The Interventional Cytopathologist: Ultrasound-Guided FNA for Pathologists

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Disclosure of Relevant Financial Relationships

No relevant financial relationships

Outline

- Ultrasound Basics
- Ultrasound Characteristics
  - Breast
  - Lymph nodes
  - Thyroid
- Pathologist-performed US-FNA
  - Technique
  - Diagnostic efficiency
  - Cost-effectiveness
- Our Experience

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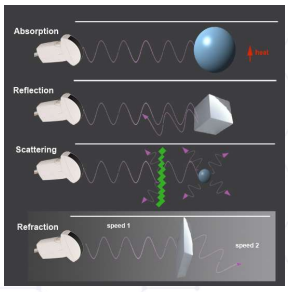
Ultrasound Basics

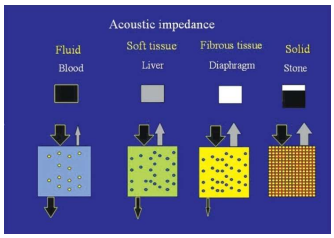
- Transducer emits waves from piezoelectric crystals
- Medical US: frequencies of 2-20 MHz
  - Lower frequency: greater depth of penetration, lower resolution
  - Higher frequency: higher resolution, less depth of penetration
- Transducer "listens" for returned echoes



http://www.sonoguide.com/physics.html

Ultrasound Basics

Different tissue types absorb or reflect ultrasound waves to varying degrees.



Abu-Zidan FM, Hefny AF, Corr P (2011) Clinical ultrasound physics. Journal of emergencies, trauma, and shock 4 (4):501-

Ultrasound Modes

"B" or Brightness Mode

Greyscale 2-D image in a ~1mm "slice"

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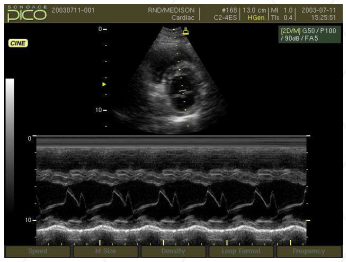
Ultrasound Modes

"M" or Motion Mode

Imaging one line over time



http://www.medison.ru/uzi/eho248.htm

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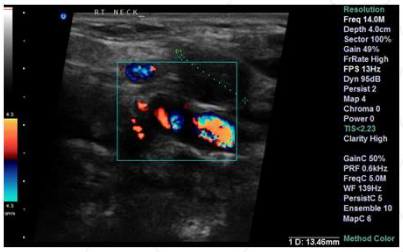
Ultrasound Modes

Doppler Mode

Measures direction and speed of tissue and blood motion



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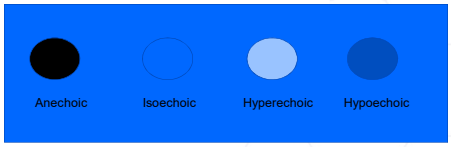
Echogenicity Terms

Anechoic – black (fluid, ex. blood, cyst fluid)
Isoechoic – same intensity as surrounding tissue
Hyperechoic – brighter than surrounding tissue
Hypoechoic – darker than surrounding tissue



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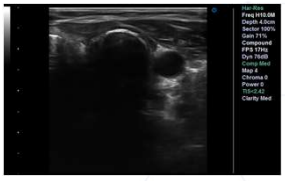
Artifacts - Posterior shadowing

Significant reflection/absorption of wave.
- Strong reflector (ex. air)
- Strong absorbers (ex. stones, bone)



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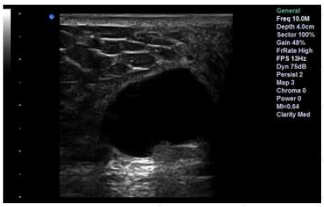
Artifacts – Posterior Enhancement

Area behind an anechoic structure appears brighter than surrounding tissue



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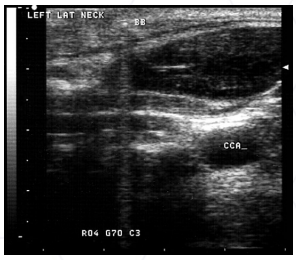
Artifacts - "Comet tail"

Reverberation artifact from front and back of very strong reflector (ex. air bubble, metal fragment)



http://www.sonoguide.com/physics.html

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Artifacts - Speed Propagation

Machines use 1.54 mm/μs as average speed of sound in soft tissue to calculate depth.

