Challenges in Thyroid Nodules Sonography

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Challenges in Thyroid Sonography

- Identification of subtle margin features cornering for malignancy
- Correctly classifying echogenic foci as colloid versus calcification
- Correctly classifying mixed cystic and solid nodules as suspicious or non-suspicious for malignancy
Thyroid Nodules

Some concepts……

• What is a thyroid nodule?

• What features are useful in identifying thyroid nodules with a relatively high risk of malignancy?

• What features are useful in identifying thyroid nodules with a relatively low risk of malignancy?
Palpable Thyroid Nodule

• About 5% of the adult US population will have a nodule that is palpable on physical exam of the neck
  – The vast majority of palpable nodules are over 1 cm

• Measure a serum TSH (to exclude a functioning nodule)

• Perform an FNA

The risk of cancer in palpable nodules is 5 to 10%
Sonographic Thyroid Nodule

- “Nodule”- one or more areas of the thyroid with a different echotexture than surrounding parenchyma
- Most nodules are not true tumors but hyperplastic regions of the thyroid
- Most thyroid nodules are detected “incidentally”

5 mm non palpable nodule
How common are thyroid nodules in the United States on Ultrasound?

Mazzaferri, N Engl J Med 1993
Hyperplastic nodule

- Area of the thyroid that is stimulated to undergo follicular hyperplasia; *architectural distortion*
- Composed of follicles of various sizes and age, colloid, macrophages
Thyroid Nodules on Ultrasound that Undergo FNA

- Benign hyperplastic nodules (at least 70%)
- Benign thyroid adenoma (10%)
- Thyroid carcinoma (5 to 12%)
  - Papillary carcinoma (70-80%) - includes mixed papillary and follicular carcinoma
  - Pure Follicular Carcinoma (10 to 15%)
  - Medullary Carcinoma (5 to 10%)
  - Anaplastic carcinoma (<1%)
- Focal area of thyroiditis (1 to 5%)
- Unusual lesions: Intrathyroidal parathyroid, true cyst, metastatic disease
What nodules can’t we feel?
Ultrasound vs. Palpation

Brander, J Clin Ultrasound 1992
Thyroid Nodules

- Endocrinologists recommend an FNA of palpable nodules
  - 5% risk of malignancy in palpable nodules
- Palpable and non-palpable nodules of the same size have the same risk of malignancy
- Clinical dilemma of how to handle the “epidemic” of nodules detected by imaging (ITNs)
Features Associated with Malignancy

• **Lymphadenopathy**
• **Local invasion**
  • Microcalcifications
  • Coarse and peripheral calcifications
  • Taller than wide shape
  • Markedly hypoechoic echotexture
  • Infiltrating margins
  • Hypoechoic echotexture with solid consistency
  • Intranodular flow in association with hypoechogenicity/irregular margins
Micro-PTC with Nodal Mets
Papillary Thyroid Cancer: Lymph node metastases

Solid with Ca++

Entirely cystic

Mixed cystic and solid
Anaplastic Tumor with Extra-thyroidal Extension (ETE)

Residual normal thyroid
Trachea
ETE: Invasion through the capsule and into muscle
Extra-thyroidal Extension

Esophagus
7x5x7mm MicroPTC with capsular invasion and extrathyroidal extension
Invasion of capsule and metastatic lymphadenopathy

Sagittal view of left lobe

Trv view of left lateral neck

11 mm Papillary Thyroid Carcinoma
Features associated with malignancy

- Lymphadenopathy
- Local invasion
  - Microcalcifications
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  - Infiltrating margins
  - Hypoechoic echotexture with solid consistency
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Microcalcifications

- Multiple bright punctate (under 1 mm) echoes without shadowing
- Highly specific sign of malignancy

Papillary carcinoma
Mixed population of calcifications

Multifocal calcified papillary cancer

Mixed coarse and microcalcifications
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
Peripheral calcification

Complete, regular or “eggshell”

Interrupted

Visible ST extension

Most benign

Papillary cancer

Follicular cancer

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

Incomplete and irregular

Papillary Ca
Extension of soft tissue beyond peripheral calcifications
1.3 cm FVPTC with Eggshell Calcifications
Medullary Cancer
Thyroid Nodule Calcifications

- Micro-calcifications**
- Large, coarse calcifications**
- Peripheral calcifications
  - Eggshell
  - Interrupted**
- Small central linear
- Small central curvilinear

** = statistically associated with PTC

Moon HJ et al, Radiology;262:1002, 2012
Small Linear Calcifications
Small Linear Calcifications
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 all solid consistency, calcifications and/or irregular margins.
HIGH RISK

Hypoechoic, solid, and hypervascular

microCa$^{2+}$

hypervascular

Papillary carcinoma
Iso- or Hyperechoic Nodules

Hyperplastic nodule

If associated with cystic spaces → most are benign

Follicular carcinoma

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
Margins

Smooth
Ill-defined
Ill-defined and irregular
Microlobulated
Lobular
Spiculated
Jagged/Irregular
Margins Associated with Malignancy

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

Subacute Thyroiditis
Margins Associated with Malignancy

Lobular

Microlobulated

www.oncoprof.net
Lobulated Margins

**Macrolobulated**

- Papillary carcinoma

**Microlobulated**

- Papillary carcinoma
Evaluation of the Margins

- Irregular or infiltrating border or lobulated margin carries an 80% specificity for thyroid cancer (range of 62 to 86%)
- High inter-observer variability

