Thyroid Insights: A Sound Approach to Health

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1

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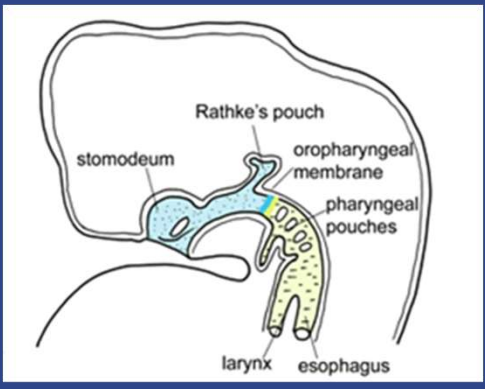
4

Objectives

- 1. Review the anatomy and function of the thyroid gland.
- 2. Outline the purpose of thyroid ultrasound and best practices.
- 3. Describe normal and abnormal findings.

5

Thyroid Gland Embryology



https://commons.wikimedia.org/wiki/File:Cross-sectional_views_of_the_developing_embryo_demonstrating_the_stomodeum_and_the_pharynx.png

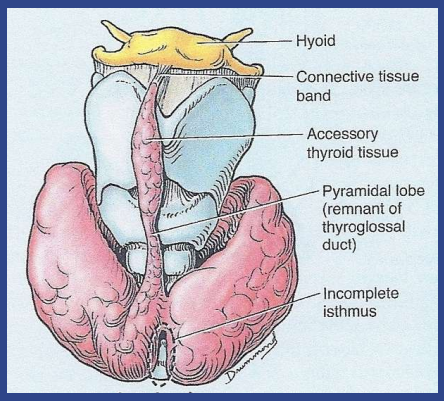
- The thyroid is the first endocrine gland to appear in the embryo (3-4 weeks of gestation).
- It develops from an invagination in the primitive pharynx and migrates downward
- This leaves behind the thyroglossal tract (duct), which normally atrophies.

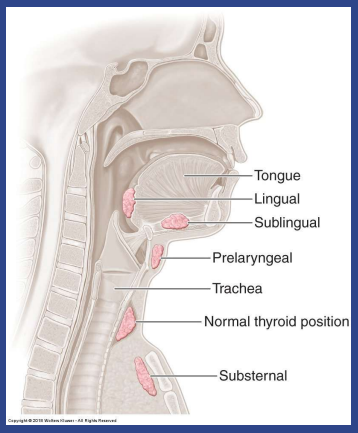
- Kawamura, D K, Nolan, T. (2023). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 5th ed. Philadelphia, PA: Wolters Kluwer

6

Anatomic Variations

- Absence of Thyroid
- Pyramidal Lobe
- Absence of Isthmus
- Ectopic Gland

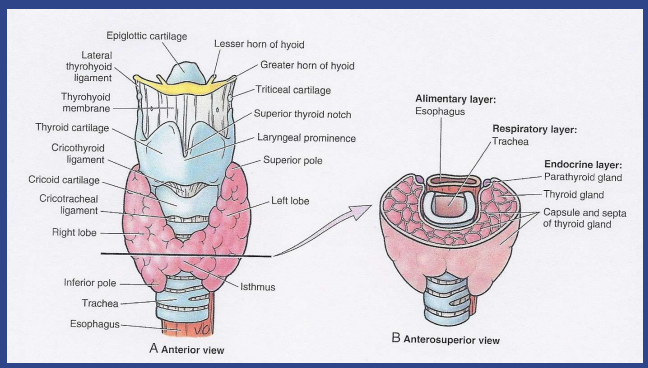




- Kawamura, D K, Nolan, T. (2023). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 5th ed. Philadelphia, PA: Wolters Kluwer

7

Thyroid Gland Anatomy

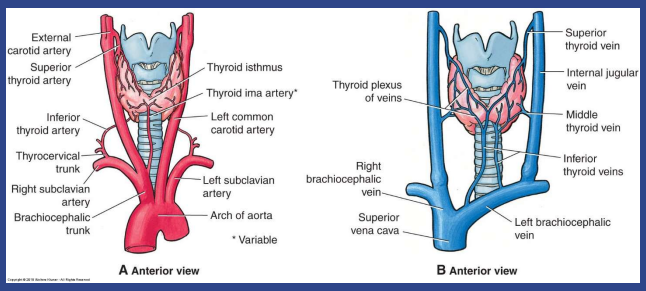


- **Location:** Located in the anterior neck, surrounded by a fibrous capsule.
- **Structure:** Consists of a right and left lobe connected by a thin isthmus, typically over the second and third tracheal rings.
- **Size:** An adult thyroid weighs about 30 g. Its size varies with age, body size, and gender, being slightly larger in females.

- Kawamura, D K, Nolan, T. (2023). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 5th ed. Philadelphia, PA: Wolters Kluwer

8

Thyroid Blood Supply



- **Arteries (4)**
  - Superior & Inferior Thyroid Arteries
  - Normal Peak Velocity 20-40 cm/sec
- **Veins**
  - 3 pairs of veins drain the thyroid plexus (Superior, Middle, and Inferior Veins)

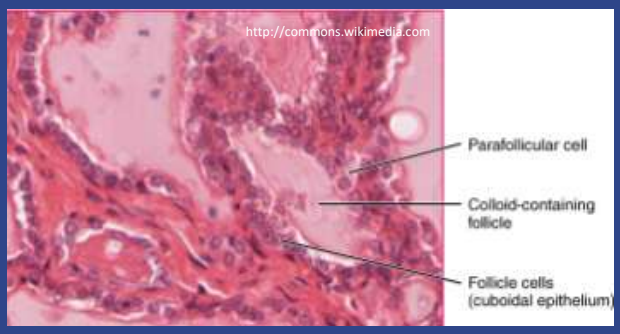
- Kawamura, D K, Nolan, T. (2023). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 5th ed. Philadelphia, PA: Wolters Kluwer

