Ultrasound of the Thyroid and Parathyroid

Indications for Thyroid US

- enlarged gland
- palpable nodule
- history of childhood XRT or other high risk category
- incidental nodule identified while imaging the neck
- neck pain

Thyroid

- high resolution linear probe (7-15 MHz)
- length - 3.5 - 4.5-ish cm
- width - not over carotid, no anterior bulge
- isthmus < 3 mm, ± pyramidal
- always check for enlarged nodes
Thyroid Pathology

- Enlarged = Goiter
- many causes
- Diffuse vs. Nodular
- ? when to biopsy
- postoperative appearance

Diffuse: Grave’s Disease

- Chronic autoimmune process
- F>M
- thyroid releases all stored hormone
  ➔ hyperthyroid
- US not typically performed
- enlarged w/ nml gray scale and “thyroid inferno” w/ color

Diffuse - Hashimoto’s

- autoimmune syndrome “chronic lymphocytic thyroiditis”
- esp middle aged F
- euthyroid - hypothyroid
- large, possibly nodular on palpation- prompts US

Diffuse - Hashimoto’s

- variable gray scale
  ➔ enlarged and coarsened - “ugly, but can’t really find a nodule to measure”
  ➔ micronodular
  ➔ hypoechoic with prominent septations
  ➔ thick isthmus
Lorocco typical Hashimoto’s sag. L.jpg

Newcomb micronodular Hash. Spinosa micronodular Hashimotos mild.

2 different patients Caaarrolo susp nodule in Hashimotos

Try not to overcall nodules

If really convincing, biopsy

Hatcher long Hashimotos now growing low grade lymphoma Sag.jpg

Diffuse - Subacute Thyroiditis

- De Quervain’s thyroiditis
- gland destroyed by granulomas and fibrosis
- hyperthyroid then hypo
- uncommon, self limited, probably viral
- elevated ESR (75-100)
**Diffuse - Subacute Thyroiditis**

- nonspecific US, but tender
- diffusely heterogeneous, or ill-defined patchy hypovascular areas that disappear at F/U
- hypocellular (fibrosis) if bx done
  - but can mimic atypical or suspicious
- adenopathy common

**Multinodular Gland**

- enlarged
- multiple nodules
- cystic, solid, mixed, variable size
- cystic changes due to colloid, necrosis, and/or hemorrhage

**Mountain subacute thyroiditis**
ESR 75

**Painful ESR 75**

**8/01**

**10/01**

Pay attention to history
Suggest ESR

**Lundblad subacute thyroiditis**
8/01
Lundblad subacute thyroiditis recovered 10/01

Pay attention to history
Suggest ESR

**MNG Sperber sag**

Measure and biopsy largest, follow for growth, could check for function
**Focal Disease - Nodules**

- Incredibly common
  - 4 - 7% people have palpable nodules
  - 50 - 70% people > 60 years at US and autopsy
  - Palpation found only 20% of nodules seen at US (Chernobyl)
  - US critical

**Thyroid Nodules - Background**

- More common in women than men
- Increasing prevalence with increasing age
- Most grow slowly over time
- 5-10% are malignant
  - Which 10%?????

**Background: Epidemiology of Thyroid Cancer**

- 1975 incidence: 4.9/100,000
- 2014 incidence: 14.3/100,000
- Women: 6.5 → 21.4
- Men: 3.1 → 6.9
- Mortality stable: 0.5 deaths/100,000

Davies, Welch JAMA/Otolaryngology 2014

**Medullary Cancer**

- Middle aged woman with palpable nodule
- SAG RT
- Kpodo medullary thyroid ca

Davies, Welch JAMA/Otolaryngology 2014
**Background: Thyroid Nodules**

The challenge is to reassure the majority of patients who have benign nodular disease, and diagnose the “aggressive” malignant minority.

**BWH Thyroid Nodule Clinic 1995-2003**

1,985 patients / 3,483 nodules. 
cancer: 14.9% (295 pts)
US Characteristics: 
885 Nodules in 729 patients 
10.8 % malignant


**Results: Likelihood of Malignancy**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.15</td>
</tr>
<tr>
<td>Sex (M)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Size</td>
<td>0.48</td>
</tr>
<tr>
<td>Composition (solid)</td>
<td>0.002</td>
</tr>
<tr>
<td>Calcifications (+)</td>
<td>0.00002</td>
</tr>
<tr>
<td>Number (single)</td>
<td>0.003</td>
</tr>
<tr>
<td>Echogenicity (hypo)</td>
<td>0.01</td>
</tr>
<tr>
<td>Halo</td>
<td>0.39</td>
</tr>
</tbody>
</table>
Likelihood of Malignancy in a Solitary Nodule: Results of Multiple Logistic Regression of Sonographic Characteristics