- If sound actually travels faster in the tissue (anechoic or hypoechoic structures), a reflector will appear closer to the transducer than its actual depth, and vice versa

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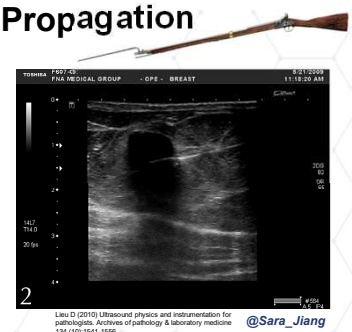
Artifacts - Speed Propagation

Basis of "bayonet sign"



Lieu D (2010) Ultrasound physics and instrumentation for pathologists. Archives of pathology & laboratory medicine 134 (10):1541-1556.

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Outline

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Ultrasound Characteristics

Breast

Lymph nodes

Thyroid

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Breast - Normal ultrasound anatomy

Lieu D (2013) Breast imaging for interventional pathologists. Archives of pathology & laboratory medicine- 137 (1):103-119.

SK-skin
SF-subcutaneous fat
CL – coopers ligaments
MZ – mammary zone
PM– pectoralis muscle
PL - pleura
L- lung

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Breast – Benign findings

Cyst
- Anechoic
- Smooth, sharp margins
- Posterior acoustic enhancement

Lieu D (2013) Breast imaging for interventional pathologists. Archives of pathology & laboratory medicine 137 (1):100-119

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Breast – Benign findings

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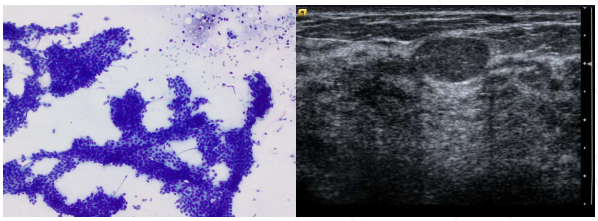
Breast – Benign findings



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Breast – Benign findings

Fibroadenoma
- Well-circumscribed, round to oval, mobile
- May have few lobulations
- May contain calcification, esp. in older women
- Hypoechoic

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Breast – Benign findings

Fat necrosis
- Varied appearance depending on fibrosis
- May be well-circumscribed or spiculated
- Hyper- to anechoic
- Lack vascularity

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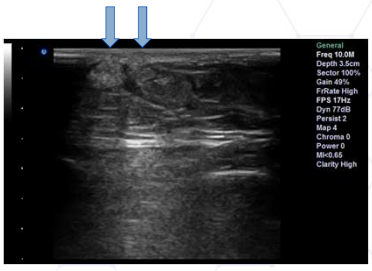
Breast

Concerning features for malignancy
- Fixed, non-compressible
- "Taller than wide" (Anterioposterior > transverse dimension)
- Irregular margins



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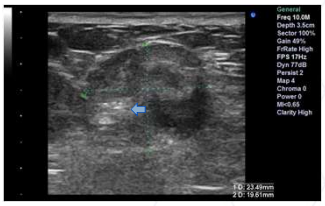
Breast

Concerning features for malignancy
- Calcifications
- Irregular internal echoes



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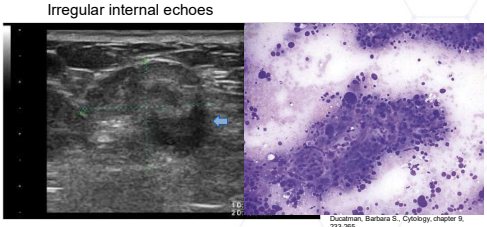

Ducatman, Barbara S., Cytology, chapter 9, 233-265

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Ultrasound Characteristics

Breast

Lymph nodes

Thyroid

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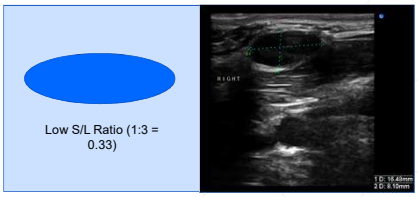
Lymph Nodes - Normal U/S Characteristics

Short axis : Long axis ratio (S/L Ratio) ≤0.5 (i.e. oval)

Hypoechoic



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Lymph Nodes - Normal U/S Characteristics

Echoic fatty hilum

Central vascularization

http://www.msdlatinamerica.com/ebooks/CoreCurriculumTheUltrasound/sid232718.html

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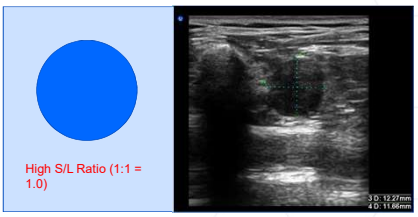
Lymph Nodes - Concerning features