9

Thyroid Cellular Structure

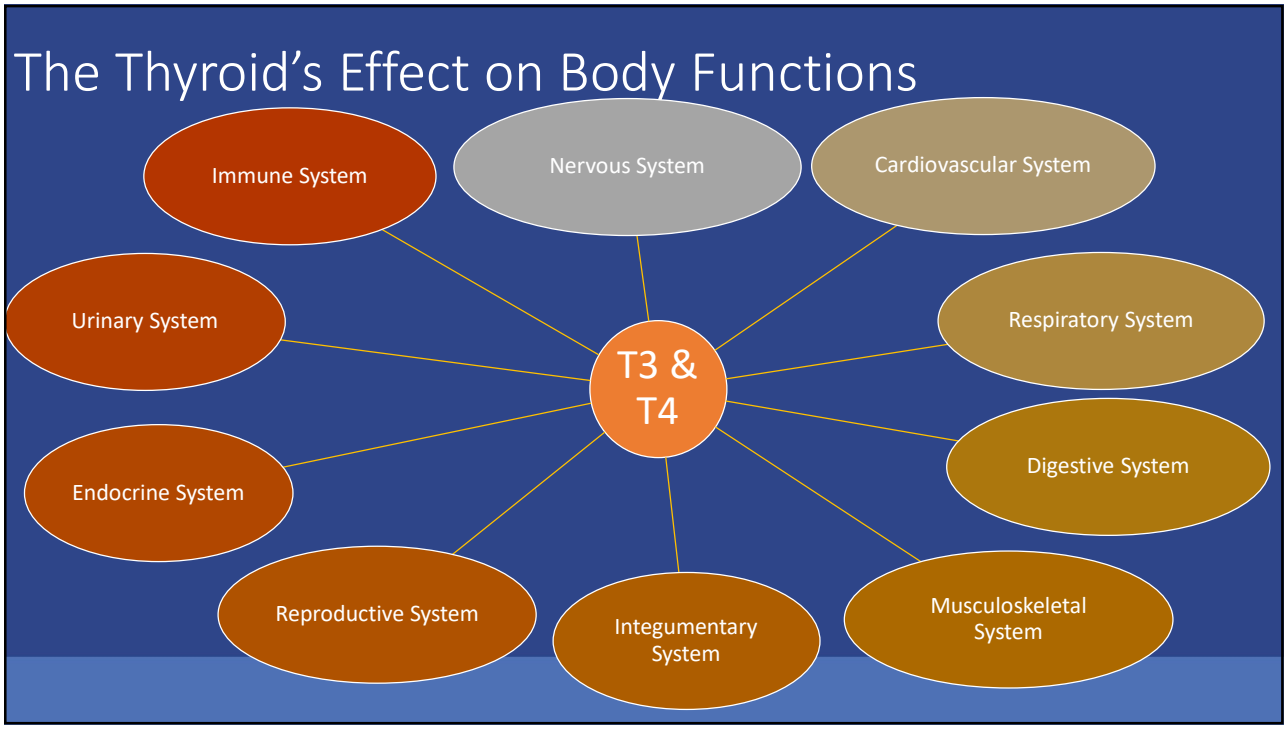
Thyroid Follicular Cells
- Tiny Spherical Sacs
- Process Iodine to produce T4 (90%) and T3 (more potent 10%)

Parafollicular C cells
- Between layers of Epithelium
- Calcitonin



10

The Thyroid's Effect on Body Functions

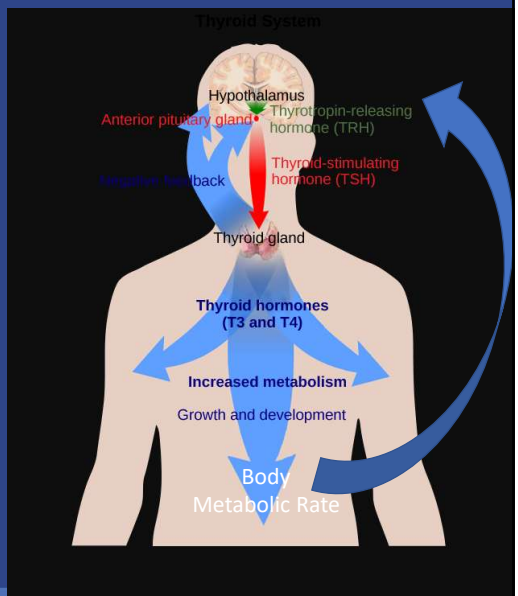


11

Negative Feedback Loop

Hypothalamus:↓ Thyroid Hormone ↑TRH

- **Pituitary Gland:** ↑TSH
- **Thyroid Gland:** ↑ **T4** (thyroxine) and **T3** (triiodothyronine).
- **Negative feedback occurs**. Optimal T3 and T4 act as a "brake" on the system, ↓TRH



http://commons.wikimedia.org

12

Calcitonin: Blood Calcium Regulation

- Inhibits osteoclasts (bone re-absorbers) activity
- Promotes calcium excretion by the kidneys
- Acts opposite to parathyroid hormone.

www.pixabay.com

13

Normal Thyroid Labs– UCLA Health

https://www.uclahealth.org/medical-services/surgery/endocrine-surgery/conditions-treated/thyroid/normal-thyroid-hormone-levels

- **Triiodothyronine (T3)**: The normal range for total T3 is **80–200 ng/dL**. The T3 uptake test (RU) is now considered obsolete and has been replaced by more accurate measurements like Free T3 and Free T4.
- **Thyroxine (T4)**: The normal range for total T4 is **4.5–12.0 µg/dL**. The normal range for Free T4 (the active, unbound form) is **0.8–1.8 ng/dL**.

14

Normal Thyroid Labs – UCLA Health

https://www.uclahealth.org/medical-services/surgery/endocrine-surgery/conditions-treated/thyroid/normal-thyroid-hormone-levels

- **Thyroid Stimulating Hormone (TSH)**: The normal range for TSH is **0.5–5.0 mIU/L**.
- **Serum Calcitonin**: Normal calcitonin levels are typically **<10 pg/mL** for men and **<5 pg/mL** for women.
  - **Elevated Levels**: Markedly elevated calcitonin levels are a key indicator for **medullary thyroid cancer**.

15

Tracking Thyroid Cancer: Thyroglobulin Test

The Immunometric Assay (IMA) is the most commonly used blood test to measure thyroglobulin (Tg) levels in patients with differentiated thyroid cancer (DTC).