<table>
<thead>
<tr>
<th>Women</th>
<th>Nodule Composition</th>
<th>Punctate Ca++</th>
<th>Coarse or Rim Ca++</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Completely solid</td>
<td>32.7%</td>
<td>26.1%</td>
<td>14.3%</td>
</tr>
<tr>
<td></td>
<td>Mostly solid</td>
<td>25.2%</td>
<td>19.6%</td>
<td>10.3%</td>
</tr>
<tr>
<td></td>
<td>Mixed solid &amp; cystic</td>
<td>15.7%</td>
<td>11.9%</td>
<td>6.0%</td>
</tr>
<tr>
<td></td>
<td>Mostly cystic</td>
<td>6.4%</td>
<td>4.7%</td>
<td>2.3%</td>
</tr>
<tr>
<td></td>
<td>Completely cystic</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
</tbody>
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Likelihood of Malignancy in a Solitary Nodule: Results of Multiple Logistic Regression of Sonographic Characteristics

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<th>Men</th>
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<th>Coarse or Rim Ca++</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Completely solid</td>
<td>47.8%</td>
<td>39.9%</td>
<td>23.9%</td>
</tr>
<tr>
<td></td>
<td>Mostly solid</td>
<td>38.7%</td>
<td>31.4%</td>
<td>17.8%</td>
</tr>
<tr>
<td></td>
<td>Mixed solid &amp; cystic</td>
<td>25.9%</td>
<td>20.3%</td>
<td>10.7%</td>
</tr>
<tr>
<td></td>
<td>Mostly cystic</td>
<td>11.3%</td>
<td>8.5%</td>
<td>4.2%</td>
</tr>
<tr>
<td></td>
<td>Completely cystic</td>
<td>0.0%</td>
<td>0.0%</td>
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Likelihood of Malignancy in a Non-Solitary Nodule: Results of Multiple Logistic Regression of Sonographic Characteristics

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<tr>
<th>Women</th>
<th>Nodule Composition</th>
<th>Punctate Ca++</th>
<th>Coarse or Rim Ca++</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Completely solid</td>
<td>18.4%</td>
<td>14.3%</td>
<td>7.2%</td>
</tr>
<tr>
<td></td>
<td>Mostly solid</td>
<td>13.2%</td>
<td>10.2%</td>
<td>5.0%</td>
</tr>
<tr>
<td></td>
<td>Mixed solid &amp; cystic</td>
<td>7.9%</td>
<td>6.0%</td>
<td>2.9%</td>
</tr>
<tr>
<td></td>
<td>Mostly cystic</td>
<td>3.0%</td>
<td>2.3%</td>
<td>1.1%</td>
</tr>
<tr>
<td></td>
<td>Completely cystic</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
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Likelihood of Malignancy in a Non-Solitary Nodule: Results of Multiple Logistic Regression of Sonographic Characteristics

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<tr>
<td></td>
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<td>28.5%</td>
<td>22.8%</td>
<td>12.1%</td>
</tr>
<tr>
<td></td>
<td>Mostly solid</td>
<td>21.2%</td>
<td>16.7%</td>
<td>8.5%</td>
</tr>
<tr>
<td></td>
<td>Mixed solid &amp; cystic</td>
<td>13.1%</td>
<td>10.1%</td>
<td>5.0%</td>
</tr>
<tr>
<td></td>
<td>Mostly cystic</td>
<td>5.2%</td>
<td>3.9%</td>
<td>1.9%</td>
</tr>
<tr>
<td></td>
<td>Completely cystic</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
</tbody>
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Thyroid Cancer

- If you could tell which nodule is cancer by sonographic appearance, you wouldn’t need to ever do an FNA…….

But, the data show:
- No sonographic appearance is predictive enough for cancer to avoid FNA and go straight to the OR.
Should we care about thyroid cancer?
- Low but persistent rate of distant mets, even with small cancers
- Pellegriti JCEM 2006 (<15mm)
  - Approx 1 in 4 had recurrent/persistent disease
- Chow Cancer 2003 (<10mm)
  - 5% LN recurrence/ 2.5% mets

Thyroid nodules at BWH – What do we do?
We biopsy all nodules ≥ 10mm
- We start with the 2 largest nodules, or any others that are sonographically suspicious, then discuss additional FNAs with patient
  (Usually stop at 4)
- It may take several visits to clear all nodules
- Exceptions: elderly, shortened life expectancy

Fine Needle Aspiration
- Most efficient means of determining the nature of a thyroid lesion
- Thyroidectomies 25%
  - Cancer dx at surgery to > 56%
  - Now 75+??
Complication - Hematoma

BWH Thyroid Nodule Clinic - Results
- Suspicious or Dx of cancer to OR
- re-aspirate all atypicals (offer Afirma)
- re-aspirate all insufficient x 2
- check TSH for functioning
- To OR
- F/U all benigns q 9-12m

Afirma
- 15-30% FNA’s are indeterminate / "atypical"
  - Surgery - most end up benign
  - multi-institutional study
    - Alexander et al, NEJM August 2012
  - tested the ability of a novel molecular classifier to accurately identify benign nodules

Afirma
- classifier uses signals from approximately 200 genes to identify benign nodules and avoid surgery
- 95% negative predictive value from single FNA sample
- $300 (or $3000) per test
SRU Consensus Conference Recommendations
Management of Nodule found at US

- Criteria for FNA change as size changes
- High risk criteria - FNA smaller size
- Low risk criteria - can wait for growth

