Thyroid, Parathyroid and neck ultrasound

Objectives

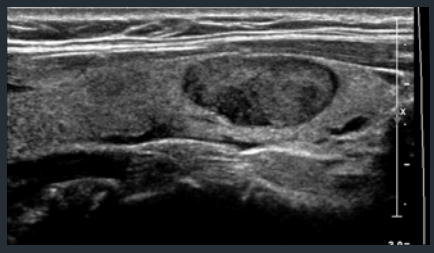
- Review cases of thyroid, parathyroid and neck diseases
- Imaging pattern based approach
- Review literature and guidelines for FNA

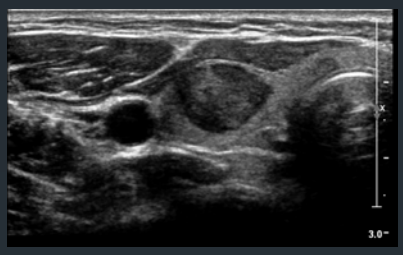
Imaging pattern based approach

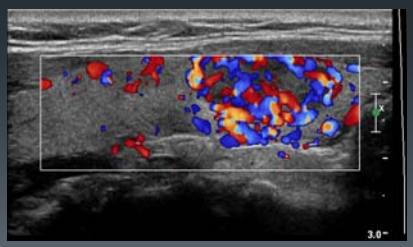
Location – Intrathyroidal or Extrathyroidal → Parathyroid

Solid	Cystic	Calcifications
Hypoechoic	Colloid	Micro
Hyperechoic	Mixed - Honeycomb	Coarse
Isoechoic		Rim

Case 1

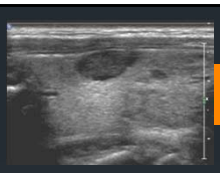




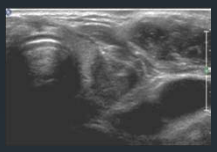


Sonographic features

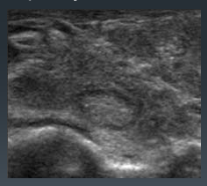
- Echogenecity
  - Most hypoechoic nodules are benign, but most thyroid cancers are hypoechoic
  - Hyperechoic nodules are usually benign but 1-4% are malignant, especially if uniformly solid and echogenic
  - Isoechoic are indeterminate



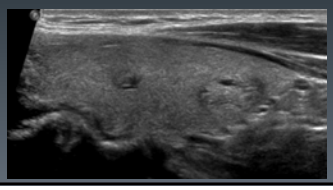
Benign hyperplastic nodule



Papillary carcinoma



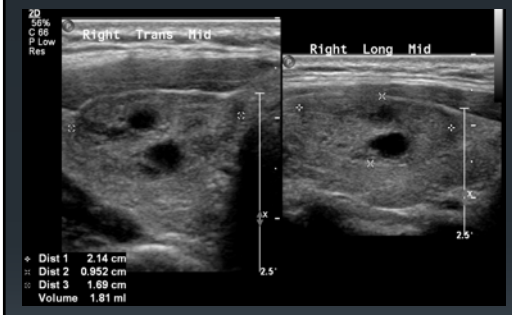
Follicular carcinoma



Hyperplastic nodule

Case 2

Old size

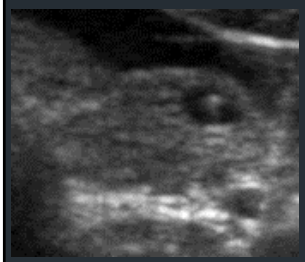


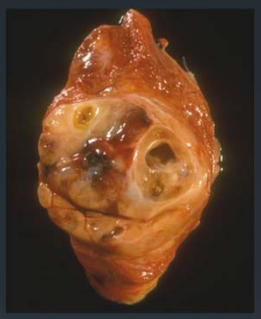
New size

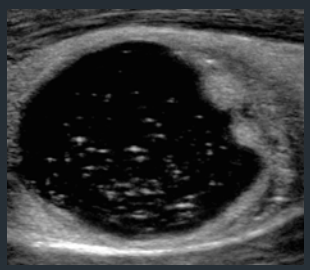
Vol – 2.29cc

Case 3

Colloid cysts

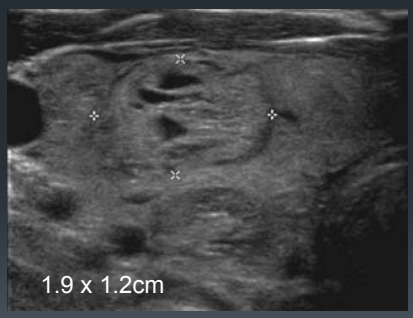




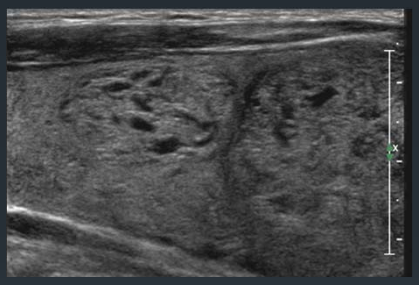


- Benign hyperplastic nodules with virtually no identifiable solid component on sonography
- Pathologically have a thin rim of follicular cells outlining large pool of colloid

Case 4



Hyperplastic nodule



- Area of thyroid that is stimulated to undergo follicular hyperplasia and accumulation of colloid.
- Composed of follicular cells of various sizes and age, colloid, macrophages