- Thyroglobulin (Tg) is a protein made only by normal and cancerous thyroid cell.
- After surgery and radioactive iodine (RAI) treatment, there shouldn't be any thyroid tissue left, so Tg levels should be very low or undetectable
- If Tg is detectable or rising, it could mean that thyroid cancer is still present or coming back.

Problem: Anti-thyroglobulin Antibodies (TgAb)

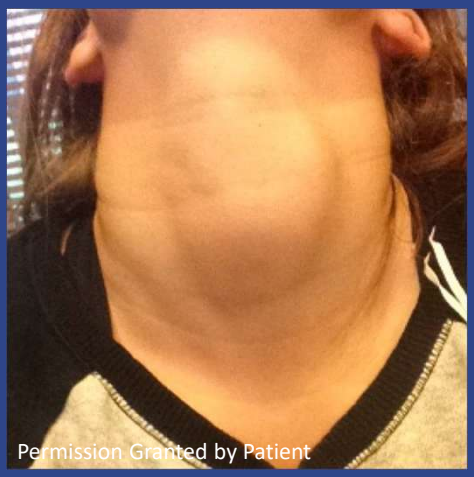
Some people have TgAb in their blood that attach to Tg.

When TgAb is present, it interferes with the IMA test by masking the presence of Thyroglobulin.

16

Indications for Sonographic Examination

- Palpable neck masses or enlargement.
- Abnormalities detected by other imaging examinations or laboratory studies
- Evaluate high-risk patients for occult thyroid malignancy.
- Follow-up of thyroid nodules.
- Localization of parathyroid abnormalities in patients with suspected primary or secondary hyperparathyroidism.
- Difficulty swallowing
- Abnormal laboratory values



17

Sonographic Technique

- Equipment
  - High frequency (7.5-15 MHz or higher) linear transducer
  - A 5-MHz transducer may be needed with thick necks or patient with rad therapy
- Patient Preparation & Position
  - No patient prep required, although limiting food and drink 1 hour prior reduces gastric reflux
  - Position the patient's neck in hyperextension.

https://www.endocrinemds.com/blogs/what-is-the-purpose-of-a-thyroid-ultrasound/

18

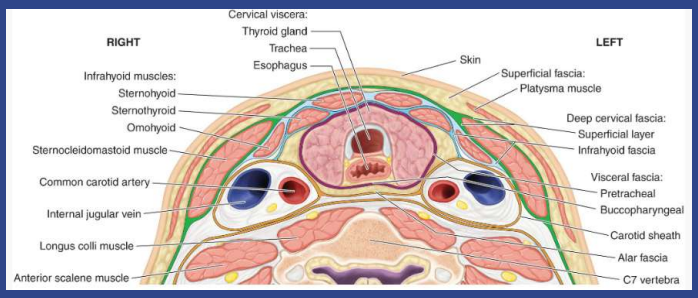
Sonographic Protocols - AIUM

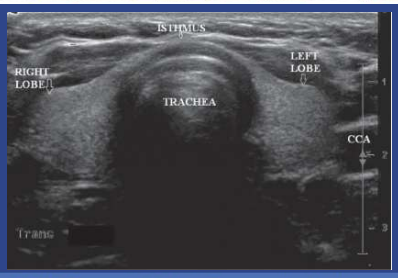
1. Image the right and left thyroid lobes in both longitudinal and transverse planes.
2. Record transverse images of the superior, mid, and inferior parts of each lobe, as well as longitudinal images of the medial, mid, and lateral portions.
3. Include a transverse image of the isthmus.
4. Measure each lobe in three dimensions: anteroposterior (AP), transverse, and longitudinal.
5. Record the AP thickness of the isthmus on the transverse view.
6. Use color or power Doppler to assess diffuse or focal abnormalities and overall gland vascularity.
7. Extend imaging superiorly to evaluate for a pyramidal lobe or a thyroglossal duct cyst, if necessary.

https://onlinelibrary.wiley.com/doi/10.7863/ultra.32.7.1319
https://www.endocrinemds.com/blogs/what-is-the-purpose-of-a-thyroid-ultrasound/

19

Sonographic Appearance: Transverse



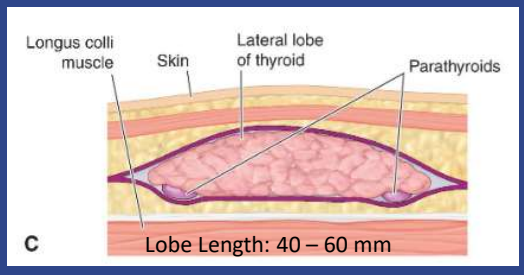


ADULT
Lobe AP: 13-18 mm
Isthmus AP: 4-6 mm

- Kawamura, D K, Nolan, T. (2023). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 5th ed. Philadelphia, PA: Wolters Kluwer

20

Sonographic Appearance

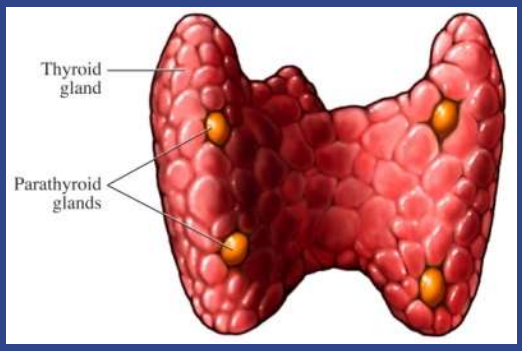


- Kawamura, D K, Nolan, T. (2023). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 5th ed. Philadelphia, PA: Wolters Kluwer

21

Parathyroid Gland

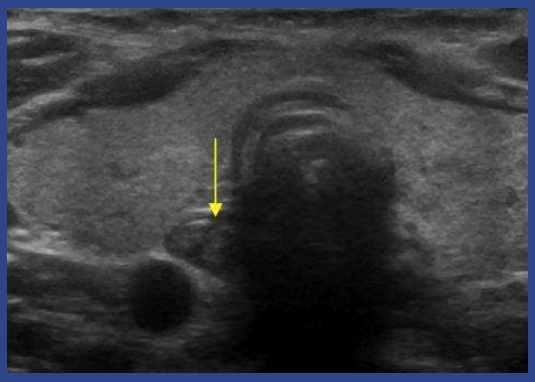
- 4 small round masses embedded on the posterior surface of the lateral lobes of the thyroid gland
- Physiology
  - Monitors Calcium Metabolism via Parathyroid Hormone
    - Serum Ca Low – PTH Secreted
    - Ca released from Bones
    - Ca absorption changed in the intestinal tract



22

Parathyroid Gland

- Echo texture similar to overlying thyroid gland
  - Normally sized <4 mm glands are usually not seen
  - Be careful to evaluate in sagittal & transverse views
    - **Do not mistake longus coli for the parathyroid!**
- Enlarged glands
  - decreased echo texture
  - appear as elongated masses between the posterior longus coli and the anterior thyroid lobe.