Frates et al Radiology 2005;237:794-800

A. Solitary Nodule (Only a single nodule that is ≥ 1 cm in maximum diameter)

<table>
<thead>
<tr>
<th>Ultrasound Features</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcalcifications</td>
<td>Strongly consider US-FNA if ≥ 1 cm</td>
</tr>
<tr>
<td>Solid (or almost entirely solid) or Coarse calcifications</td>
<td>Strongly consider US-FNA if ≥ 1.5 cm</td>
</tr>
<tr>
<td>Mixed solid and cystic or Almost entirely cystic with a solid mural component</td>
<td>Consider US-FNA if ≥ 2 cm</td>
</tr>
<tr>
<td>None of the above but Grown substantially since prior US</td>
<td>Consider US-FNA</td>
</tr>
<tr>
<td>Almost entirely cystic and None of the above characteristics and No substantial growth (or no prior US)</td>
<td>US-FNA likely unnecessary</td>
</tr>
</tbody>
</table>

B. Multiple Nodules (At least two nodules ≥ 1 cm in maximum diameter)

Recommendation: Consider US-FNA of one or more nodules; selection to be prioritized based on the previously stated criteria, in the order listed above

1 Fine needle aspiration is likely unnecessary in diffusely enlarged glands with multiple nodules of similar sonographic appearances without intervening normal parenchyma.
2 The presence of abnormal lymph nodes overrides the sonographic features of the thyroid nodule(s) and should prompt US-FNA or biopsy of the lymph node and/or an ipsilateral thyroid nodule.

What to do?

- SRU consensus (ACE guidelines)
- BWH system
  - Every nodule > 10 mm
  - Repeat if >15% growth/year
- Insufficient data for “pattern approach” at present
- TIRADS is coming!

Learn the signs to recognize cancers or worrisome nodules

- microCa++, solid, hypervascular
- taller than wide
- solitary
- adenopathy, esp with Ca++
- high risk group
- firm on exam
- rapid growth nodule
Post-Surgical Evaluation

- may see residual normal tissue
- recurrence in bed – usually nodes
- cervical adenopathy - esp midline low
- combine with thyroglobulin (papillary) or calcitonin (medullary)

Lymph Nodes

**Benign:**
- short axis / long axis < 0.5 (long and thin)
- echogenic hilus- due to lymphatic channels, not fat
- ends that taper
- color:
  - normally enters at hilus and then branches
Lymph Nodes

Malignant:
- short axis / long axis > 0.5 (fat, round)
- trv diameter > 7 mm
- irregular margins
- microcalcifications
- cystic center – necrosis
- echogenic center - coagulation necrosis
- mass effect on vessels

Doppler not useful, but ? Power (color enters from ends)
Lymph Nodes

- Characterize every node as you scan
- Report enlarged (>7mm Trv) nodes with a descriptor “Benign, indeterminate or suspicious"
- Report sonographically abnormal nodes even if “too small”

Parathyroids

- 4 glands: sup / inf, right / left
- normally not seen sonographically
- superior most often behind mid thyroid, deep and medial
- inferior at lower tip, 20% in upper thymus
- supernumerary glands - 3-5%

1° Hyperparathyroidism

- parathyroid hormone regulates calcium
- ↑ calcium and ↑/nml PTH
- Causes:
  - adenoma: one(90%)/two enlarged(5%)
  - hyperplasia: all enlarged (5%)
  - cancer: rare, dx at surg/path

Parathyroid Adenoma

- esp 40-60 yo women, postmenopausal
- Sx: bone pain/osteoporosis, renal calculi, muscle weakness, fatigue, GI, psychiatric issues
  - “stones, bones, groans and moans”
Parathyroid Adenoma

- Minimally invasive surgery requires localization of the abnormal gland
- US: solid, homogeneous hypoechoic, flat or soft
- feeding vessel enters pole/arc along edge
- *Tech 99m Sestamibi for localization if US unsuccessful
- rapid serum PTH levels intraop

Is it a Parathyroid Adenoma?

- Series of 1600+ patients (Frasoldati JCU 1999)
- hypoechoic oval nodules near thyroid in 2.3%
  FNA – 24% parathyroid
  58% thyroid
  11% lymph node
  8% nondiagnostic

***Parathyroid adenomas not important unless biochemically active ****

Parathyroid Adenoma

- role of FNA for Dx
- don’t do it!
- single vessel enters the end of the gland, easily damaged at biopsy
- induces fibrosis/necrosis which can make resection more difficult and mimic cancer at pathology

***Parathyroid adenomas not important unless biochemically active ****
End stage renal disease
Parathyroid Hyperplasia
NOT a MN Gland

Atypical Parathyroid Adenoma

Echogenic Parathyroid Adenoma - occasional

Parathyroid Carcinoma
- Rare (<1%) of enlarged parathyroids
- Clues: peroperative Ca++ and PTH extremely high – nonspecific
- Local invasion at surgery
- Dx: external path or metastases (up to 30% at presentation)

Metastatic/recurrent esophageal cancer
Hodgkin’s Lymphoma
(any superior mediastinal mass)

- Thyroid
- FNA
- Lymph nodes
- Parathyroids