Challenges in the Sonographic Assessment of Thyroid Nodules

ATA 2016
Ultrasound Course

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Diagnostic thyroid ultrasound

Risk stratification

ATA Guidelines 2009; AACE/AME/ETA Guidelines 2010
Topics for discussion

- Echogenicity
- Bright reflectors
- Margins
- Shape

Trees (individual features) then forest (sonographic patterns) later . . .
Echogenicity

- Normal thyroid is homogeneously hyperechoic compared to the strap muscles
- Nodule echogenicity is defined relative to the normal thyroid (Hashi’s background)
  - Isoechoic/Hyperchoic grouped together
  - Hypoechoic
  - Sensitivity 81%, Specificity 53%
  - Marked hypoechogenicity, defined as relative to strap muscles

1Kim et al, AJR 2002
Normal thyroid
Hypoechoic nodules

- Most papillary cancers are hypoechoic
- However, since benign nodules are much more common, most hypoechoic nodules are benign!
- The likelihood of a cancer increases if hypoechogenicity is combined with a solid consistency, calcifications and/or intranodular flow
Hypoechoic nodules

Hypoechoic
c/w strap muscles

Markedly hypoechoic
c/w strap muscles
Iso/Hyperechoic Nodules

Hyperplastic nodule

Follicular carcinoma

If associated with cystic spaces → hyperplastic
If uniformly solid or associated with an irregular halo → concerning for a neoplasm such as Follicular or Hurthle cell adenoma/carcinoma or Follicular variant PTC
20-30% of all cancers are iso/hyperechoic: predominantly follicular/ Hürthle cell

- Benign Hürthle cell adenoma
- PTC foll variant Could be NIFTP!
- Follicular thyroid cancer
- Hyperplastic nodule
- Hyperplastic nodule
Sonographic features of Papillary thyroid cancer

- Hypoechoic
- Irregular margins
- Solid
- MicroCa2+

Frequency (%)

$n=259$ pts

Chan, J Ultrasound Med 2003; Yuan, Clin Imaging 2006; Jeh, Korean J Rad 2007
Sonographic features: Papillary vs. Follicular thyroid cancer

- Hypoechoic
- Irregular margins
- Solid
- MicroCa2+

References:
- Chan, J Ultrasound Med 2003
- Yuan, Clin Imaging 2006
- Jeh, Korean J Rad 2007

**86th Annual Meeting of the American Thyroid Association, September 21, 2016, Denver, Colorado**

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Sonographic features: Papillary vs. Follicular Variant of PTC

Kim J Ultrasound Med 2009
Partially cystic nodules: the solid part--what’s the difference?

Solid components

- LOWER risk (ATA Very low suspicion pattern): Concentric configuration with blunt angles
- HIGHER risk (ATA Low suspicion pattern): Eccentric configuration with acute angles

PEARL! Cystic papillary cancer solid component is iso/hyperechoic and rare time microcalcs not in hypoechoic solid area
Cystic Papillary Cancer

- <5% of PTC are >50% cystic
- Usually with frond-like regions and/or marked vascular flow and calcifications

Henrichsen J Clin Ultrasound 2010;38:361
Cystic papillary cancer
Bright reflectors
Calcifications (present in about 30%)

- Macro calcifications: hyperechoic spots with acoustic shadowing
- Microcalcifications: hyperechoic spots <1mm without acoustic shadowing (thought to represent psammoma bodies)

*Sensitivity 44%, Specificity 89%*

- Interrupted curvilinear calcifications
Calcifications

**Microcalcifications** (psammomatous) in papillary thyroid cancer

**Macro calcifications** in follicular thyroid cancer
Microcalcifications—the impact of post acquisition image processing
Macrocalkifications $>2\text{mm}$

- **A** = SOLITARY - linear or round, larger than 2mm, central
- **B** = SOLITARY - linear or round, larger than 2mm, at margin
- **C** = CURVILINEAR - greater than $120^0$ of margin
- **D** = COARSE NOS

Kim, J Ultrasound Med 2008; 27:1179
Curvilinear (peripheral) calcification

Complete, regular or “eggshell”

Interrupted with soft tissue excrescence

Papillary cancer

Follicular cancer

Usually benign

Nam-Goong Thyroid 2003; Lee J Ultrasound Med 2009
Peripheral Calcification

Incomplete and irregular

Sagittal

Transverse
1.3 cm PTC FV with Eggshell Calcification
Coarse calcifications

• Coarse calcifications are common in multinodular goiters secondary to dystrophic calcifications in long standing benign nodules
• When present in a solitary nodule have malignancy rates approaching 75%

Khoo ML, Arch Oto Head Neck Surg 2002
Medullary Cancer

Hypoechoic, infiltrative borders with coarse calcification
### Macrocalcifications

#### Pathology of 174 resected nodules with macrocalcifications

<table>
<thead>
<tr>
<th>Pathology</th>
<th>Solitary</th>
<th>Curvilinear</th>
<th>Coarse</th>
<th>Total</th>
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<tbody>
<tr>
<td>Malignant</td>
<td>36 (60)</td>
<td>52 (64.2)</td>
<td>28 (84.8)</td>
<td>116</td>
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<tr>
<td>Benign</td>
<td>24 (40)</td>
<td>29 (35.8)</td>
<td>5 (15.2)</td>
<td>58</td>
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<tr>
<td>Total</td>
<td>60</td>
<td>81</td>
<td>33</td>
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#### Greyscale suspicious features:
- Marked hypoechogenicity
- Irregular or lobulated margin
- Taller than wide

