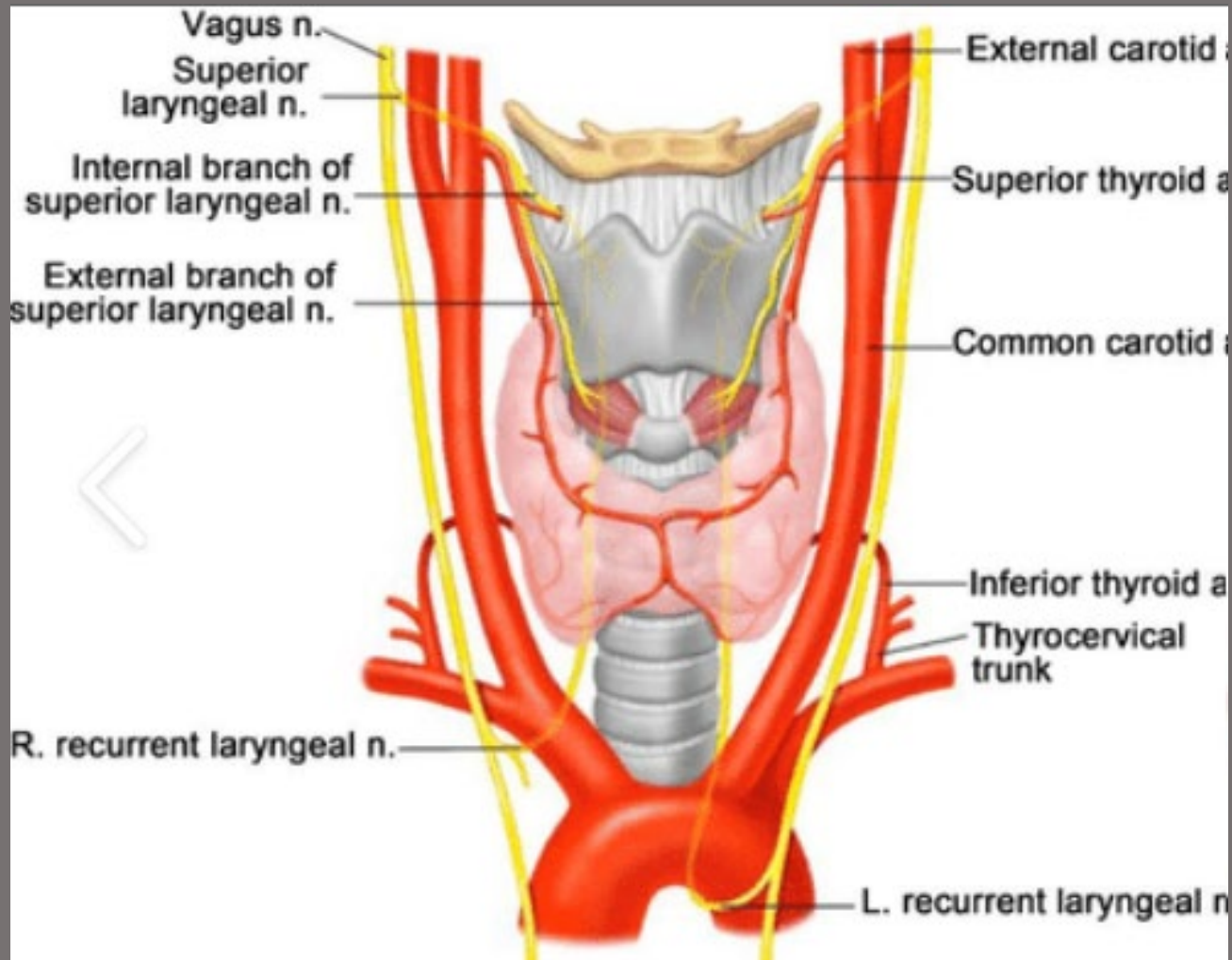


Parathyroid Lesions

- Transition from bilateral neck extrapolation to minimally invasive surgery
- Intraoperative PTH assay for treatment response
 - PTH half-life=3.5 min.
 - >50% drop of PTH within 10 mins of removal
 - 8 min assay with 3-4 measurements

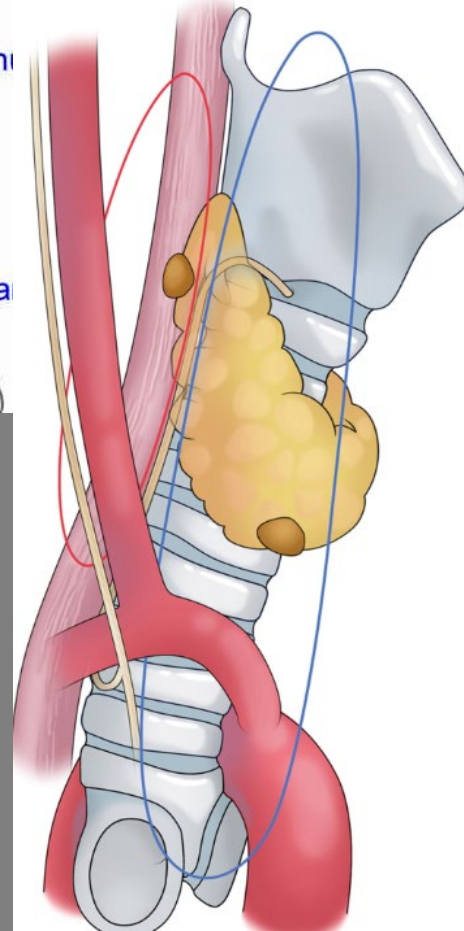
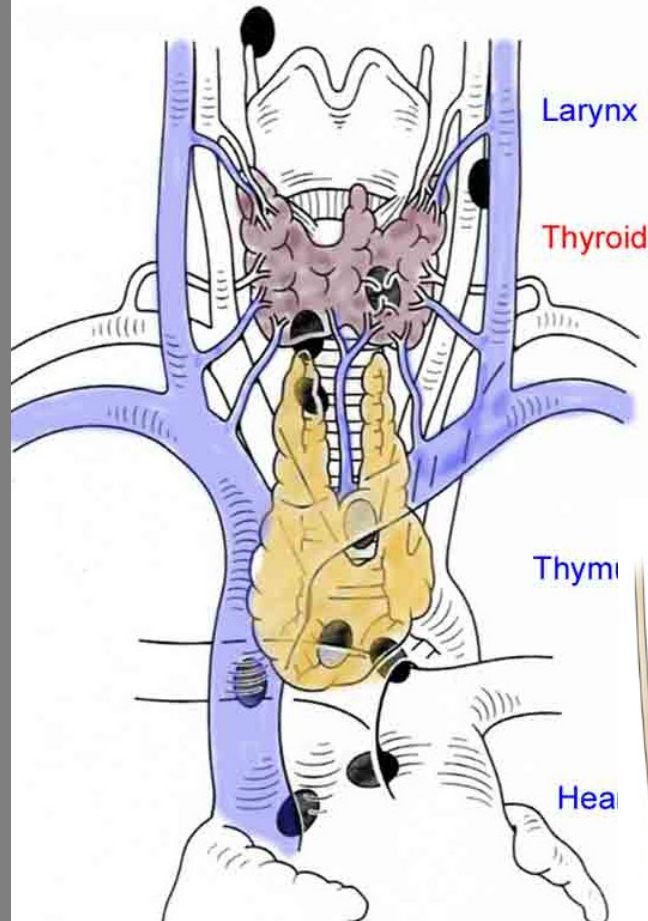
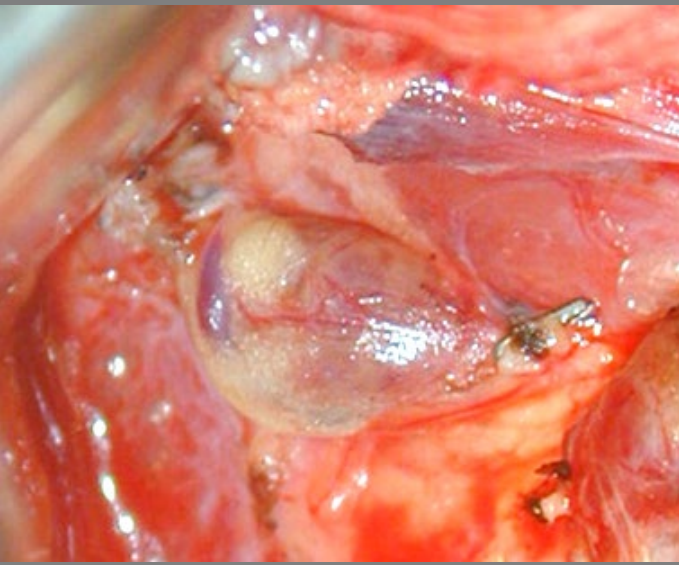