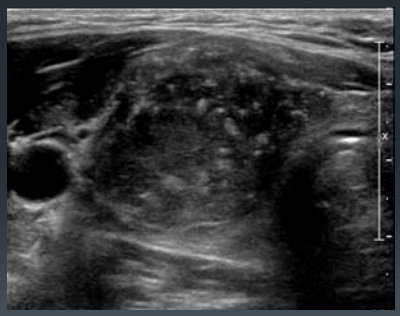
Cystic change

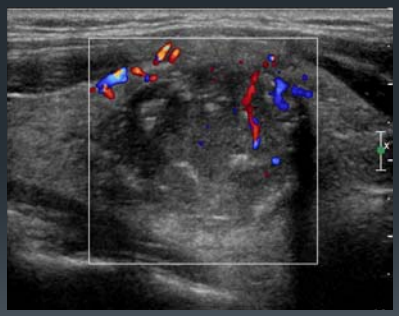
- 30% of thyroid nodules have some degree of cystic change
- More common in benign nodules: hyperplastic nodules or degenerated adenoma
- True cysts are rare

Predominantly cystic thyroid nodules

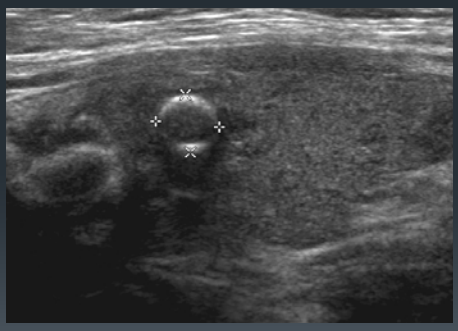
- 50% or greater cystic component, up to 50% non-diagnostic rate on FNA
- Malignancy rate - 20%
- Indications for surgery:
  - large cyst size (over 3 or 3.5 cm),
  - bloody aspirate,
  - recurrence after repeated aspiration,
  - h/o previous irradiation.

Case 5





Case 6

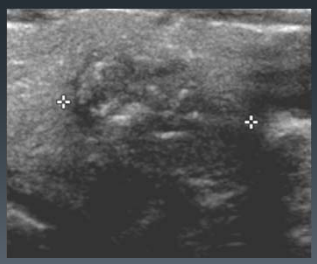


Calcifications

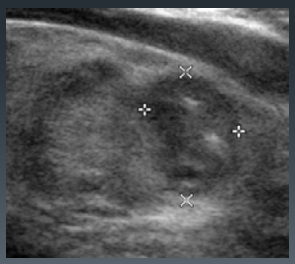
- In general, common in benign and malignant disease
- Found in over one third of all thyroids on US
- Carries a much higher risk (50-75%) if the calcification is present in a solitary nodule than in a MNG

Microcalcifications

- Multiple bright punctate (under 2 mm) echoes with or without shadowing
- Usually found in a solid nodule
- Pitfall: Colloid in a hyperplastic nodule ("spongiform" composition)

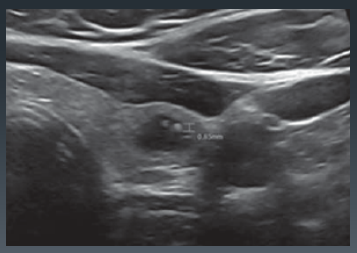


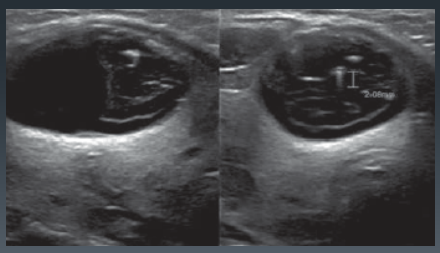
Papillary carcinoma



Hyperplastic nodule

Echogenic Foci in Thyroid Nodules: Significance of Posterior Acoustic Artifacts Malhi et al. December 2014, Volume 203, Number 6

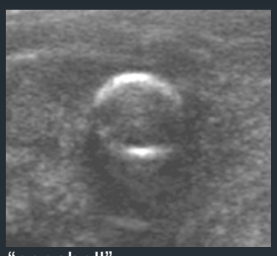




Coarse calcifications

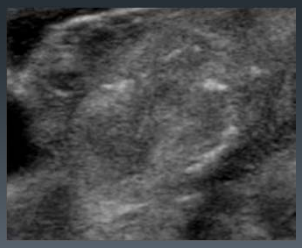
- Larger than 2 mm with shadowing
- Common in MNG
- Concerning if occur in a solitary nodule or mixed with microcalcifications

Rim calcification



"eggshell"

Irregular



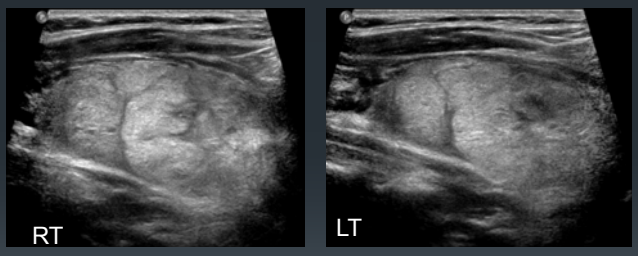
Interrupted

Calcifications in thyroid nodules

	Cancer	Benign
Calcification (n=57)	31 (54%)	26 (46%)
Microcalcifications	9	2
Coarse	15	14
Peripheral	6	8
Calcified spot	1	2
No calcification (n = 94)	35 (37%)	59 (63%)

Taki S. Clinical Imaging 2004

Case 7

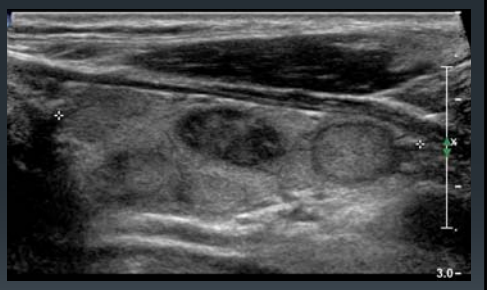


Multinodular goiter

- Virtually no normal intervening parenchyma
- Gland is replaced by multiple hyperplastic nodules
- Often foci of hemorrhage (complex fluid) and dystrophic calcifications occur over time