23

Parathyroid Pathology

https://www.ultrasoundcases.info/cases/head-and-neck/parathyroid-glands/parathyroids/

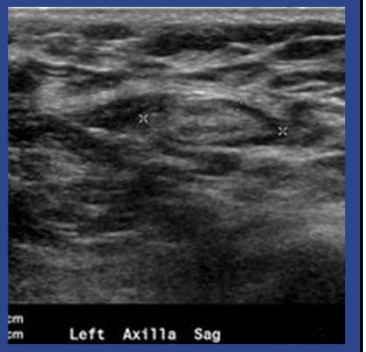
- **Primary Hyperparathyroidism**
  - Increased function of parathyroid gland
- Adenomas
  - **Most common cause of primary hyperparathyroidism**
  - Benign and usually less than 3 cm
- Hyperplasia
  - Increased size, may be asymmetric
- Carcinoma
  - Most are small, irregular, and rather firm masses that may adhere to surrounding structures.
- **Secondary Hyperparathyroidism (Chronic)**
  - Patients with renal failure, vitamin D deficiency, or malabsorption syndromes

24

Sonographic Protocols – Beyond the Normal Thyroid
(Intermountain Healthcare)

Lymph nodes: when thyroid nodules are present or if a patient has had a thyroidectomy– look for lymphadenopathy

a) Image the right neck followed by the left neck.
b) Image and measure all nodes (>1cm) in size or larger beginning cranially and progressing caudally.
c) Nodes should be measured in three dimensions on two consecutive images.
d) Nodes should be labeled by locations (sub mandibular, high cervical, mid cervical, low cervical or supra clavicular)

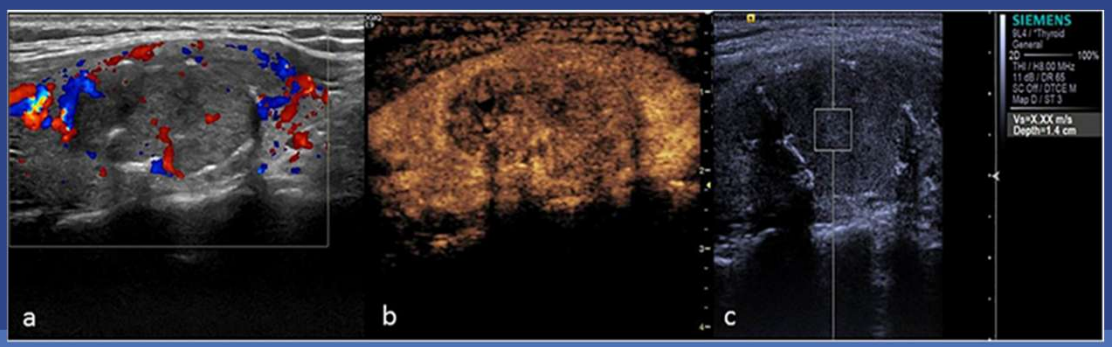


A practical approach to imaging the axilla - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Normal-lymph-node-On-ultrasound-lymph-nodes-typically-are-smooth-gently-lobulated_fig12_269999737 [accessed 13 May, 2019]

25

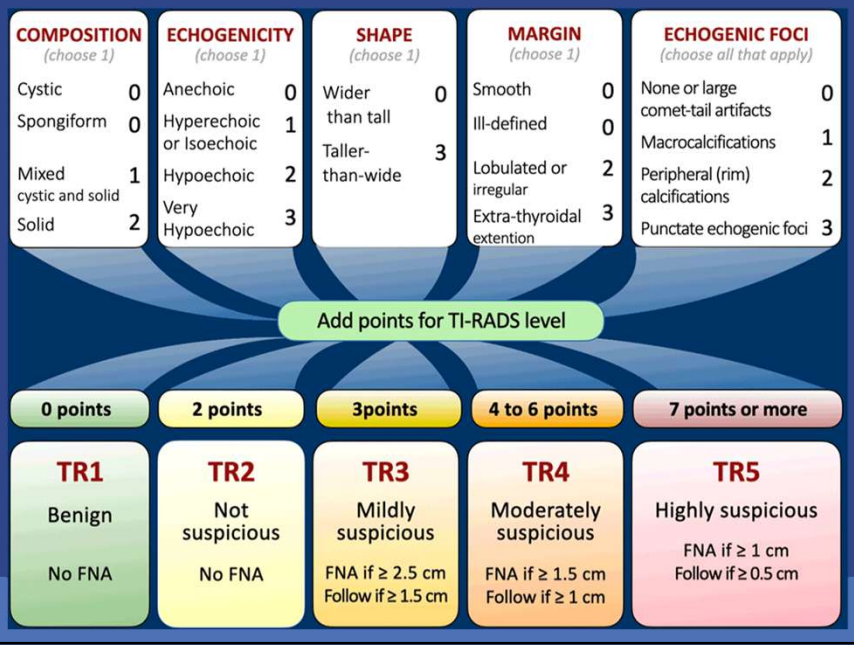
Sonographic Protocols – Beyond the Normal Thyroid
(Intermountain Healthcare)

- Color Evaluation:
  a) Obtain a minimum of one color Doppler image, particularly in the setting of heterogeneity/thyroiditis



26

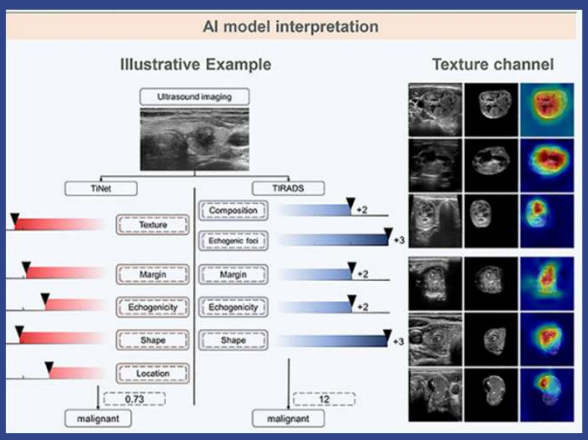
TIRADS - Thyroid Imaging Reporting and Data System



27

AI Assistance

- Research shows Artificial Intelligence (AI) models demonstrate promising accuracy in evaluating thyroid nodules, with studies showing comparable or improved performance to experienced clinicians in identifying malignancy and reducing unnecessary biopsies.