Recurrent Laryngeal Nerve



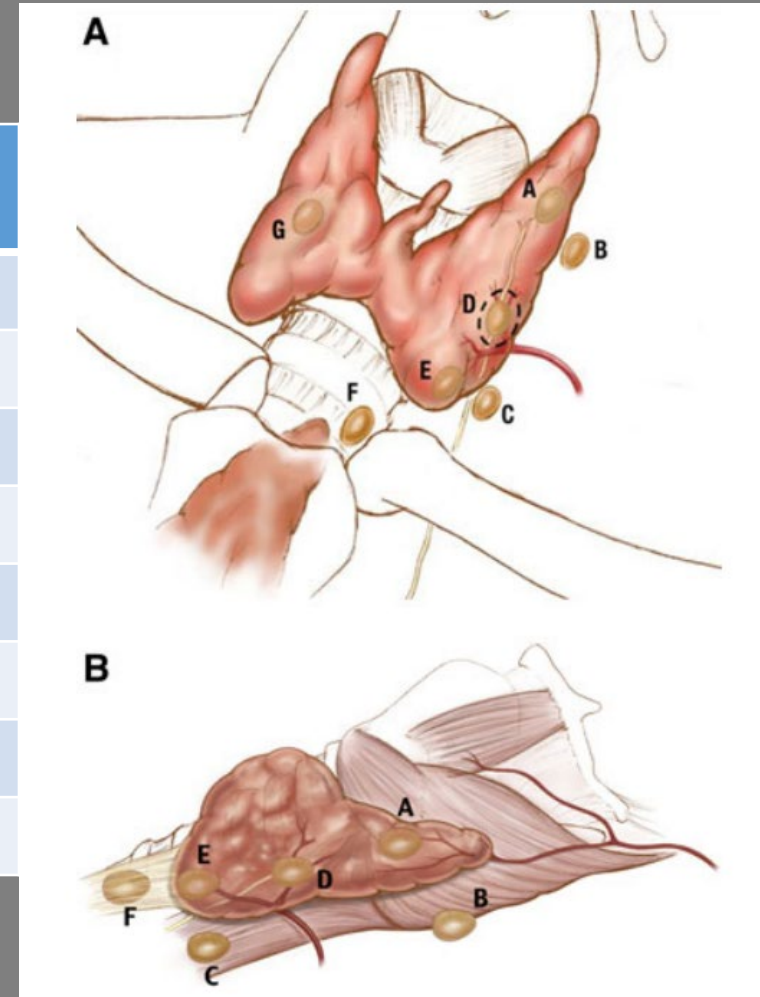
Anatomy

- Variable size, number, location
- Supplied by superior and inferior thyroidal artery
- 30-40 mg, 3-8 mm per gland
- Oval, flat, discoid shaped
- Yellow to reddish colored



Relative Distribution of PTH Adenomas

Gland location No. patients (N=271)		
A -adherent to thyroid capsule	34	12.5%
B -TE groove	47	17.3%
C -TE groove	37	13.7%
D -On the RLN	33	12.2%
E -inf. thyroid pole	70	25.8%
F -thymus	20	7.4%
G -intrathyroid	1	0.4%
Multigland	29	10.7%



Ectopic Locations

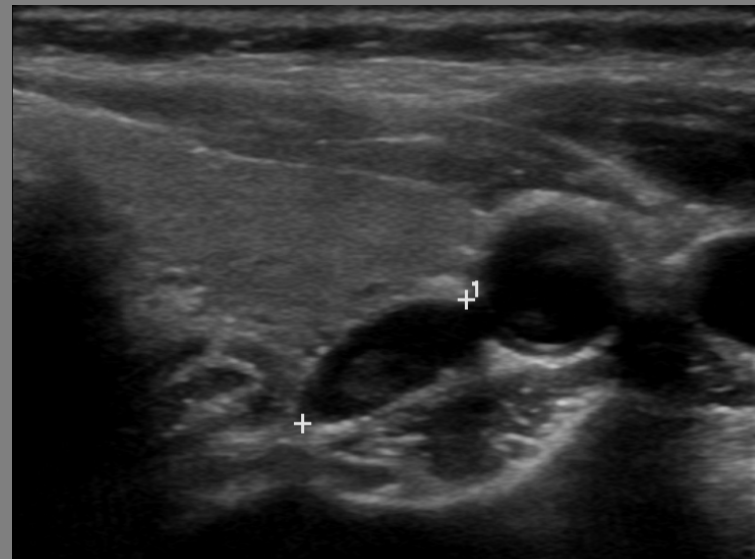
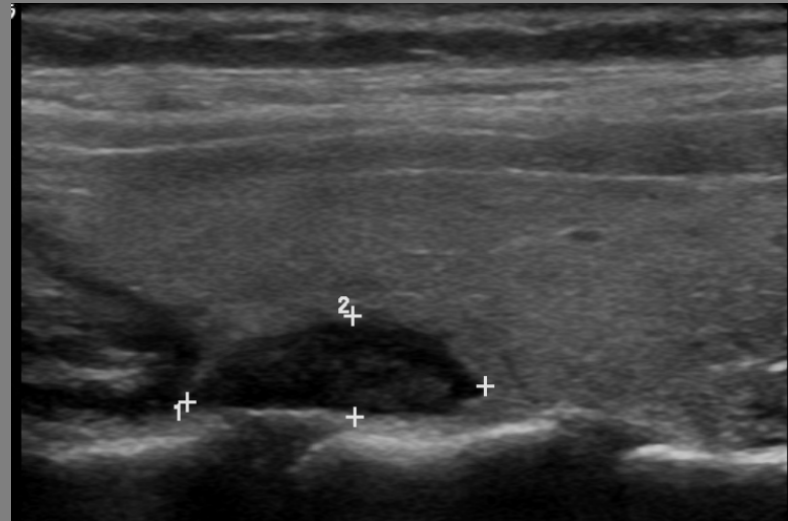
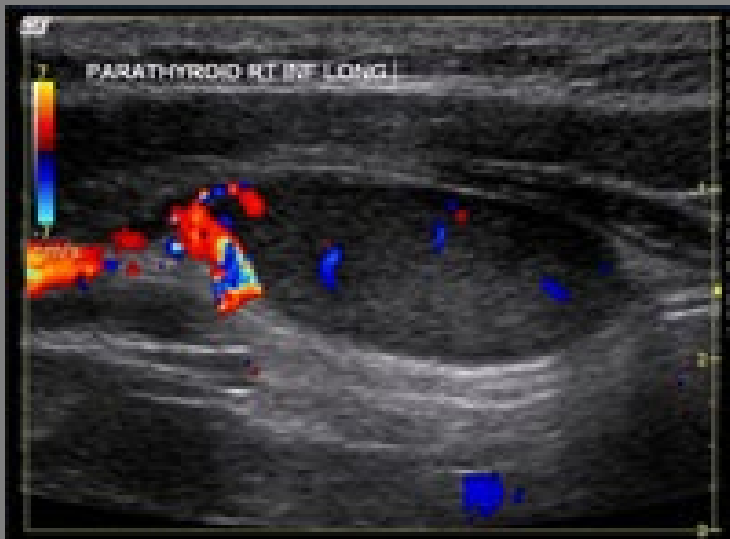