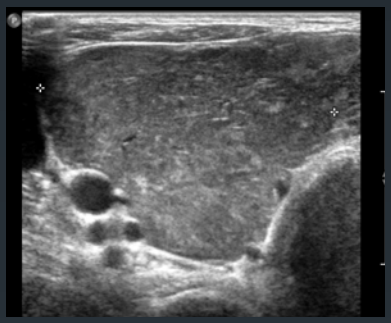
Multinodular goiter # Multiple nodular gland

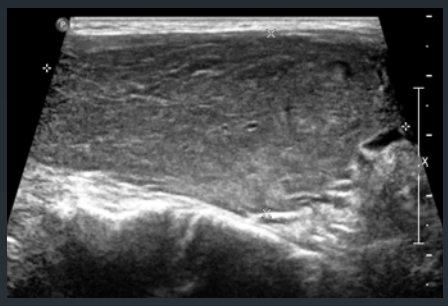
Enlarged thyroid with multiple sonographically similar nodules with little or no normal parenchyma

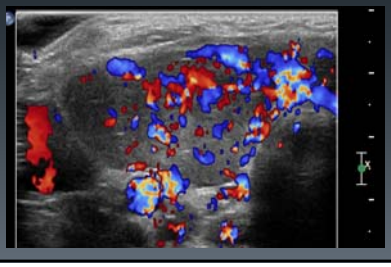


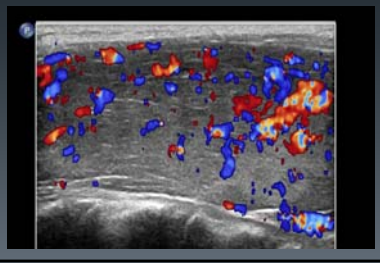
Normal sized gland with more than one nodule

Case 8

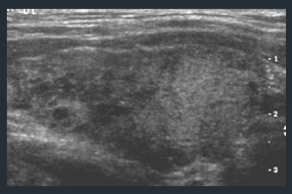


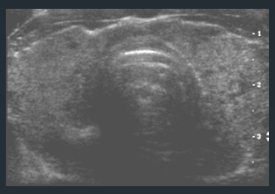


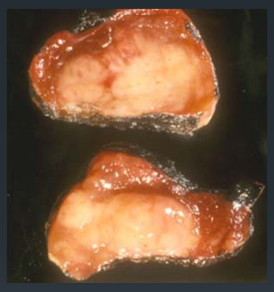




Chronic Lymphocytic Thyroiditis

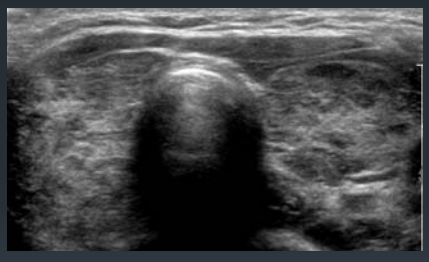


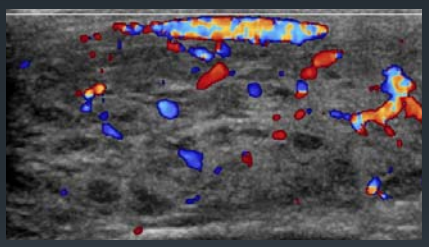




- Hashimoto's thyroiditis is often asymmetric
- The pseudo-nodules maybe lymphocytic aggregates (hypoechoic) or islands of follicular cells (hyperechoic)
- Can be a solitary focal lesion
- Accounts for up to 10% of focal lesions in surgical series

Graves' Disease





- May have focal areas of increased echotexture
- Represents islands of follicular hyperplasia superimposed on a lymphocytic infiltrate

Features associated with malignancy

- Microcalcifications
- Coarse calcifications in a solid nodule
- Markedly hypoechoic echotexture
- Hypoechoic echotexture with solid consistency
- Irregular, infiltrating margins
- Intranodular flow in association with hypoechogenecity/irregular margins/Ca++
- Absence of a halo
- Taller than wide shape

US prediction of thyroid cancer

	Sensitivity	Specificity
Microcalcifications	40%	90%
Absence of halo	66%	46%
Irregular margins	64%	84%
Hypoechoic	83%	49%
Incr. intranodular flow	70%	65%
MicroCa + Irreg margin	30%	95%
MicroCa + hypoechoic	28%	95%
Solid + hypoechoic	73%	69%

Brkljacic et al J Clin Ultrasound 1994; Takashima et al J Clin Ultrasound 1994; Rago et al Euro J Endrocrinol 1998; Leenhardt et al, J Clin Endocrinol Metab 1999; Kim et al AJR 2002; Papini et al J Clin Endrocrinol Metab 2002

Can US characteristics help predict malignancy in small thyroid nodules?

- Leenhardt – 1999
  - US – FNA of 365 nodules 4-37mm (median 12 mm)
  - 16 cancers
- Papini 2002
  - US – FNA of 402 nodules 8-50 mm
  - 31 cancers

Leenhardt et al, J Clin Endocrinol Metab 1999;
Papini et al J Clin Endrocrinol Metab 2002

US prediction of Malignancy

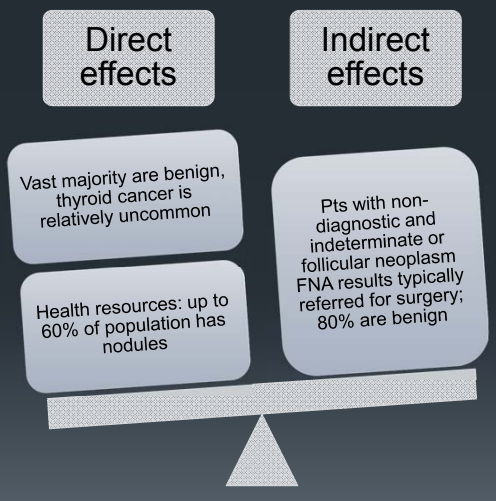
	# nodules aspirated	Cancers found	Cancers missed
Size criteria			
> 10 mm (1)	286/365	10 (63%)	6 (37%)
> 10 mm (2)	325/402	19 (61%)	12 (39%)
	# nodules aspirated	Cancers found	Cancers missed
US criteria			
Hypoechoic and solid(1)	139/365	13 (81%)	3 (19%)
Hypoechoic and irregular margins, increased vascularity or MicroCa+(2)	125/402	27 (87%)	4 (13%)