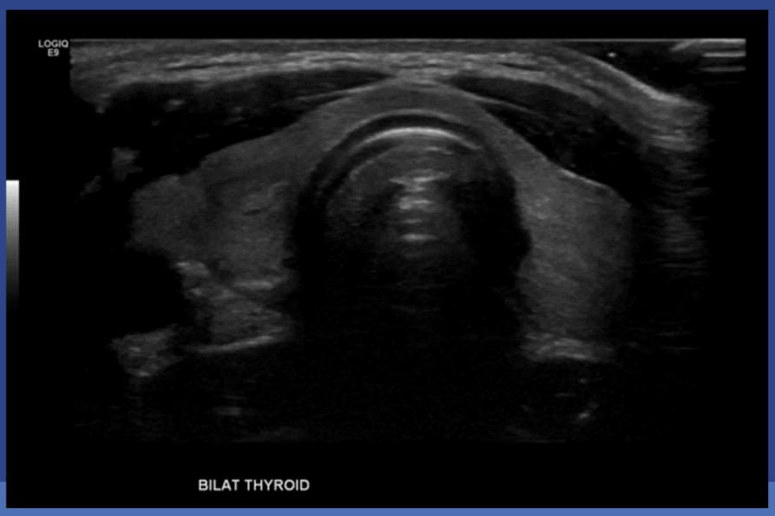


ArticleVolume 26, Issue 4106530April 21, 2023Open access
Human understandable thyroid ultrasound imaging AI report system — A bridge between AI and clinicians
Siqiong Yao1,6 · Pengcheng Shen1,6 · Tongwei Dai1 · Fang Dai1 · Yun Wang3 wangyun31415926@163.com · Weituo Zhang4 zhangweituo@sjtu.edu.cn · Hui Lu

28

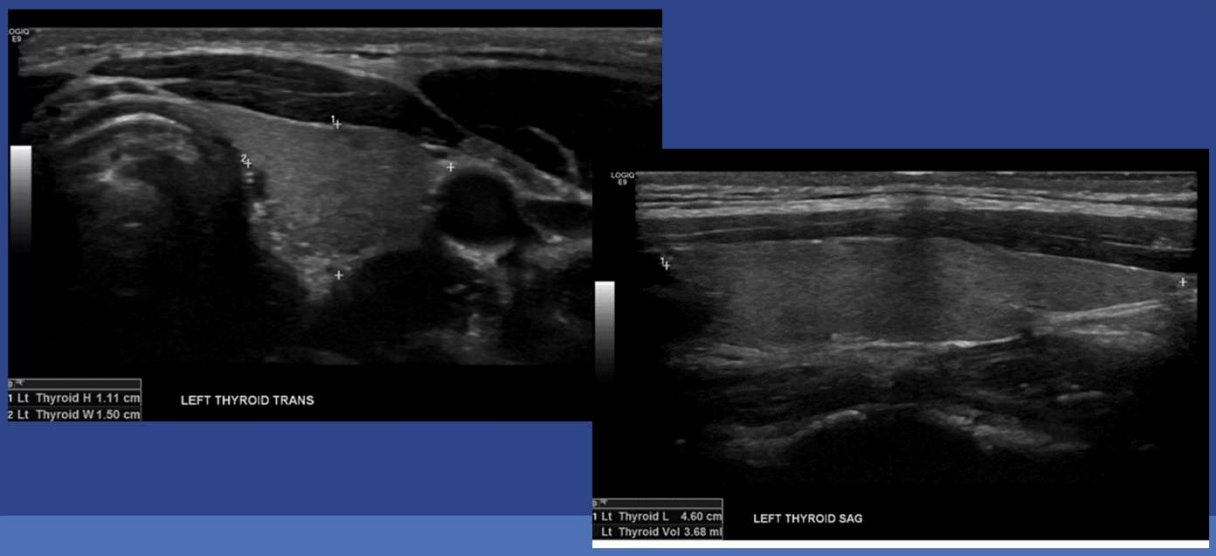
Check Your Understanding

- 25-Year-Old Female Presents with a neck lump.