Imaging

- Ultrasound
- Tc-Sestamibi
- CT
- MRI

PT Adenoma: US

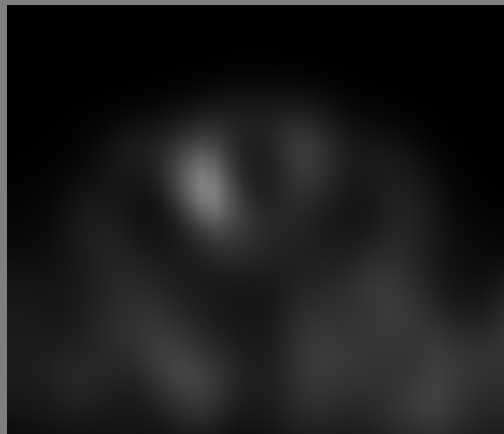




Tc-Sestamibi



Planar

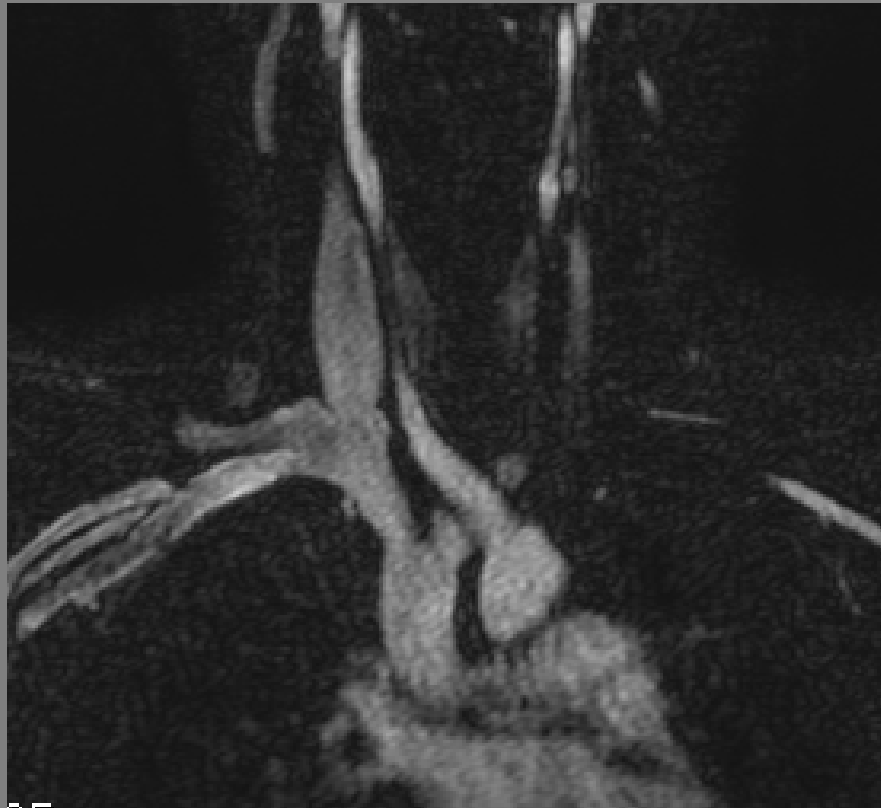


SPECT

Delayed

Early

PT Adenoma: MRI

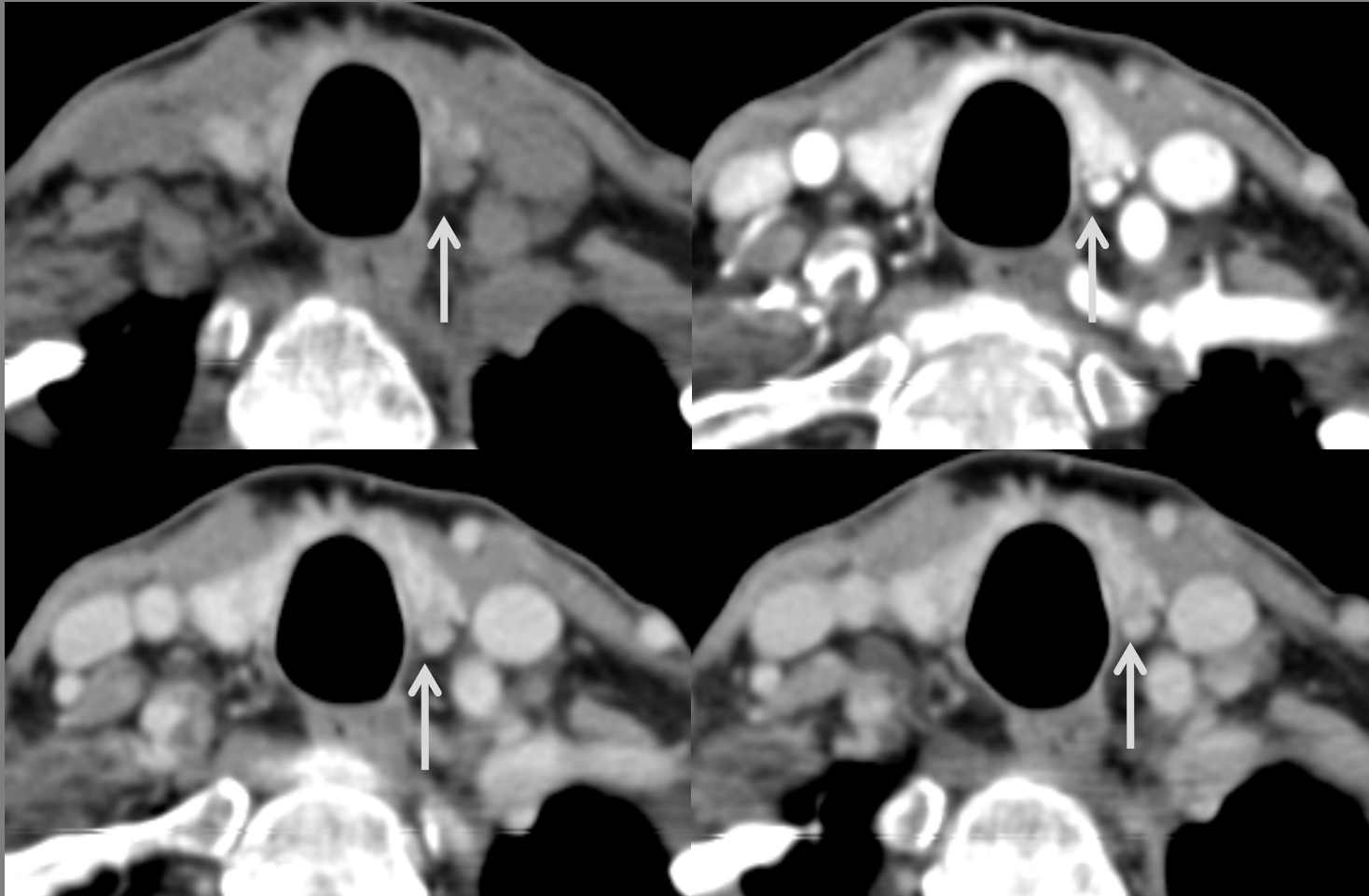




4-Phase CT Technique

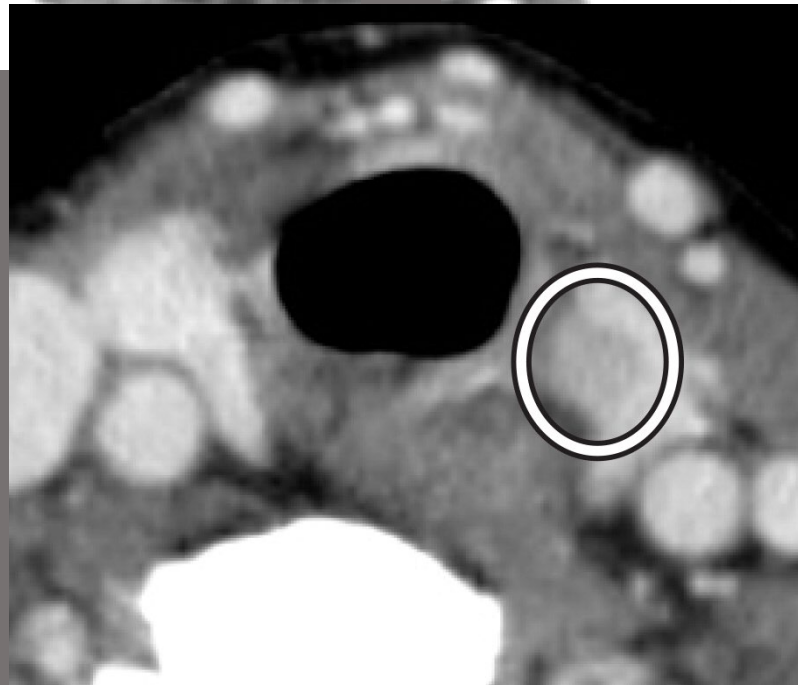
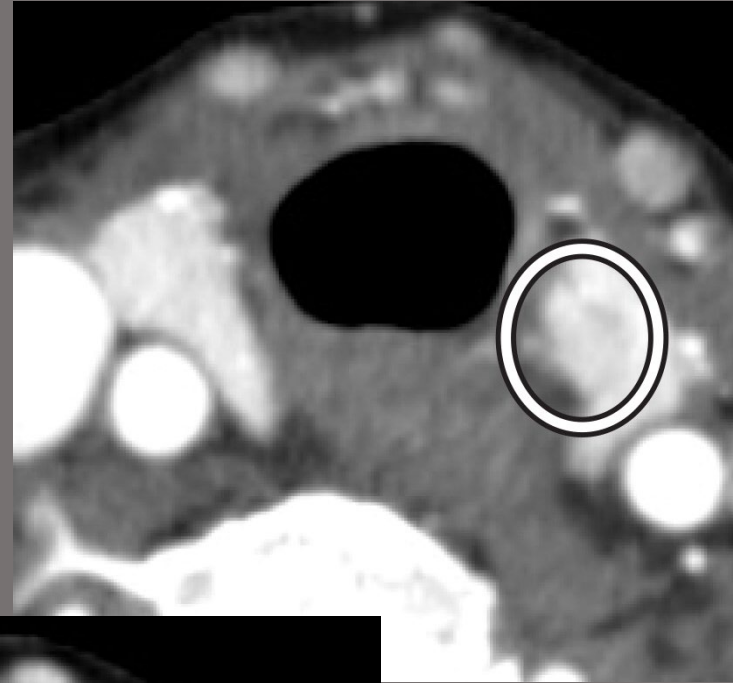