High Short axis : Long axis ratio (S/L Ratio)



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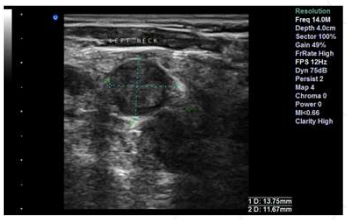
Lymph Nodes - Concerning features

Internal heterogeneity



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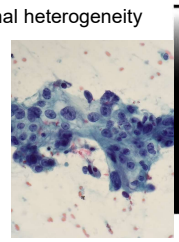

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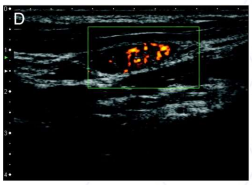
Lymph Nodes - Concerning features

Irregular margin with surrounding tissue
Absent fatty hilum
Increased vascularity/ vessels outside the hilum



Leboulleux S, Girard E, Rose M, et al. Ultrasound Criteria of Malignancy for Cervical Lymph Nodes in Patients Followed Up for Differentiated Thyroid Cancer. Journal of Clinical Endocrinology & Metabolism, Published in 1 2023 DOI: [illegible]

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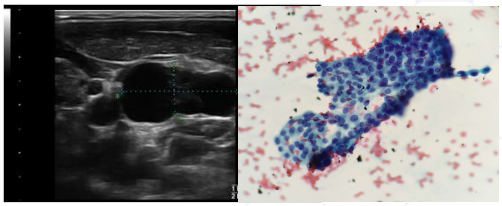
Lymph Nodes – Cystic mets

Thyroid cancer, H/N SCC
Hyperechoic punctuations / calcifications



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Ultrasound Characteristics

Breast
Lymph nodes
Thyroid

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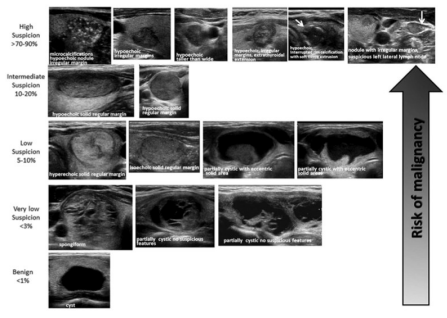

Haugen et al. Thyroid. 2015 American Thyroid Association Management Guidelines for Adult Patients with Thyroid Nodules and Differentiated Thyroid Cancer

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Ultrasound pattern	Risk of malignancy %	FNA size cut off
High suspicion	>70-90	>1 cm
Intermediate suspicion	10-20	> 1cm
Low suspicion	5-10	> 1.5 cm
Very low suspicion	<3	> 2cm vs observation
Benign	<1	No biopsy

Haugen et al. Thyroid. 2015 American Thyroid Association Management Guidelines for Adult Patients with Thyroid Nodules and Differentiated Thyroid Cancer

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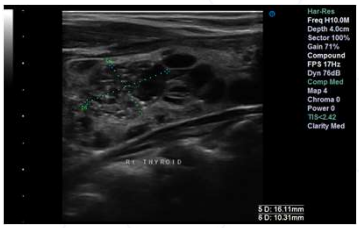
Thyroid Nodules - Likely Benign Patterns

<10mm size, fluid-filled

"Honeycomb" morphology



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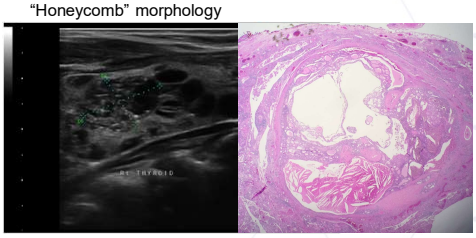

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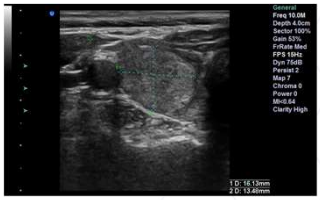
Thyroid Nodules - Likely Benign

Markedly hyperechoic solid with regular border

Colloid nodule or focal nodular Hashimoto thyroiditis



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Thyroid Nodules - Likely Benign