Leenhardt et al, J Clin Endocrinol Metab 1999; Papini et al J Clin Endrocrinol Metab 2002

Nodules which are likely benign

- Entirely cystic
- Nearly entirely cystic nodule with no flow or calcification in the solid part (under 2 cm)
- Honeycomb or spongiform nodule without calcifications (under 2 cm)
- “Pseudo-nodules” in autoimmune thyroid disease
- Mixed cystic and solid nodules with a solid functioning component (any size)

Why not biopsy all thyroid nodules?



Cooper DS et al, Thyroid 2006

Society of Radiologist in Ultrasound Criteria

- Convened panel of specialists (Radiologists, Endocrinologists and Pathologists) in Oct. 2004
- Goal =
  - define recommendations based on US characteristics for which thyroid nodules should undergo US guided FNA
  - determine if it is benign or malignant to provide treatment at earliest stage possible, but avoid unnecessary tests and surgery.
- Applies to nodules > 1.0 cm
  - **uncertain if diagnosis at smaller size improves life expectancy**
  - **nodules with worrisome features, cutoff lower**
  - **measure with caliper outside any halo**
  - **use maximum diameter**

Radiology 2005; 237: 794-800

Society of Radiologist in Ultrasound Criteria

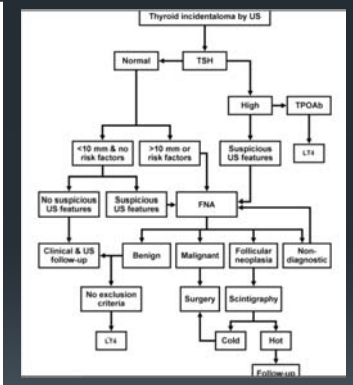
US feature		**Recommendation**
Solitary Nodule		
	Microcalcifications	Strongly consider US-guided FNA ≥ 1 cm
	Solid (or almost entirely solid) or coarse calcs	Strongly consider US-guided FNA if ≥ 1.5 cm
	Mixed solid and cystic or almost entirely cystic with solid mural component	Consider US-guided FNA if ≥ 2cm
	None of the above but with substantial growth	Consider US-guided FNA
	Almost entirely cystic and none of the above and no substantial growth (or no prior US)	US-guided FNA probably unnecessary
Multiple nodules		Consider US-guided FNA of one or more nodules, with selection prioritized on basis of criteria (in order listed) for solitary nodule*

Other guidelines

- AACE guidelines

Key Recommendations Regarding Ultrasonography and Other Diagnostic Imaging in Patients With a Thyroid Nodule*

- US evaluation
  - Not recommended (*grade C*†): as a screening test in the general population; in patients with normal thyroid on palpation and low risk for thyroid cancer
  - Recommended (*grade C*): for high-risk patients (history of familial thyroid cancer, MEN2, or external irradiation); for all patients with palpable thyroid nodules or MNG; for those with adenopathy suggestive of a malignant lesion
- US reporting criteria (*grade C*):
  - Describe position, shape, size, margins, content, echogenic pattern, and, whenever possible, the vascular pattern of the nodule
  - Identify the nodule at risk to be malignant, and stratify the nodule with a risk score based on the US findings
  - Identify the nodules for FNA biopsy
- No US-FNA of nodules <10 mm unless suspicious US findings or high-risk history (*grade C*)
- US-FNA of nodules of any size in patients with history of neck irradiation or family history of MTC or MEN2 (*grade C*)
- US-FNA should be based on US features (*grade B*)
- US-FNA should be performed on all hypoechoic nodules ≥10 mm with irregular margins, chaotic intranodular vascular spots, a more-tall-than-wide shape, or microcalcifications (*grade B*)
- US findings suggestive of extracapsular growth or metastatic cervical lymph nodes warrant an immediate cytologic evaluation, no matter the size of the lesions (*grade B*)
- In complex thyroid nodules, obtain US-FNA sampling of the solid component of the lesion before fluid drainage (*grade C*)
- Thyroid incidentalomas should be followed by US in 6-12 months and regularly thereafter (*grade D*)
- MRI and CT are not indicated in routine nodule evaluation (*grade C*)



Other guidelines

- ATA guidelines

Table 3. Sonographic and Clinical Features of Thyroid Nodules and Recommendations for FNA

Nodule sonographic or clinical features	*Recommended nodule threshold size for FNA*
High-risk history[a]	
Nodule WITH suspicious sonographic features[b]	>5 mm Recommendation A
Nodule WITHOUT suspicious sonographic features[b]	>5 mm Recommendation I
Abnormal cervical lymph nodes	All[c] Recommendation A
Microcalcifications present in nodule	≥1 cm Recommendation B
Solid nodule	
AND hypoechoic	>1 cm Recommendation B
AND iso- or hyperechoic	≥1–1.5 cm Recommendation C
Mixed cystic–solid nodule	
WITH any suspicious ultrasound features[b]	≥1.5–2.0 cm Recommendation B
WITHOUT suspicious ultrasound features	≥2.0 cm Recommendation C
Spongiform nodule	≥2.0 cm[d] Recommendation C
Purely cystic nodule	FNA not indicated[e] Recommendation E

[a]High-risk history: History of thyroid cancer in one or more first degree relatives; history of external beam radiation as a child; exposure to ionizing radiation in childhood or adolescence; prior hemithyroidectomy with discovery of thyroid cancer, ^{18}FDG avidity on PET scanning; MEN2/FMTC-associated RET protooncogene mutation, calcitonin >100 pg/mL. MEN, multiple endocrine neoplasia; FMTC, familial medullary thyroid cancer.
[b]Suspicious features: microcalcifications; hypoechoic; increased nodular vascularity; infiltrative margins; taller than wide on transverse view.
[c]FNA cytology may be obtained from the abnormal lymph node in lieu of the thyroid nodule.
[d]Sonographic monitoring without biopsy may be an acceptable alternative (see text) (48).
[e]Unless indicated as therapeutic modality (see text).