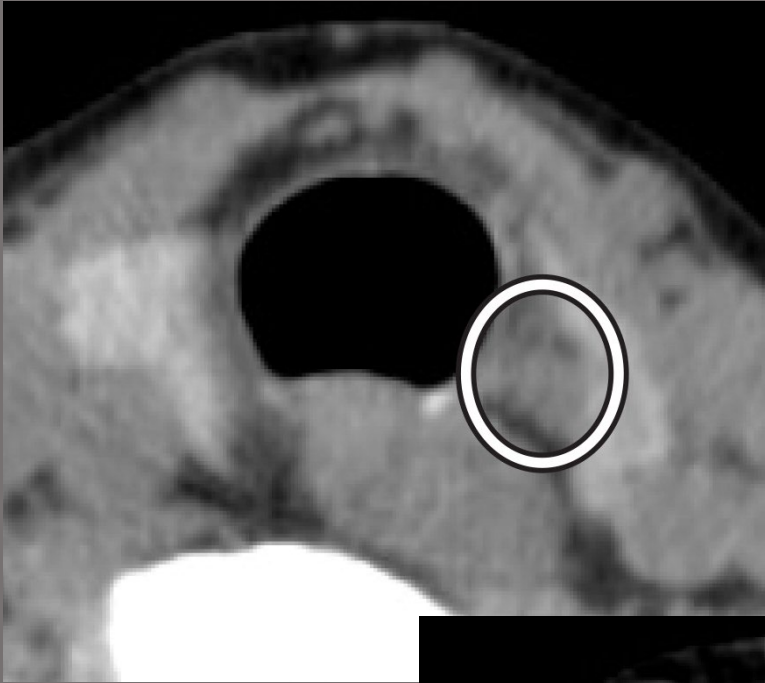
- Non-contrast neck to include the thyroid
- Inject 100 ml contrast @ 3-4 ml/sec
- Scan from the hyoid to carina
- Arterial phase; 25 sec from the start of injection
- Venous phase; 68 sec.
- Delayed Venous phase; 111 sec after the end of the arterial phase
- kVp 120, mAs: automatic, pitch: 0.75
- Cranio-caudal acquisition