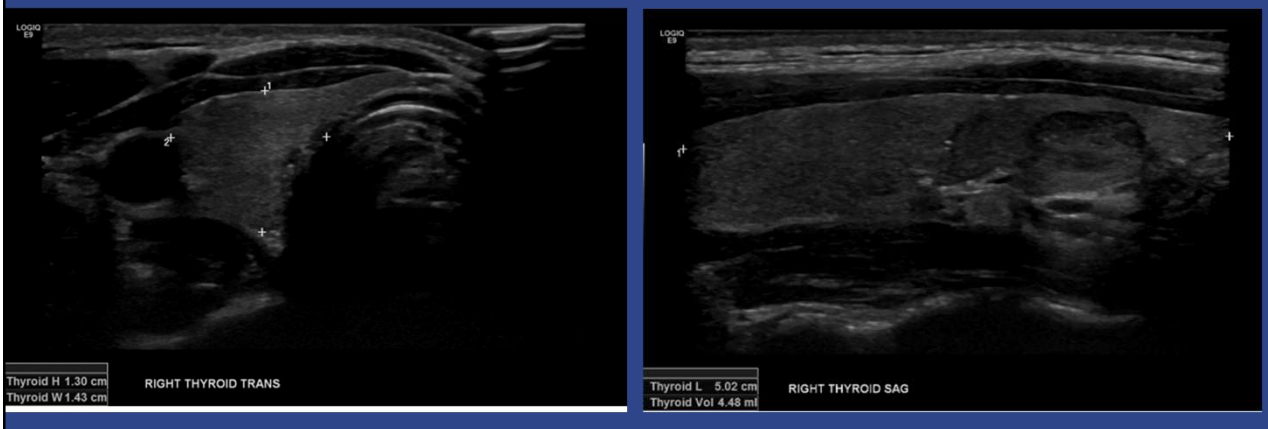
29

Left Thyroid

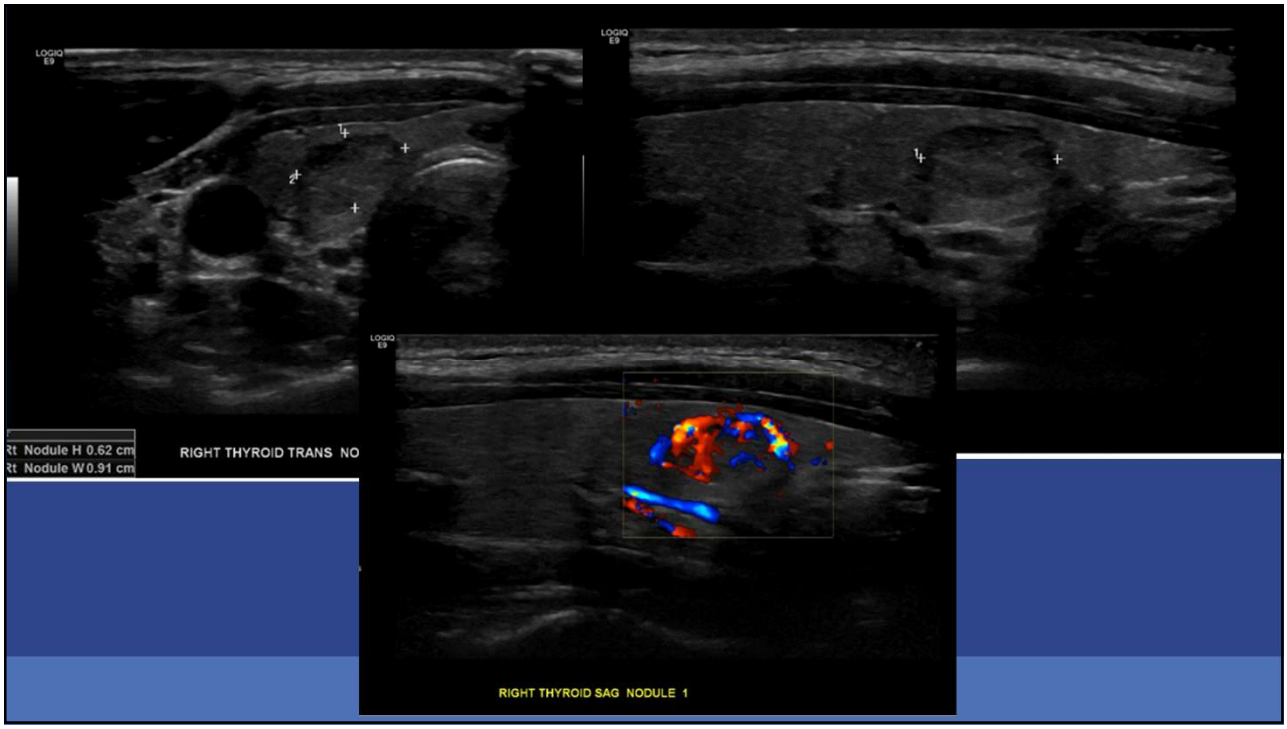


30

Right Thyroid

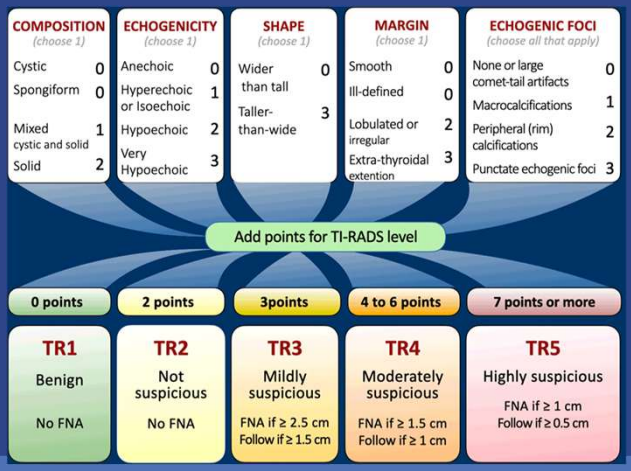


31



32

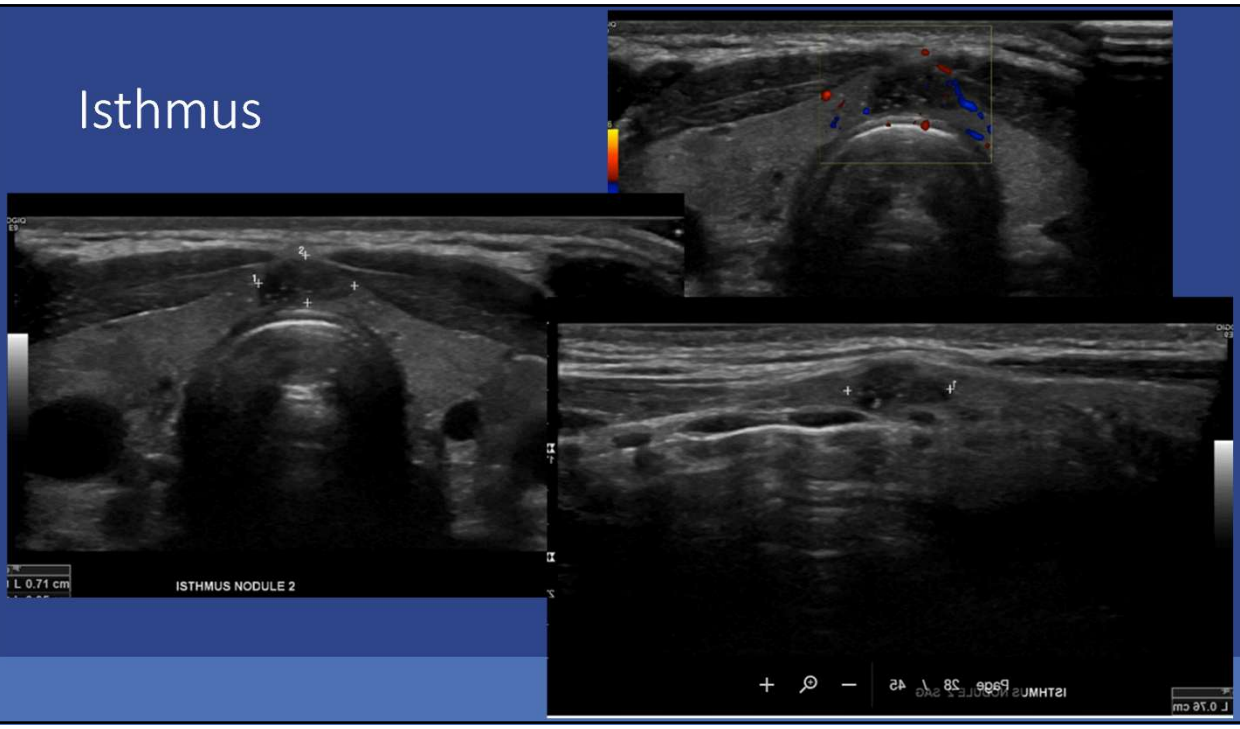
TIRADS



- Composition = 2 (Solid or almost completely solid)
- Echogenicity = 1 (Hyperechoic or Isoechoic)
- Shape = 0 (Wider than Tall)
- Margin = 0 (Smooth)
- Echogenic Foci = 0 (None)

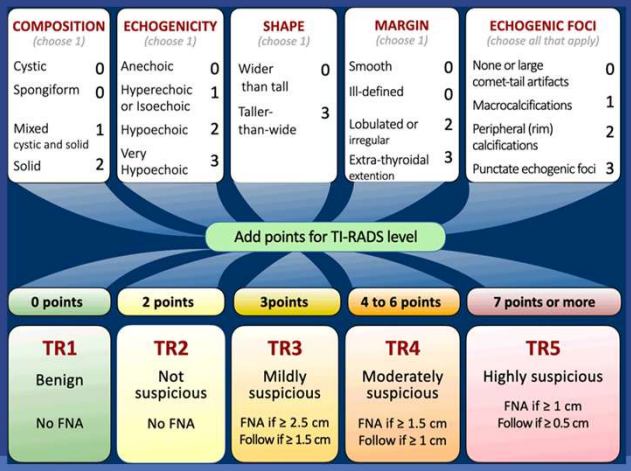
33

Isthmus



34

TIRADS



- Composition = 2 (Solid or almost completely solid)
- Echogenicity = 3 (Very Hypoechoic)
- Shape = 0 (Wider than Tall)
- Margin = 0 (Smooth)
- Echogenic Foci = 3 (Punctate Echogenic Foci)

35

BENIGN THYROID MASSES

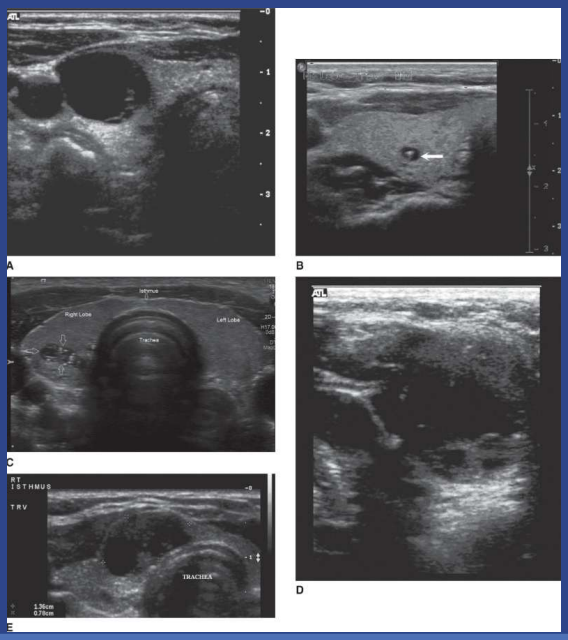
36

Cysts and Cystic Nodules