Markedly hyperechoic nodule

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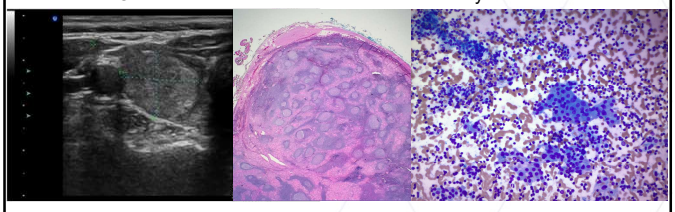

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Thyroid Nodules - Likely Benign

Large, predominantly cystic nodules

Cystic thyroid carcinoma rarely has cystic change occupying >50% of nodule (if >50%, calcification or abnormal vessels usually present. in addition)

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Thyroid Nodules - Concerning Patterns

Solid hypoechoic nodule with discrete / coarse echogenic foci
Both papillary and medullary carcinomas are hypoechoic

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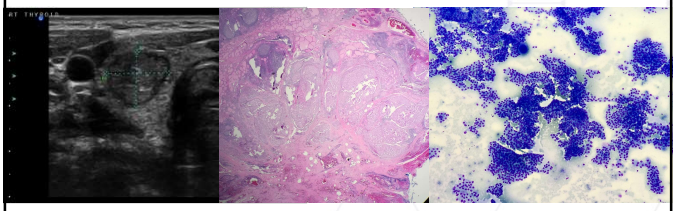

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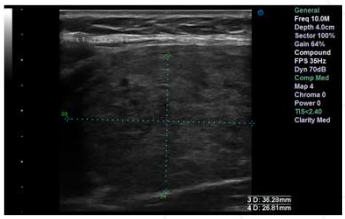
Thyroid Nodules - Concerning Patterns

Solid oval nodules with thin capsule
Appearance of benign and malignant follicular lesions



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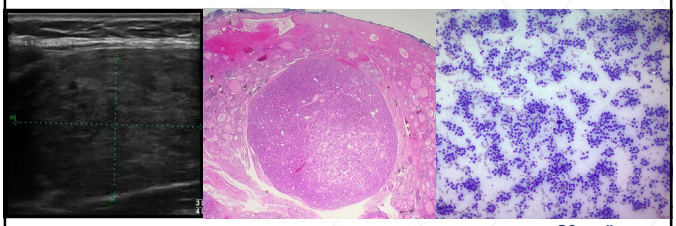

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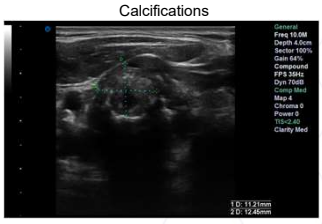
Thyroid Nodules - Concerning Patterns

"Taller than wide"
Irregular borders
Calcifications



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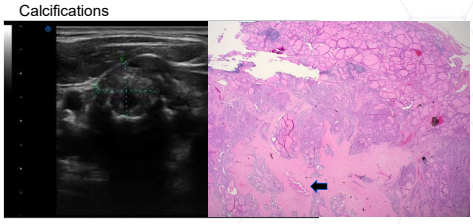
Thyroid Nodules – Concerning Features

"Taller than wide"
Irregular borders
Calcifications



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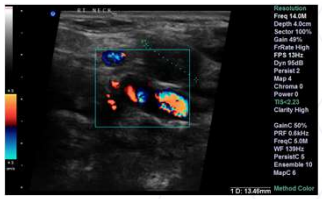
Advantages of Ultrasound

Able to biopsy non-palpable lesions
Direct visualization of needle tip
Avoid trauma to important structures



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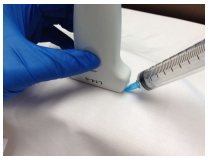
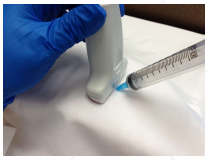
US-FNA Technique

- Needle parallel to transducer (in beam)
- Needle perpendicular to transducer (out of beam)

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US-FNA Technique

- Needle guide
- French (Zajdela) technique
- Negative pressure technique

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Diagnostic Efficiency

Thyroid literature shows increase in diagnostic yield for thyroid nodules with ultrasound guidance

Inadequate rate	Ultrasound-Guided	Palpation-Guided
Carmeci et al. 1998	7%	16%
Hatada et al. 1998	17%	30%
Cesur et al. 2006	21.4%	32.3%
Redman et al. 2006	3%	7%