PT Adenoma: 4-Phase CT

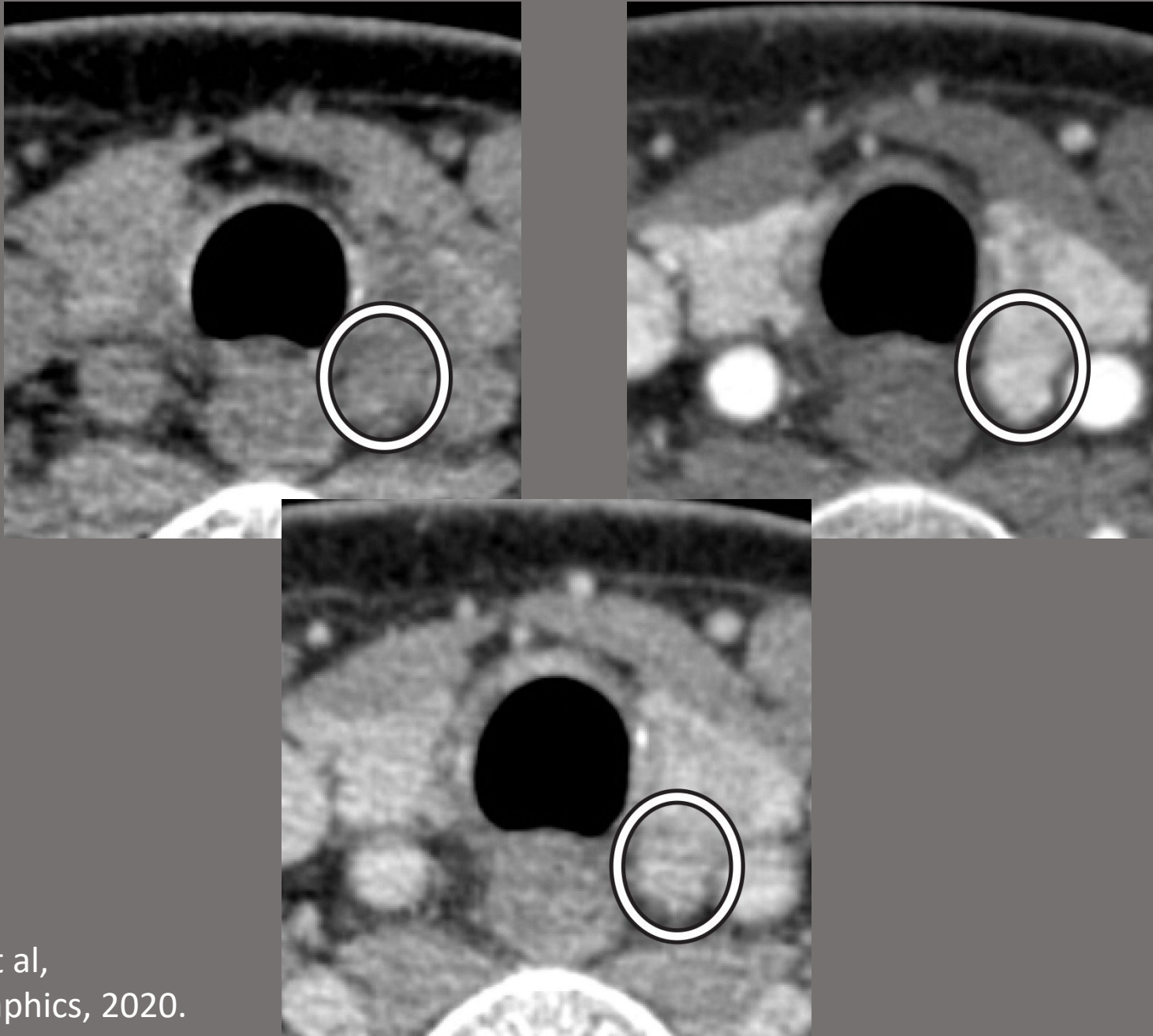


Rodgers SE, et al. Improved preoperative planning for directed parathyroidectomy with 4-dimensional computed tomography. *Surgery* 2006;140(6):932–940; discussion 940–941.