- **True Cysts**
- **Benign Nodular Disease**
  - **Sonographic Appearance**

    Simple Cyst
    - Circular/Oval
    - Discrete Marging
    - No internal Echoes
    - Posterior Enhancement

    Complex
    - Comet Tail Artifact (Colloid)
    - Debris, Septa, and Fluid levels (Hemorrhage)
    - Irregular Margins (Finger-like projections)

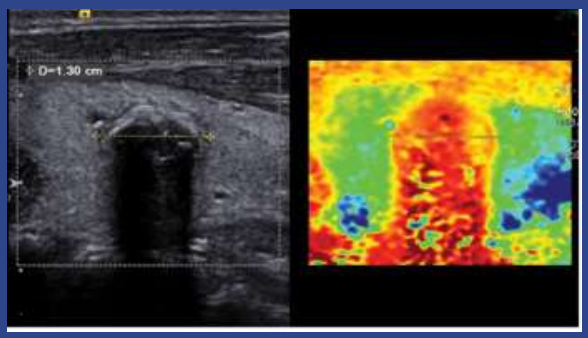


- Kawamura, D K, Nolan, T. (2023). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 5th ed. Philadelphia, PA: Wolters Kluwer

37

Adenomas

- Most common benign solid thyroid mass
- Classified based on Cellular Structure
- Clinical Features
  - Most dormant until 50-60 years of age
  - Slow growing; must be 0.5 – 1 cm to be palpated
  - Toxic and non-toxic