Redman et al. found fewest passes and lowest unsat rate achieved by endocrinologist/pathologist team (vs surgeons, community physicians, radiologists)
Did not assess aspirations performed by pathologist alone

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Diagnostic Efficiency

- Lieu D. – Single-operator pathologist-performed US-FNA series

Table III. Distribution of Diagnoses

Location	*Number of cases*	*Satisfactory*	*Diagnoses*
Thyroid	234	228 (97.4%)	194 (82.9%) Colloid goiter 19 (8.1%) Follicular lesion/atypical 11 (4.7%) Thyroiditis 4 (1.7%) Papillary carcinoma
Breast	184	184 (100%)	61 (33.2%) Cyst 56 (30.4%) Fibroadenoma 33 (17.9%) Malignant/atypical 11 (6.0%) Fibrocystic 23 (12.5%) Other
Head and neck	64	63 (98%)	33 (51.6%) Lymphadenitis 7 (10.9%) Benign tumor 4 (6.2%) Metastases 19 (29.7%) Other
Other sites	18	18 (100%)	8 (44.4%) Malignant 5 (27.8%) Benign 4 (22.2%) Inflammatory 1 (5.6%) Other
Total	500	493 (98.6%)	

Lieu D. Cytopathologist-performed ultrasound-guided fine-needle aspiration and core-needle biopsy: A prospective study of 500 consecutive cases. Diagnostic Cytopathology. 2008;36(5):317-324.

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Diagnostic Efficiency

Wu M. - Single-operator pathologist-performed US-FNA series

Table I. Summary of Diagnostic Rates Comparing Pathologists Performed FNA With or Without Ultrasound Guidance

FNA type	*PGFNA (n = 100)*	*USGFNA (n = 100)*
Diagnostic rate (%)	83	86
Suspicious/atypical/suggestive (%)	10	13
Nondiagnostic rate (%)	7	1

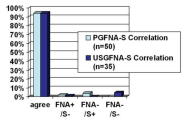

Fig. 3. FNA surgical correlations in 50 PGFNA compared to 35 USGFNA cases. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

Wu M. A comparative study of 200 head and neck FNAs performed by a cytopathologist with versus without ultrasound guidance: Evidence for improved diagnostic value with ultrasound guidance. Diagnostic Cytopathology. 2010;38(10):743-751.

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Cost-effectiveness

Palpation vs US-guided FNA of thyroid nodules

- Khalid et al. 2008 - Incremental cost per additional correctly diagnosed case of $289
- Can 2009 – Incremental savings per additional correctly diagnosed case of 138 euros (~$183)

Table 5: Cost-effectiveness comparison between palpation- and ultrasound-guided thyroid fine-needle aspiration biopsies with costs from this study and outcomes from previous studies

Author Year	n	P-FNA Inadequate	P-FNA Strategy Cost*	P-FNA Accuracy	USG-FNA Inadequate	USG-FNA Strategy Cost*	USG-FNA Accuracy	ICER	Reference
Danese 1998	9683	9%	€270	0.73	4%	€337	0.76	+€22233	[3]
Hirishi 1998	166	30%	€395	0.48	17%	€413	0.68	+€790	[4]
Cesur 2006	285	32%	€430	0.77	21%	€437	0.89	+€58	[5]
Izquierdo 2006	376	11%	€290	0.61	7%	€344	0.80	+€284	[6]
Can 2009	268	42%	€534	0.64	29%	€523	0.72	-€138	This study

n: total number of nodules, P-FNA: palpation-guided thyroid fine-needle aspiration biopsy, Inadequate: inadequate rate, USG-FNA: ultrasound-guided thyroid fine-needle aspiration biopsy, ICER: incremental cost-effectiveness ratio, ICER is calculated by dividing the difference between strategy cost of USG-FNA and strategy cost of P-FNA to the difference between accuracy of USG-FNA and P-FNA. A positive ICER value indicates more, a negative ICER value indicates less expense for USG-FNA strategy over P-FNA strategy *Strategy cost is derived from figure 1 or 2, table 1 and cytology outcomes from references.