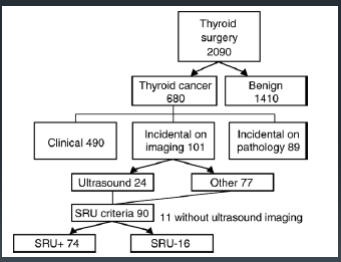
"Sonographic triage" of nodules

- Helpful in selecting which nodule or nodules should be biopsied in patients with MNG
- May be helpful to screen for occult carcinoma in high risk patients
- May affect approach to an incidentally detected nodule

Original Research
Ultrasonography

Thyroid Cancers Incidentally Detected at Imaging in a 10-year Period: How Many Cancers Would Be Missed with Use of the Recommendations from the Society of Radiologists in Ultrasound?

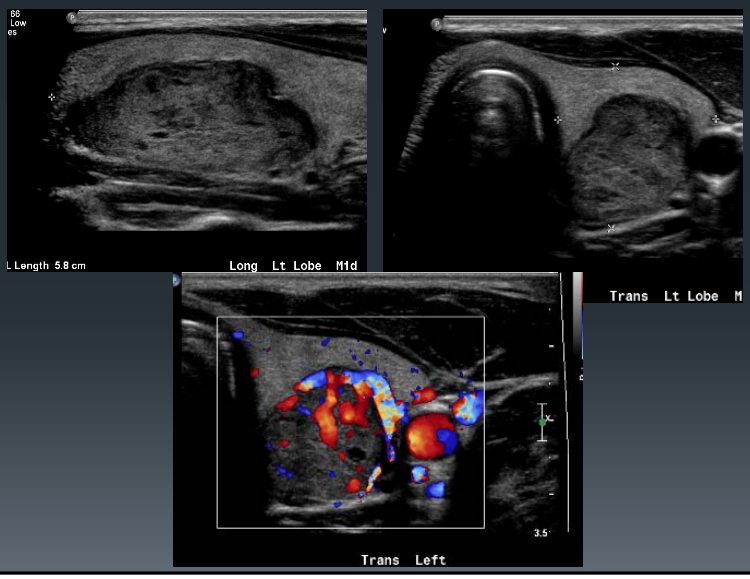
Radiology June 2014



2% (16 of 680)

SRU criteria–negative tumors were smaller than SRU criteria–positive tumors (mean, 1.1 cm [range, 0.9–1.4 cm] vs mean, 2.5 cm [range, 1.0–7.6 cm]; *P* , .001) and were more likely to be stage I (15 [94%] of 16 vs 47 [64%] of 74; *P* = .02).

Case 9



Parathyroid adenoma

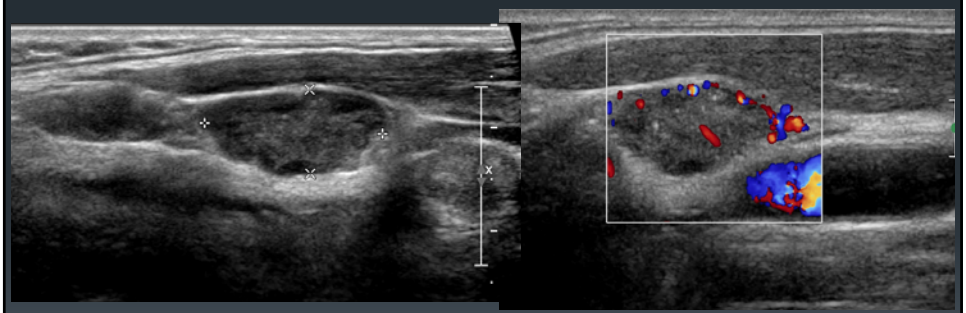
- Single adenomas - 85% of primary PTH (5% - multiple adenomas, 12% - primary hyperplasia, <1% - adenocarcinoma)
- Peak incidence – 3rd to 5th decades
- Increased incidence in multiple endocrine neoplasia 1 and 2A syndromes.

  Usually 4 in number (from 2-6)

US appearance

- Typically hypoechoic, lobulated extra-thyroidal masses with well-defined margins
- Posterior to the mid-portion of the thyroid gland (superior parathyroid) or inferior to the lower pole of the thyroid (inferior parathyroid).
- Small adenomas - usually ovoid; Larger adenomas- may be more oblong (often parallel to the long axis of the neck), lobulated or bulbous.
- Very vascular

Case 10



Cervical neck nodes

- Metastatic node –
  - unilateral
    - reduces 5 year survival to 50%
  - Bilateral
    - reduces 5 year survival to 25%
- Lymphoma,
- Infection

- US –
  - sensitivity 98%
  - specificity (95%)
  - when combined with fine-needle aspiration cytology (FNAC)
- Power Doppler sonography
  - vasculature of the lymph nodes can also be evaluated

Som PM. Detection of metastasis in cervical lymph nodes: CT and MR criteria and differential diagnosis. Am J Roentgenol 1992;158:961-9.