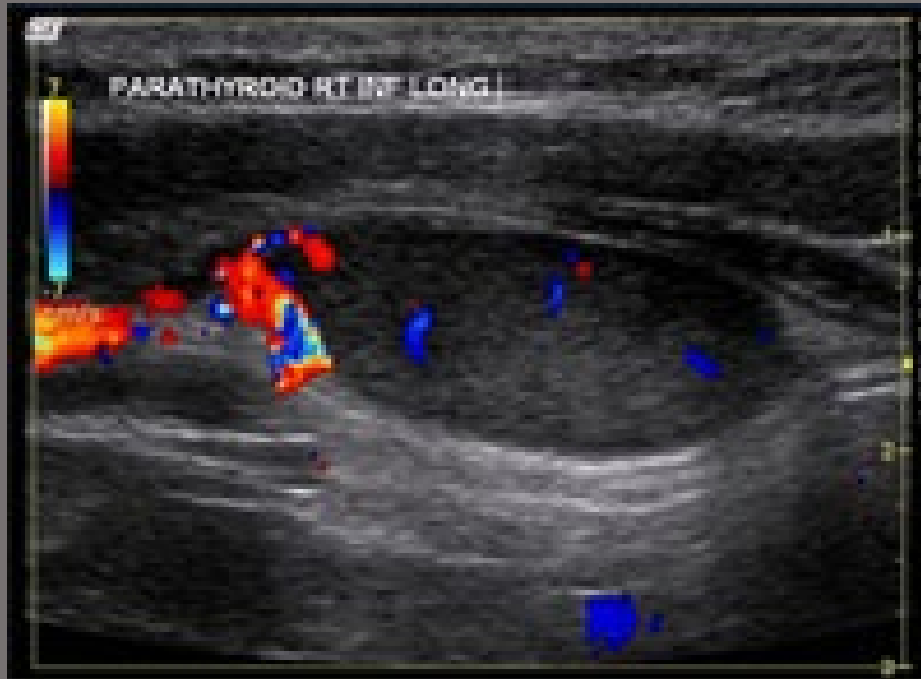
Variant Enhancement Patterns- Type B



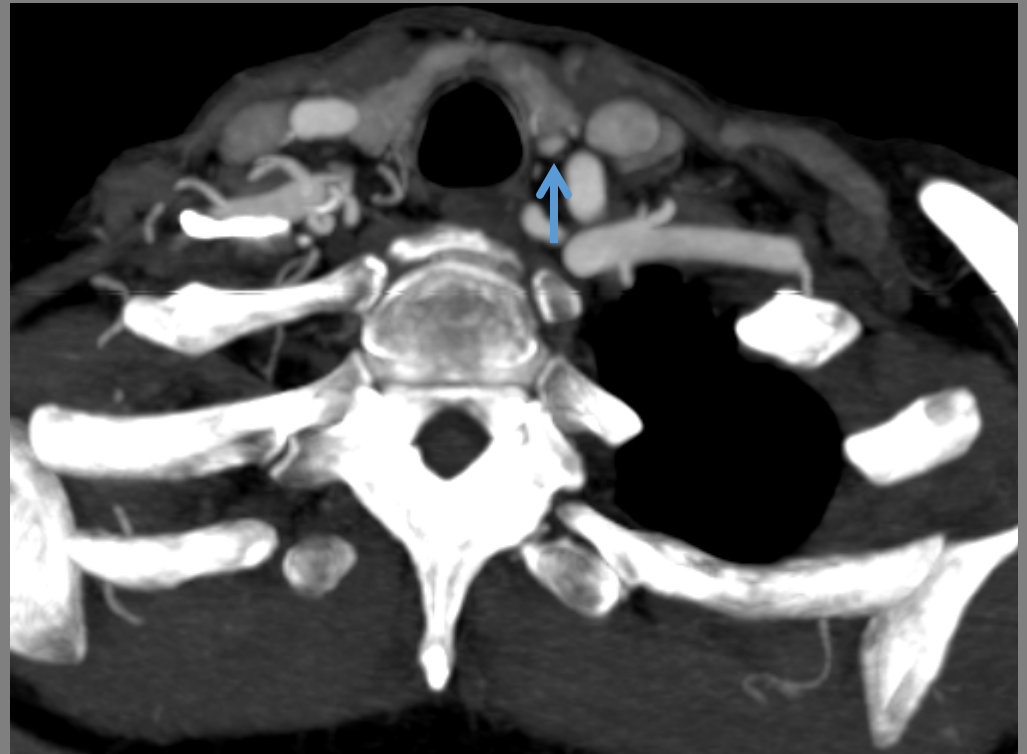
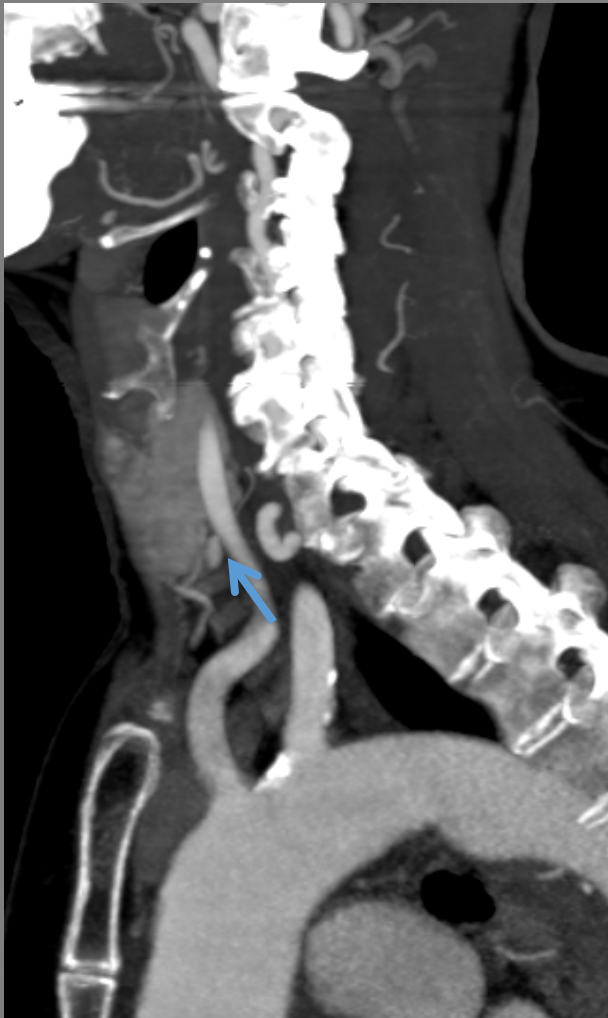
Variable Enhancement Patterns- Type C