Papillary carcinoma

Papillary carcinoma
Halo-Dark Rim Around a Nodule

- Maybe partial or complete
- Most common in follicular adenomas
- Lacking in most carcinomas but also in most benign nodules
- Very common for benign nodules to have poorly defined margins (*not infiltrative or lobulated*)
Ill-defined, **BUT NOT** an infiltrative or jagged margin is not a risk for thyroid malignancy.
“Taller than wide” Shape

- Nodule is taller than wide on the transverse view
- Most commonly noted in small, less than 10 mm nodules
- Reflects aggressive growth

Kim AJR 2002; Cappelli Clin Endocrinol 2005; Moon Radiology 2008
<table>
<thead>
<tr>
<th>Nodule size</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
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<td>0-0.5 cm</td>
<td>81.4</td>
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Ren J, et al. JUM 2015; 34:19-26
# US Prediction of Cancer

<table>
<thead>
<tr>
<th>Feature</th>
<th>Sensitivity</th>
<th>Specificity</th>
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<tr>
<td>Microcalcifications</td>
<td>43%</td>
<td>91%</td>
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<tr>
<td>Irregular margins</td>
<td>53%</td>
<td>73%</td>
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<td>Hypoechoic</td>
<td>75%</td>
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<td>Increased intranodular flow</td>
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<td>Tall&gt;Wide</td>
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<td>$\text{MicroCa}^{2+} + \text{irreg margin}$</td>
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<tr>
<td>$\text{MicroCa}^{2+} + \text{hypoechoic}$</td>
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<td>Solid + hypoechoic</td>
<td>68%</td>
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20 to 30% of Thyroid Cancers are Predominantly Follicular Lesions

Follicular variant papillary thyroid cancer

Pure Follicular Thyroid Cancer
Sonographic features:

Papillary vs. Mixed Papillary and Follicular Thyroid Cancer

Chan, J Ultrasound Med 2003; Yuan, Clin Imaging 2006; Jeh, Korean J J Rad 2007
Patterns of nodular flow

sagittal

peripheral vascularity

intranodular vascularity

sagittal
Intra-nodular flow

- The risk for malignancy is about 30 to 40% for solid and hypervascular nodules
- However, still over 50% of hypervascular nodules are benign

[Images of Adenoma and Hyperplastic nodule]
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 HJ et al Radiology: Volume 255: Number 1—April 2010*
MULTIVARIABLE analyses of sonographic features

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High % Foll ca
US Features

CANCER

BENIGN

BENIGN

BENIGN

BENIGN

BENIGN
Completely cystic: Colloid cysts

Comet-tail artifact
“Spongiform” nodules

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

Moon Radiology 2008; 247: 762–70
Bonavita AJR 2009; 193:207–13
LOW RISK: “Spongiform” nodules

Only 1 of 360 cancers had this appearance → specificity 99.7%

Moon, Radiology 2008; 247:762-770
Given that 7-9% of nodules are cancers, for every 1000 nodules that LACK:

- Taller than wide shape
- Spiculated, infiltrative margin
- Hypoechogenicity
- Microcalcifications
- Macrocalcifications

Only 9 of 1000 (0.9%) are cancer!!!!*

96% of the cancers were PTC

*by Bayes’ theorem  
“Spongiform” and Under 2 cm

Very low risk of malignancy
Small bright foci- are these microcalcifications??

NO!!!
Types of Non-Shadowing Echogenic Foci

- Foci with large comet-tail; Inverted triangle
- Round, bright No posterior echoes
- Linear without clear triangle
- Punctate and Small (< 1mm)
Large Comet Tail
Comet Tail-Inverted triangle
Echogenic foci without reverberation
Echogenic focus with small comet tail
Linear without reverberation
Types of Non-Shadowing Echogenic Foci

Comet-tail; Inverted triangle (100% B, 6/6)

Linear without clear triangle (100% B, 15/15)

Round, bright No posterior echoes (96% B, 13/14)

Punctate and Small (< 1mm) (69% B, 9/13)

Beland MD et al, JUM 2011:30:753-760
• Examine other nodule features
• Real time exam or cine loops
• Lower frequency probe
• Colloid DOES NOT mean benign
Microcalcs???????
Clumped Colloid

3 months earlier
Mixed Cystic and Solid nodules

- 6% of PTC are predominantly cystic
- Cystic PTC usually has frond-like regions and/or marked vascular flow and calcifications

Predictors of Cystic PTC

Solid components which show

- Eccentric configuration with acute angles
- Microcalcs
- Macrolobulation
- Irregular free margin

- A = concentric configuration, smooth margin
- B = eccentric with blunt angle
- C = acute angle, microlobulation
- D = acute angle, macrolobulation, hypoechogenicity and calcs
Cystic Papillary Carcinoma
Cystic papillary cancer
Cystic PTC
Summary of Ultrasound Appearance

• No single US feature or combination is adequately SENSITIVE to identify all malignant nodules

• However, certain features and combination of features have high PREDICTIVE value to indicate if a nodule is likely to be malignant and the ABSENCE of these features has high NEGATIVE PREDICTIVE VALUE
Challenges in Thyroid Sonography

- Identification of subtle margin features cornering for malignancy
- Correctly classifying echogenic foci as colloid versus calcification
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Is it possible to have too much challenge in one day?