Lymph node

- Cortex
  - densely packed lymphocytes, which group together to form spherical lymphoid follicles.
- Medulla
  - Medullary trabeculae, sinuses and cords.
- Vessels enter at the hilum

Size

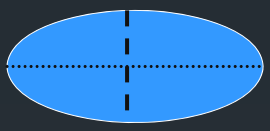
Regions	Optimum short axis when combined with the optimum S:L ratio
Submental	3 mm (0.5)
Submandibular	8 mm (0.7)
Parotid	5 mm (0.5)
Upper cervical	4 mm (0.4)
Middle cervical	3 mm (0.3)
Posterior triangle	3 mm (0.4)

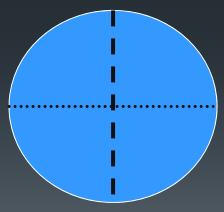
- Different locations – different sizes
- Single measurement not as helpful
- Increasing size on serial exams – highly suggestive of metastasis

Shape

- Oval
- Round

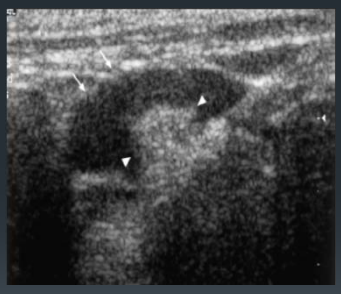
- S/L ratio of 0.5





Echogenic hilus

- More commonly seen in larger nodes
- Echogenic hilus consisted of sinuses, small intranodal arteries and veins, and fatty tissue



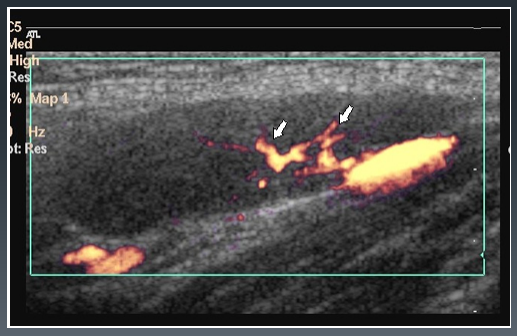
Solbiati L, Cioffi V, Ballarati E. Ultrasonography of the neck. Radiol Clin North Am, 1992;30:941–954

Vascular feature

- Hilar –
  - flow signals branching radially from the hilus and the signals are not along the periphery of the nodes
- Peripheral –
  - flow signals along the periphery of the lymph nodes, with branches perforating the periphery of the node and not arising from the hilar vessels
- Mixed –
  - presence of hilar and peripheral flow signals
- Apparently avascular –
  - absence of vascular signals within the lymph nodes

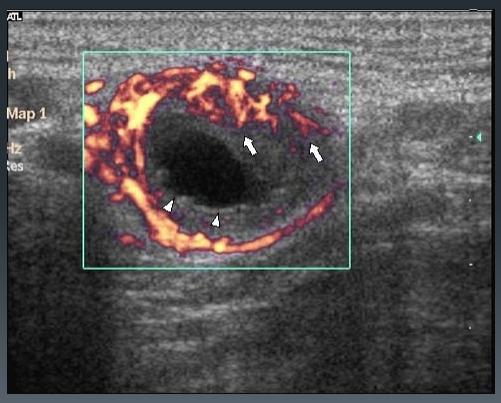
Vascular feature

- Normal and reactive lymph nodes
  - hilar vascularity or appear apparently avascular



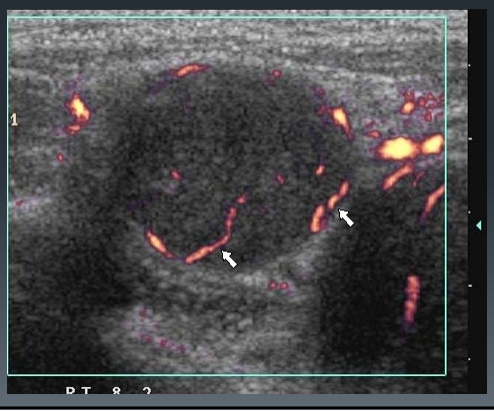
Vascular feature

- Metastatic nodes
  - peripheral or mixed vascularity



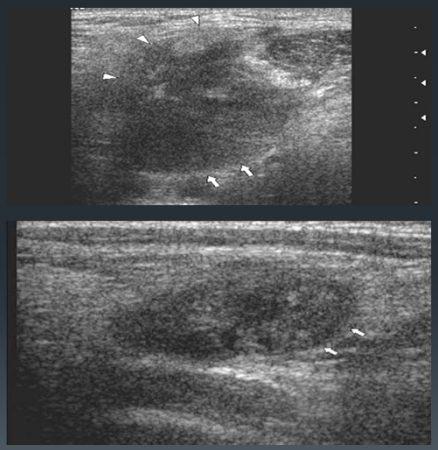
Vascular feature

- Lymphomatous nodes
  - mixed vascularity



Nodal border

- Metastatic and lymphomatous nodes
  - sharp borders
- Reactive and normal nodes
  - unsharp borders



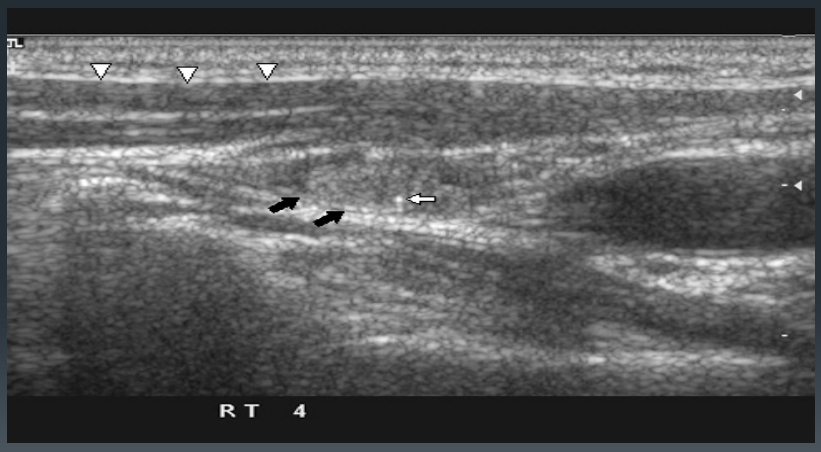
Echogenecity

- Normal, reactive, lymphomatous and tuberculous nodes
  - hypoechoic
- Metastatic nodes
  - hypoechoic
- Metastases from papillary carcinoma
  - hyperechoic