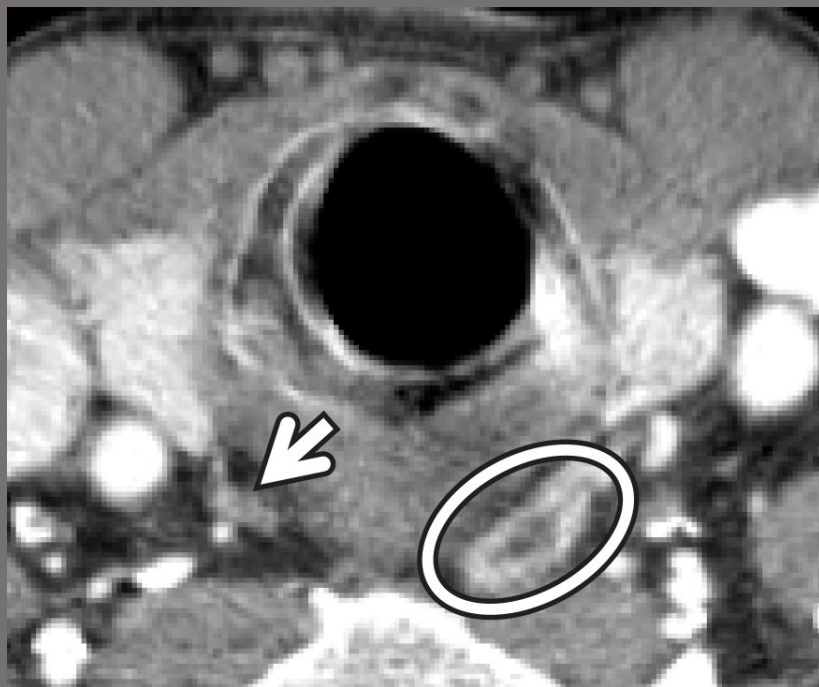
Polar Vessel Sign



MPR and MIPS can be very helpful



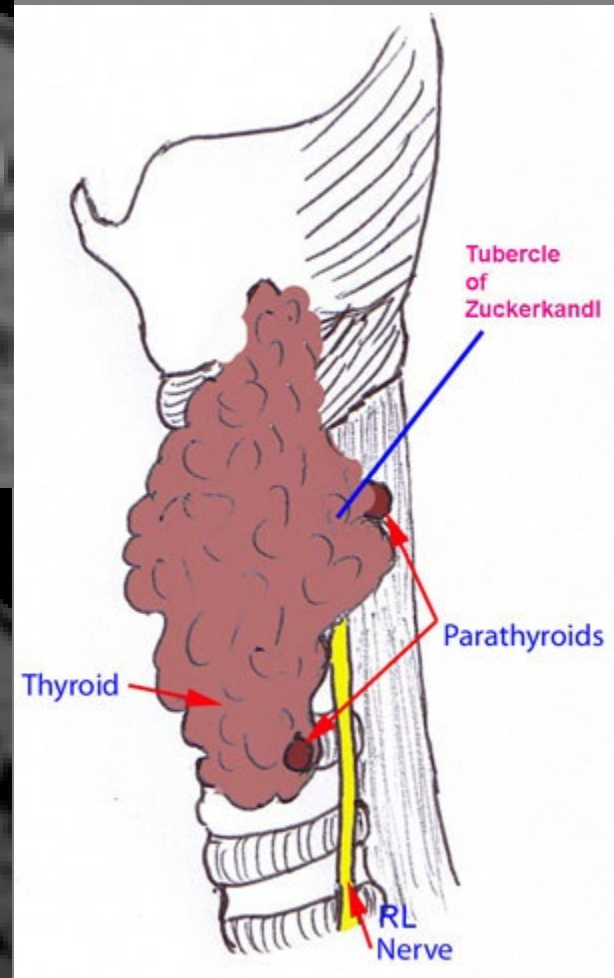
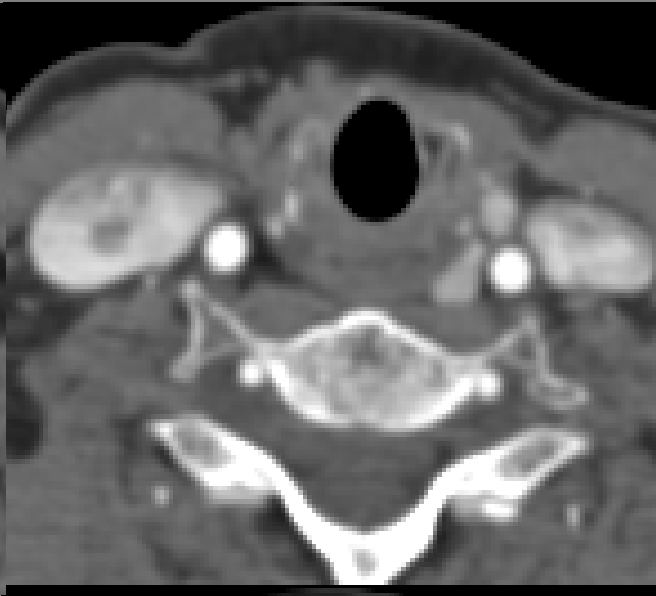
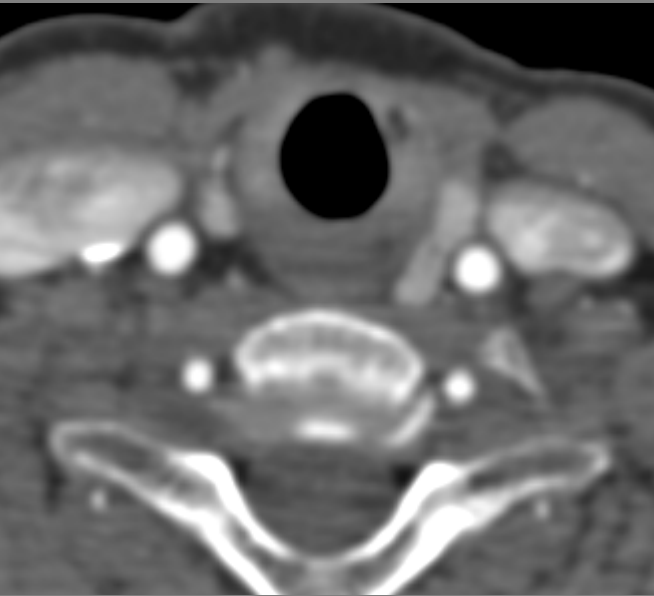
Lesion Features



Parathyroid Carcinoma

- Rare and difficult to diagnose prospectively
- Young patient, very elevated PTH
- Coarse calcifications, large lesion, heterogeneity

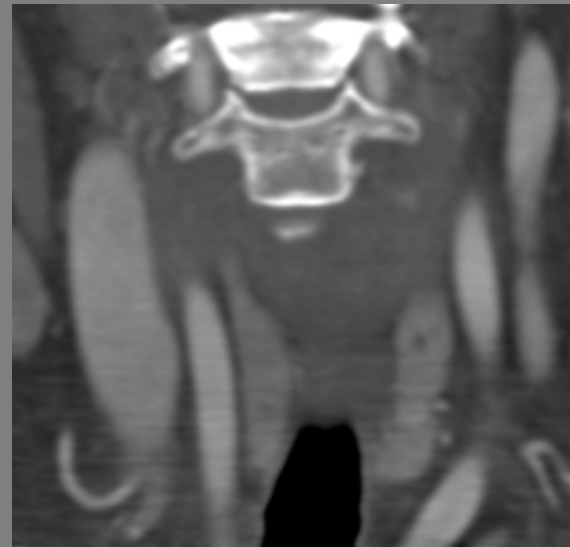
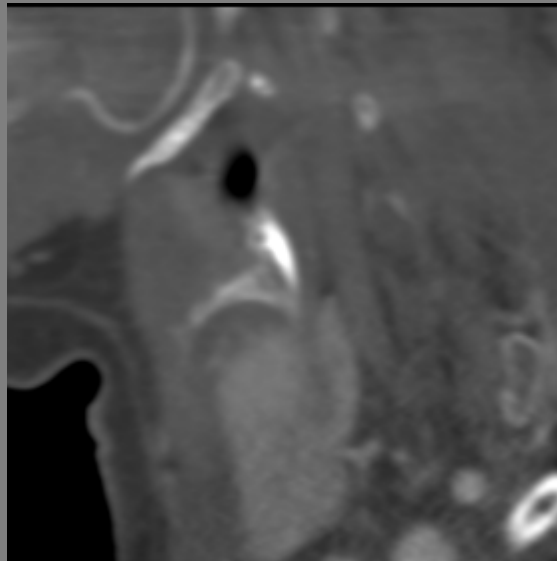
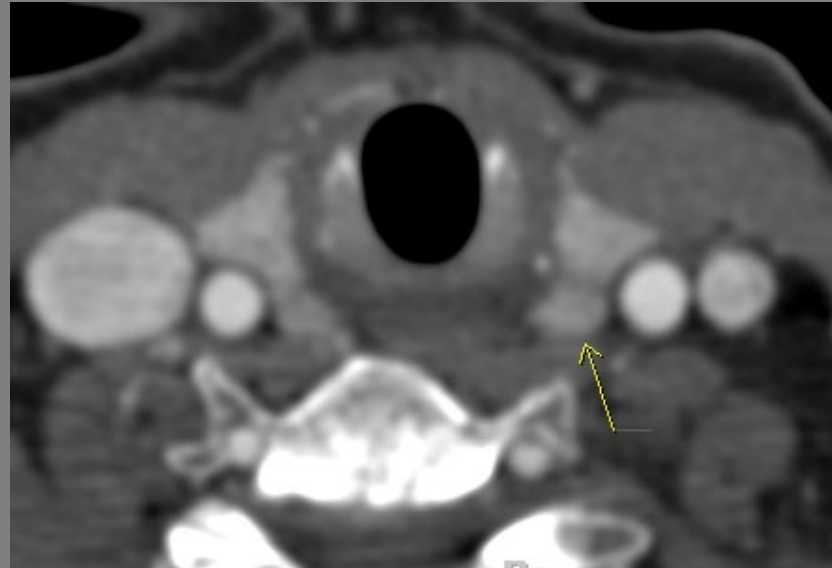
Zuckerkindl's Tubercle