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Cost-effectiveness

Layfield et al. 2001 – Medicare payment insufficient to compensate for on-site evaluation (OSE) unless pathologist both performs and interprets aspirate

Nasuti et al. 2002 – Estimated ~$400,000 savings/yr when OSE used to avoid repeat FNA

Zanocco et al. 2013 – OSE for US-guided FNA of thyroid nodules is not cost-effective unless:

- Adequacy rate without OSE <85%
- 35% cost-reduction in cost of OSE

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Cost-effectiveness

Potential for improved cost-effectiveness for pathologist-performed US-FNA

- Pathologist both performs and interprets aspirate
- Centralized clinic reduces cost of OSE by improving pathologist efficiency
- Less personnel required

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Outline

Ultrasound Basics

Ultrasound Characteristics
- Breast
- Lymph nodes
- Thyroid

Pathologist-performed US-FNA
- Technique
- Diagnostic efficiency
- Cost-effectiveness

Our Experience

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Ultrasound-Guided FNA Clinic

Initiated October 2011

Stand-alone "walk-in" clinic

Initially: Ultrasonix SonixTouch

Now: Philips Affinity 50
- Linear transducer
- "Hockey-stick" transducer

https://www.usa.philips.com/healthcare/

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Ultrasound-Guided FNA Clinic

Prior to initiation:

- Attending cytopathologists were certified by the College of American Pathologists in US-FNA
- Multiple on-site training sessions for the ultrasound instrument were held
- Referring clinicians were informed by direct communication
- Educational session held by director of cytopathology for endocrinologists

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Clinic Workflow

- Clinician pages FNA team
- Patient arrives with referral request to clinic
- Clinic staff checks-in patient and put them in room
- Biopsy performed
- Patient returns to clinician or home

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Original Article

Pathologist-performed ultrasound-guided fine-needle aspirations of the thyroid: A single institution observational study

David R. McKenzie, MD; Evelyna G. Kliassov, MD; Rajesh C. Dash, MD; Wen-Chi Foo, MD; Claudia K. Jones, MD; and Xiaoyin Jiang, MD

TABLE 1. Distribution of Bethesda categories

Bethesda Category	Female, No. (%)	Male, No. (%)	Total No.	% of Total[a]
I. Nondiagnostic	80 (5.4)	31 (6.8)	111	7.3
II. Benign	812 (55.2)	190 (39.9)	1002	65.4
III. AUS/FLUS/HCLUS	237 (16.1)	58 (12.2)	295	19.3
IV. Suspicious for follicular neoplasm or follicular neoplasm	29 (2.0)	27 (5.7)	56	3.7
V. Suspicious for malignancy	15 (1.0)	5 (1.1)	20	1.3
VI. Malignant	23 (1.6)	24 (5.0)	47	3.1
Total	1396	475	1531	100.0

Abbreviations: AUS, atypia of undetermined significance; FLUS, follicular lesion of undetermined significance; HCLUS, Hurthle cell lesion of undetermined significance.

biopsied associated with a definitive diagnosis. *Cancer Cytopathol* 2022;130:735-739. © 2022 American Cancer Society.

KEY WORDS: Bethesda; fine-needle aspiration; pathologist; thyroid; ultrasound.

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Diagnostic Cytopathology

ORIGINAL ARTICLE

Pathologist-performed ultrasound-guided fine needle aspiration biopsies of extrathyroidal sites: An observational study

Evelyna George Kliassov MD, David Robert McKenzie MD, Rajesh Chandra Dash MD, Xiaoyin Jiang MD, Claudia Kay Jones MD, Wen-Chi Foo MD

First published: 24 November 2022 | https://doi.org/10.1002/dc.25083

Table 1: Frequency of extrathyroidal pathologist-performed ultrasound-guided fine needle aspiration biopsies by site

Site	Number of Cases	Percentage of Cases (%)
Abdomen	6	4.2
Axilla	3	2.1
Breast	7	4.9
Chest wall	1	0.7
Extremity	5	3.5
Head	4	2.8
Inguinal	7	4.9
Neck	68	47.6
Salivary gland	16	11.2
Soft tissue	15	10.5
Supraclavicular	11	7.7
Total	143	100

Table 3. Distribution of biopsies by diagnostic category

Diagnostic category	Number of cases	Percentage of cases (%)
Negative for malignancy	73	51
Atypical/Inconclusive	14	9.8
Suspicious for malignancy	8	5.6
Diagnostic of malignancy	38	26.6
Non-diagnostic	10	7
Total	143	100

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Take-homes

- Ultrasound expands range of lesions that may be targeted
- Understanding basics of ultrasound is helpful for aspiring interventional cytopathologists
- Ultrasound examination provides useful information for interpretation and performance of FNA of common sites
- Pathologist-performed US-FNA is safe, effective
- Potential for improving cost-efficiency
- Well-received in our experience by patients and referring colleagues
- Good performance in tertiary care teaching hospital setting

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