Hypoechoic nodes

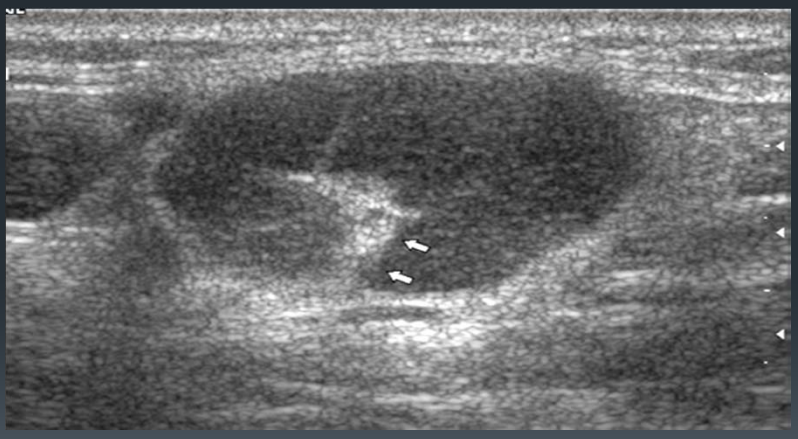
Ahuja A, Ying M. Sonographic evaluation of cervical lymphadenopathy: is power Doppler sonography routinely indicated? Ultrasound Med Biol 2003;29:353-9.

Hyperechoic nodes



Ahuja A, Ying M. Sonographic evaluation of cervical lymphadenopathy: is power Doppler sonography routinely indicated? Ultrasound Med Biol 2003;29:353-9.

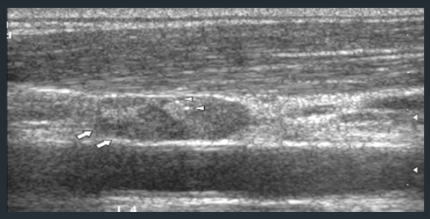
Pseudocystic appearance

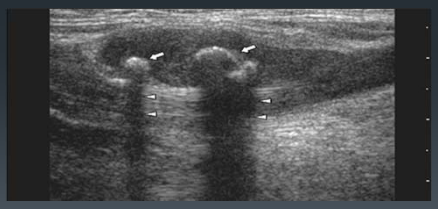


Ahuja A, Ying M. Sonographic evaluation of cervical lymphadenopathy: is power Doppler sonography routinely indicated? Ultrasound Med Biol 2003;29:353-9.

Intranodal calcification

- Papillary carcinoma
- Lymphomatous and tuberculous nodes after treatment

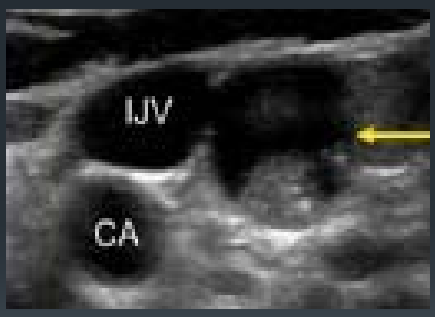




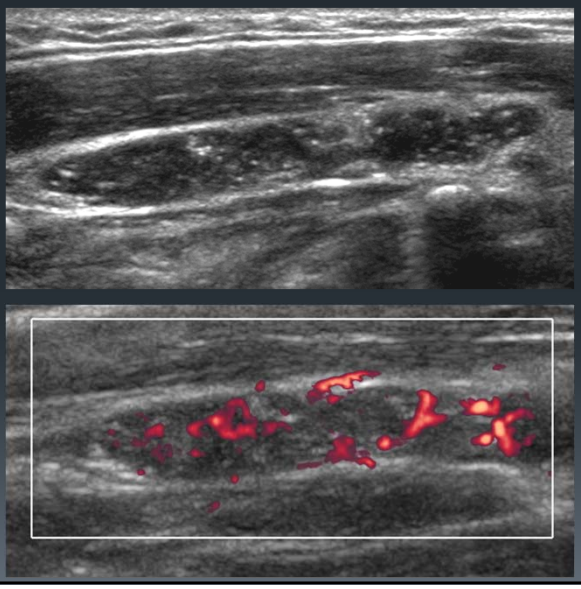
Ahuja A, Ying M. Sonographic evaluation of cervical lymphadenopathy: is power Doppler sonography routinely indicated? Ultrasound Med Biol 2003;29:353-9.

Intranodal necrosis

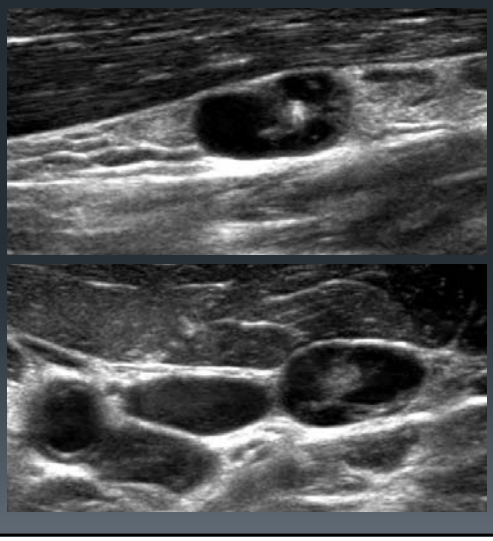
- Cystic necrosis
  - tuberculous nodes
  - metastatic nodes from squamous cell carcinomas
  - papillary carcinoma of the thyroid.