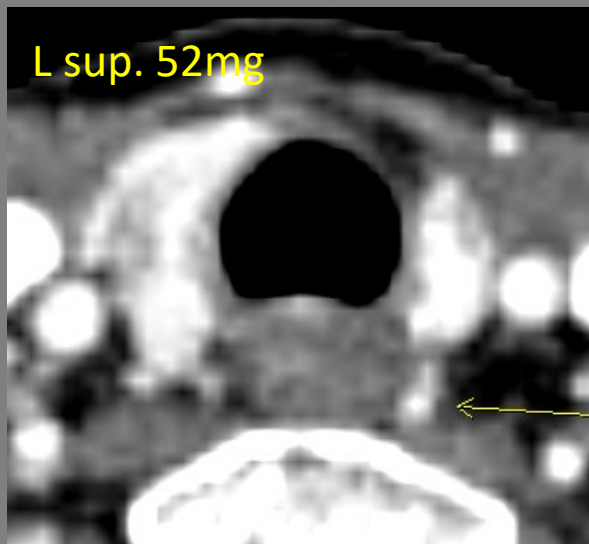
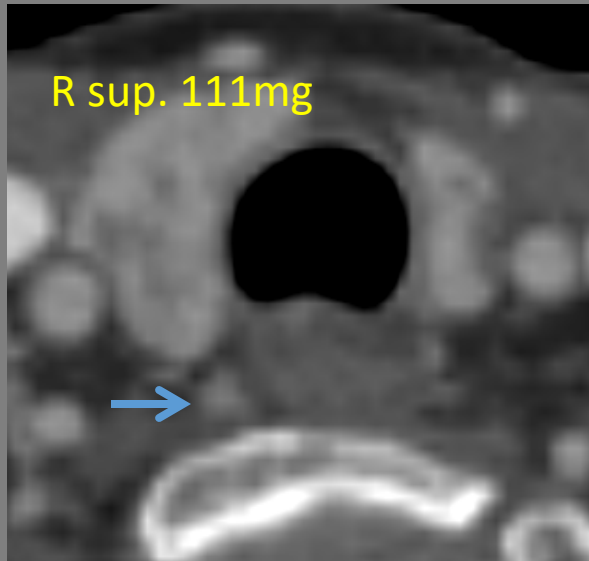
Thyroid Surface Lobulations



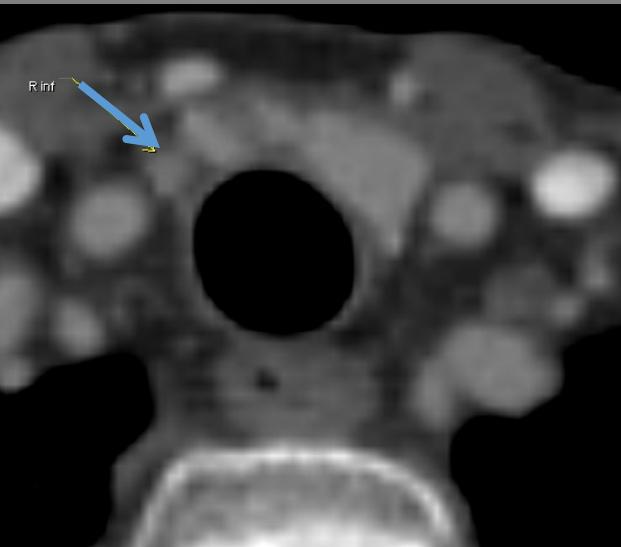
Fat Cleft



Hyperplasia vs. Multiple Adenoma



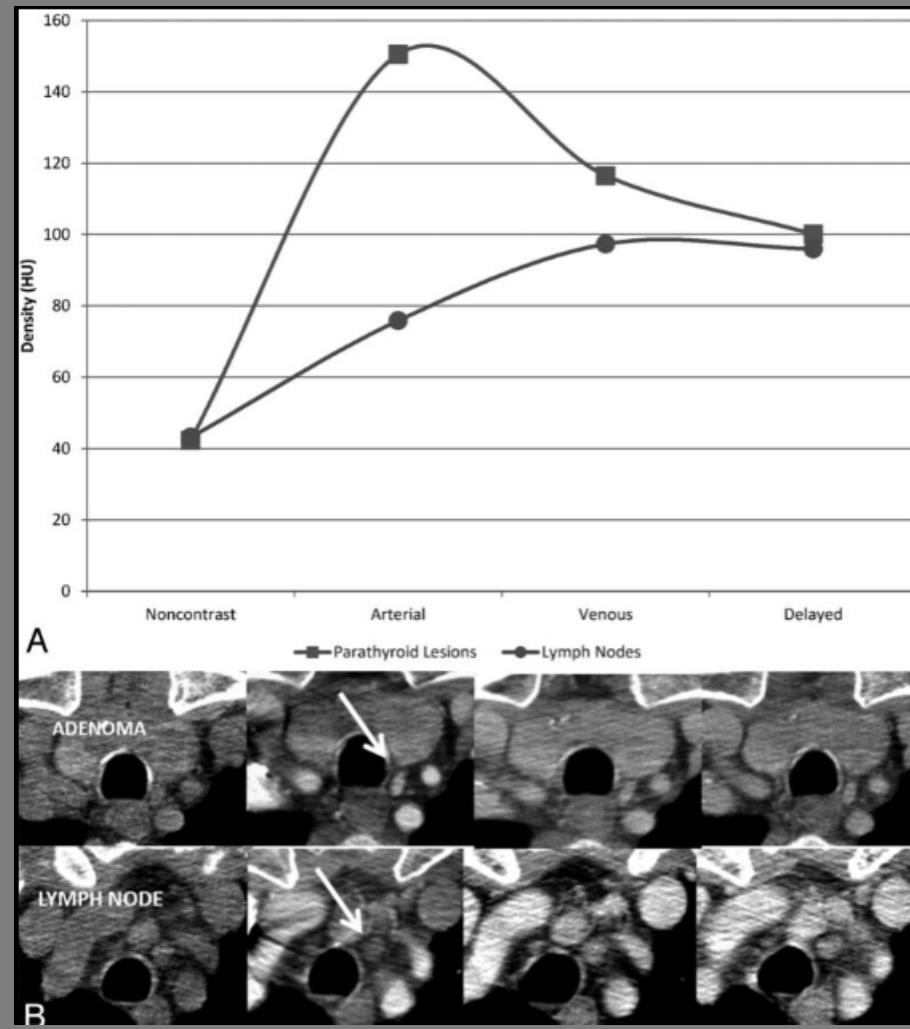
Hyperplasia vs. Multiple Adenoma





How many Phases are needed?

- No difference in lateralization or localization bw 2, 3 and 4-phase PT CT
- Counterpoint: Not all adenomas will show on arterial phase
 - 20% show on arterial phase
 - 60% on delayed venous
 - 20% on non-contrast



Dynamic CT for Parathyroid Disease: Are Multiple Phases Necessary? AJNR Am J Neuroradiol. 2014 Jun 5.
Multiphase computed tomography for localization of parathyroid disease in patients with primary hyperparathyroidism: How many phases do we really need? Surgery. 2014 Sep 24.



Summary

- Look carefully for adenomas in typical, and atypical locations
 - Most missed adenomas are at the usual sites
- Classic pattern (type A) only in 20%
 - Use pre, arterial and venous phases
- Pitfalls: thyroid lobulations, ectopic thyroid, lymph nodes, arteries
- Hyperplasia if smaller lesions and multiple, or no lesion
- Communicate and follow up