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

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
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
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

<table>
<thead>
<tr>
<th></th>
<th>Cancer</th>
<th>Benign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcification (n=57)</td>
<td>31 (54%)</td>
<td>26 (46%)</td>
</tr>
<tr>
<td>Microcalcifications</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Coarse</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Peripheral</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Calcified spot</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>No calcification (n = 94)</td>
<td>35 (37%)</td>
<td>59 (63%)</td>
</tr>
</tbody>
</table>
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 may be 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

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcalcifications</td>
<td>40%</td>
<td>90%</td>
</tr>
<tr>
<td>Absence of halo</td>
<td>66%</td>
<td>46%</td>
</tr>
<tr>
<td>Irregular margins</td>
<td>64%</td>
<td>84%</td>
</tr>
<tr>
<td>Hypoechoic</td>
<td>83%</td>
<td>49%</td>
</tr>
<tr>
<td>Incr. intranodular flow</td>
<td>70%</td>
<td>65%</td>
</tr>
<tr>
<td>MicroCa + Irreg margin</td>
<td>30%</td>
<td>95%</td>
</tr>
<tr>
<td>MicroCa + hypoechoic</td>
<td>28%</td>
<td>95%</td>
</tr>
<tr>
<td>Solid + hypoechoic</td>
<td>73%</td>
<td>69%</td>
</tr>
</tbody>
</table>

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

### US prediction of Malignancy

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

Leenhardt et al, J Clin Endocrinol Metab 1999; Papini et al J Clin Endocrinol 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?

**Direct effects**
- Vast majority are benign, thyroid cancer is relatively uncommon
- Health resources: up to 80% of population has nodules

**Indirect effects**
- Pts with non-diagnostic and indeterminate or follicular neoplasm
- FNA results typically referred for surgery; 80% are benign

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

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

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

- **AACE guidelines**

- **ATA guidelines**

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

<table>
<thead>
<tr>
<th>Sonographic and Clinical Features</th>
<th>Recommended Nodule Threshold Size for FNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-risk features: Nodule with suspicious sonographic features (^a)</td>
<td>&gt;5 mm</td>
</tr>
<tr>
<td>Nodule WITHOUT suspicious sonographic features (^b)</td>
<td>(&gt;10 \text{ mm} )</td>
</tr>
<tr>
<td>Abnormal cervical lymph nodes</td>
<td></td>
</tr>
<tr>
<td>Microcalcifications present in nodule</td>
<td></td>
</tr>
<tr>
<td>Solid nodule</td>
<td>AND hypoechogenic</td>
</tr>
<tr>
<td>Mixed cystic-solid nodule</td>
<td>AND low- or hyperechogenic</td>
</tr>
<tr>
<td>Mixed cystic-solid nodule</td>
<td>(&gt;1.5 \text{ cm} )</td>
</tr>
<tr>
<td>Spiculated nodule</td>
<td>(&gt;2.0 \text{ cm} )</td>
</tr>
<tr>
<td>Purely cystic nodule</td>
<td>(&gt;2.0 \text{ cm} )</td>
</tr>
<tr>
<td>Nodule (&gt;2.0 \text{ cm} ) (^c)</td>
<td>(&gt;2.0 \text{ cm} )</td>
</tr>
</tbody>
</table>

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\(^a\) High-risk features: History of thyroid cancer in one or more first-degree relatives, history of external beam radiation to the neck, exposure to thorium dioxide (thorium dioxide) by inhalation, or history of Hashimoto thyroiditis or thyroiditis; history of thyroid disease, goiter, or thyroid nodule; \(>0.5 \text{ cm} \) \(^c\) \(>2.0 \text{ cm} \) \(>2.0 \text{ cm} \) | Recommendation C |
"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

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

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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**

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

<table>
<thead>
<tr>
<th>Regions</th>
<th>Optimum short axis when combined with the optimum S/L ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submental</td>
<td>3 mm (0.5)</td>
</tr>
<tr>
<td>Submandibular</td>
<td>8 mm (0.7)</td>
</tr>
<tr>
<td>Parotid</td>
<td>5 mm (0.5)</td>
</tr>
<tr>
<td>Upper cervical</td>
<td>4 mm (0.4)</td>
</tr>
<tr>
<td>Middle cervical</td>
<td>3 mm (0.3)</td>
</tr>
<tr>
<td>Posterior triangle</td>
<td>3 mm (0.4)</td>
</tr>
</tbody>
</table>

**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


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

Intranodal calcification

- Papillary carcinoma
- Lymphomatous and tuberculous nodes after treatment


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

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 $\geq 1$ cm in patients under 35 years of age, and an increased size cutoff of $\geq 1.5$ cm in patients 35 years or older. Hoang JK et al. JACR. November 2014

Thank you