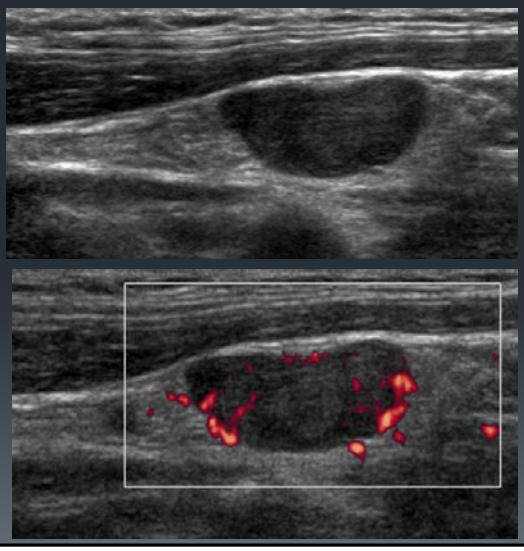
Papillary thyroid carcinoma metastases



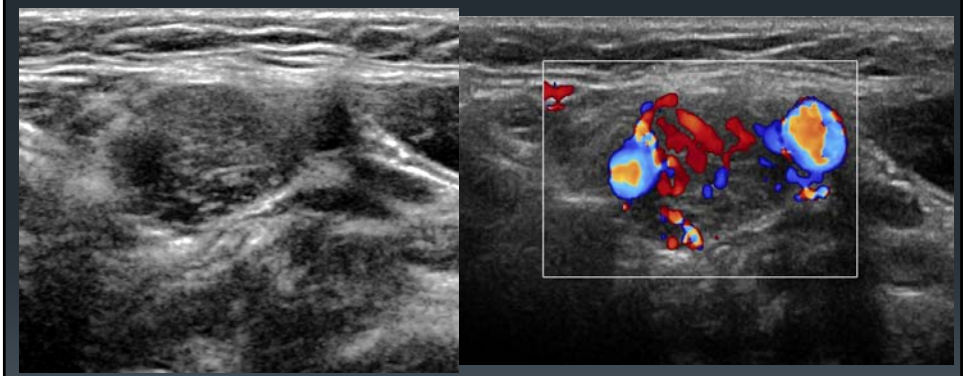
Papillary thyroid carcinoma metastases



Papillary thyroid carcinoma metastases



Case 11



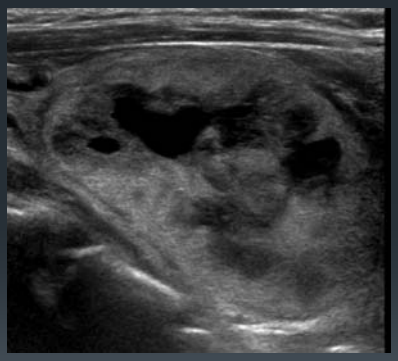
Paraganglioma

- Highly vascular glomus tumor arising from the paraganglion cells of the carotid body
- Located at the carotid bifucation with characteristic splaying of the ICA and ECA.
- Female prediliction
- 4th to 5th decades
- Can be familial – autosomal dominant

Imaging appearance

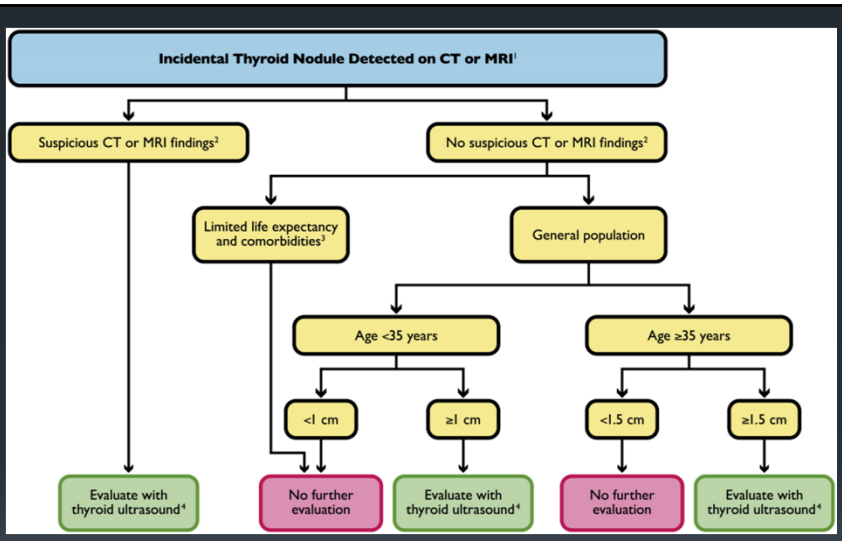
- **CT**
  - Contrast enhanced CT is excellent at depicting these lesions. Typical appearances are:
    - soft tissue density on non-contrast CT (similar to muscle)
    - bright and rapid (faster than schwannoma) enhancement
    - splaying of the ICA and ECA
- **MRI**
  - **T1**
    - iso to hypointense compared to muscle
    - salt and pepper appearance when larger, representing a combination of punctate regions of hemorrhage or slow flow (salt) and flow voids (pepper)
    - intense enhancement following gadolinium
  - **T2**
    - hyper intense compared to muscle
    - salt and pepper appearance also seen on T2

Case 12



Thyroid nodules and CT

- 16% on CT and MRI
- CT and MRI no reliable signs to indicate if a thyroid nodule is benign or malignant
- ACR formed the Incidental Thyroid Findings Committee to derive a practical approach to managing ITNs on CT, MRI, nuclear medicine, and US
- Committee recommends against both mentioning an ITN in the Impression/Conclusion section of the report, and recommending further evaluation or follow-up imaging, if the ITN does not meet criteria for further evaluation



Macro - In patients with normal life expectancy and without suspicious imaging findings, the American College of Radiology consensus panel recommends workup with dedicated thyroid ultrasound for nodules ≥ 1 cm in patients under 35 years of age, and an increased size cutoff of ≥ 1.5 cm in patients 35 years or older. Hoang JK et al. JACR. November 2014

Thank you