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<th>Malignant</th>
<th>Benign</th>
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<td>0</td>
<td>20 (17.2)</td>
<td>28 (65.5)</td>
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<td>1</td>
<td>38 (32.8)</td>
<td>14 (24.1)</td>
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<td>2</td>
<td>30 (25.9)</td>
<td>6 (10.4)</td>
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<td>3</td>
<td>28 (24.1)</td>
<td>0</td>
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<tr>
<td>Total</td>
<td>116</td>
<td>58</td>
</tr>
</tbody>
</table>

Kim, J Ultrasound Med 2008; 27:1179
? Coarse calcification

No dropout
Clumped Colloid

3 months earlier
Other echogenic foci
Echogenic foci with comet tail artifact

In pure cystic nodules, comet artifact indicates a benign cyst

Comet tail artifacts
- Large (> 1 mm long) less likely cancer (4%)
- Small (≤ 1 mm long) more likely cancer (16%)

30% CANCER RISK if small comet tail in hypoechoic nodule

Mahli AJR 2014; 203:1310
Comet tail (short) and microcalcifications
More echogenic foci and comet tail

Small hyperechoic linear streaks just posterior to small cystic area: posterior acoustic enhancement!
More echogenic foci and comet tail

Linear streak  Comet tail (large)
Note triangular shape
“Spongiform” nodules

- aggregation of multiple microcystic components in more than 50% of the volume of the nodule
- “honeycomb of internal cystic spaces”

<2% chance of malignancy

Margins

- Well-defined and regular or smooth
- IRREGULAR--Infiltrative, spiculated, lobulated\(^1\)
  - Sensitivity 55%, Specificity 79%
  - some malignant nodules have a predominately regular border but are irregular in only small portion requiring high-resolution technique
- Remember POORLY or ILL DEFINED is NOT the same as DEFINED AND IRREGULAR

\(^1\)Kim et al, AJR 2002
What defines the margins of a nodule?

- Hypoechoic or sonolucent rim surrounding ISO/HYPERechoic nodule (thought to represent the compressed perinodular vessels)—HALO
  - Smooth and thin thought to represent compressed perinodular blood vessels
  - Thick or irregular—more suggestive of CAPSULE of neoplasm (follicular or Hurthle cell carcinoma or adenoma; encapsulated papillary cancer)\(^1\)

\(^1\) Cerbone et al, Hormone Res 1999
Smooth halo  Thick, irregular halo

Thin halo is compressed blood vessels  Follicular cancer
What defines the margins of a nodule?

- Hypoechoic or sonolucent rim surrounding ISO/HYPERechoic nodule (thought to represent the compressed perinodular vessels)—HALO
  - Smooth and thin thought to represent compressed perinodular blood vessels
  - Thick or irregular—more suggestive of CAPSULE of neoplasm (follicular or Hurthle cell carcinoma or adenoma; encapsulated papillary cancer)

- Difference in echogenicity from surrounding thyroid parenchyma, i.e. HYPOechoic nodule c/w normal thyroid

1 Cerbone et al, Hormone Res 1999
Margins

- Smooth
- Ill-defined
- Irregular and ill-defined
- Microlobulated
- Lobular
- Spiculated
- Irregular/Jagged

http://www.oncoprof.net/Generale2000/g04_Diagnostic/Mammographie/gb04_mm06.html
Margins: differences in nodule’s echogenicity

- Spiculated
  - Papillary cancer
- Irregular/Jagged
  - Anaplastic cancer
- Macro-lobulated
  - Papillary cancer
- Micro-lobulated
  - Papillary cancer
Pitfall of Infiltrating Margins

Subacute Viral Thyroiditis
Margins—difference in nodule’s echogenicity

Margins ill-defined, NOT DEFINED and INFRINGEMENT
Note interface between cyst fluid and thyroid parenchyma

SPONGIFORM
Larger spongiform nodules

Hyperplastic nodule

- Area of the thyroid with follicular hyperplasia and accumulation of colloid
- Composed of follicles of various sizes and age, colloid, macrophages
Extrathyroidal invasion: Invasion through the capsule into muscle
Extrathyroidal invasion

Esophagus
Invasion of capsule and metastatic lymphadenopathy

Sagittal left lobe

Transverse left lateral neck

11 mm Papillary Thyroid Carcinoma
Shape: taller (anterior/posterior) than wide (transverse)

- Nodule is taller than wide on the transverse view—AP > transverse
  Sensitivity 48%, Specificity 92%

Kim AJR 2002; Cappelli Clin Endocrinol 2005; Moon Radiology 2008
Taller than wide shape better predictor of malignancy in SMALLER but NOT larger nodules

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<tr>
<th>Nodule size</th>
<th>Sensitivity</th>
<th>Specificity</th>
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<td>0-0.5 cm</td>
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<td>&gt;1.0 cm</td>
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Ren J Ultrasound Med 2015; 34:19-26
Vascularity
Patterns of nodular flow

sagittal

peripheral vascularity

sagittal

intranodular vascularity
Vascularity of nodules in Korea

- Study of 1083 nodules comparing vascularity as an independent predictor of malignancy (96% PTC)
- “Vascularity itself or a combination of vascularity and grayscale US features was not as useful as the use of suspicious gray-scale US features alone for predicting thyroid.”
  - Marked hypoechogenicity, ill-defined margins, microcalcifications, taller than wide

Moon Radiology 2010;255:260
### MULTIVARIABLE analyses of sonographic features

<table>
<thead>
<tr>
<th></th>
<th>Micro Ca(^{2+})</th>
<th>Hypo-echoic</th>
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<th>Tall-wide</th>
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Constellation of Sonographic features

ULTRASOUND PATTERN
High Suspension 70-90%

Intermediate Suspension 10-20%

Low Suspension 5-10%

Very low Suspension <3%

Benign <1%

ATA Nodule Sonographic Pattern Risk of Malignancy

Risk of malignancy