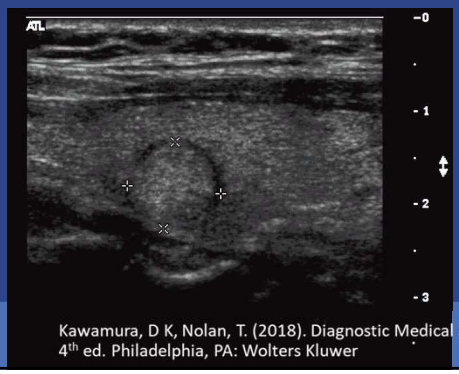


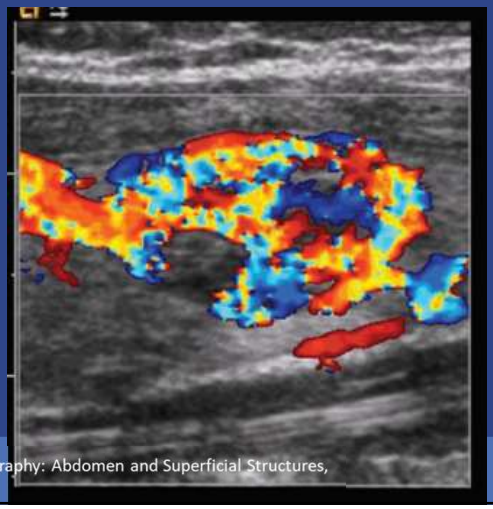
Kawamura, D K, Nolan, T. (2018). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 4th ed. Philadelphia, PA: Wolters Kluwer

38

Adenomas: Common Sonographic Appearance

- Well circumscribed; oval or circular shaped
- **Peripheral halo**
- Increased Color Flow Doppler Patterns – "Spoke Wheel"
- Cystic areas / Degeneration
- Rim Calcification





Kawamura, D K, Nolan, T. (2018). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 4th ed. Philadelphia, PA: Wolters Kluwer

39

Nontoxic Goiter

- Simple, Colloid, or Multi-nodular
  - Enlargement of the entire gland
- Causes
  - Lack of Iodine

Sporadic Goiter

- Ingestion of Substances (blocks synthesis)
- Hereditary enzymatic defects

https://commons.wikimedia.org/wiki/File:Struma_001.jpg

40

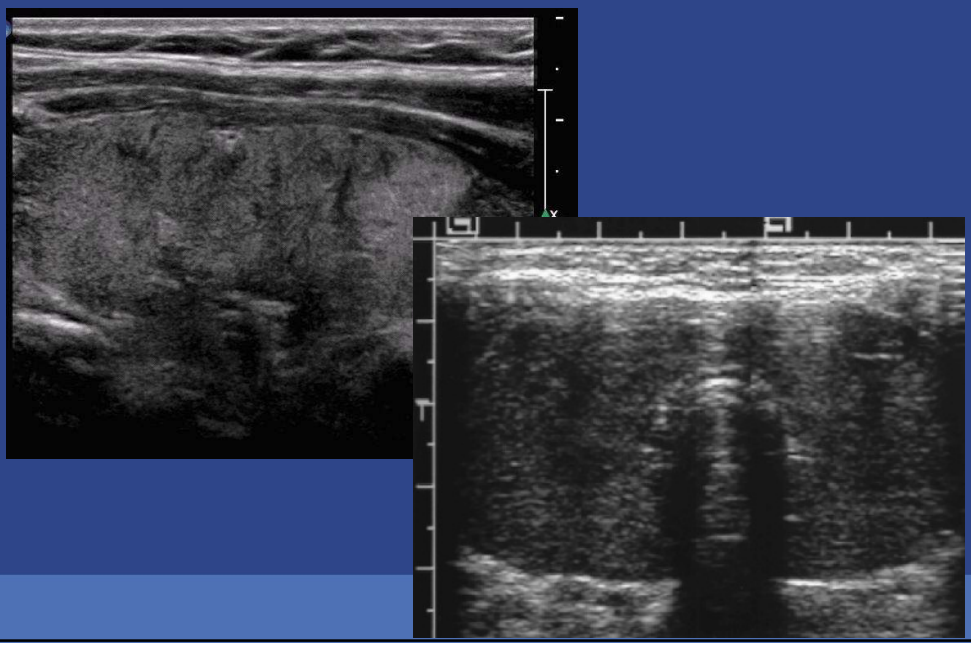
History

- 1884 – 1st Thyroidectomy
- 1960 – WHO defines a goiter
  - Thyroid lobes exceed the volume of the terminal phalanges of the thumbs of an examined individual.
- Endemic Goiter World-wide problem!
  - "Goiter Belt" – Pacific Northwest, North-Central States, Great Lake District, and the Appalachian Highlands
    - Iodine-depleted soil and water, tobacco smoking, and diet lacking seafood
- 1920 – Universal Iodine Program in US

Viduetsky, A., & Herrejon, C. (2019). Sonographic Evaluation of Thyroid Size: A Review of Important Measurement Parameters

41

Nontoxic Goiter



42

Hyperthyroidism / Thyrotoxicosis

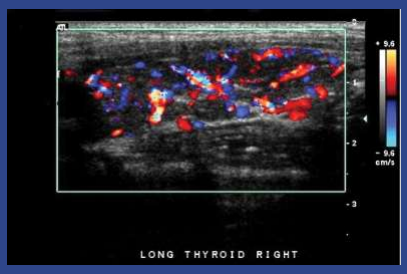
Elevated T3 and T4

- **Hyperthyroidism:** elevated levels of hormone from hyper-function
- **Thyrotoxicosis:** excessive leakage of hormone out of a non-hyperactive gland
  - **Primary Hyperthyroidism:** Form of thyrotoxicosis in which excessive thyroid hormone is synthesized and secreted by the thyroid glands.
  - **Secondary Hyperthyroidism:** Rare and caused by TSH-secreting pituitary adenomas.

43

Grave's Disease - Autoimmune

- **Clinical Signs**
  - Diffuse thyroid enlargement
  - Hyper-metabolism
  - Ophthalmopathy
  - Subcutaneous swelling on the anterior portions of the legs
  - Cutaneous formations (periorbital and dorsum of feet)



- **Sonographic Findings**
  - Diffuse enlargement with reduced echogenicity.
  - Heterogenous without palpable nodules
  - Markedly increased vascularity ("thyroid inferno")
    - Similar characteristics as Hashimotos, but enhanced!

Kawamura, D K, Nolan, T. (2018). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 4th ed. Philadelphia, PA: Wolters Kluwer

44

Hypothyroidism

- Most common thyroid function disorder
- Deficient Production of Thyroid Hormone
  - Clinical Signs
    - Myxedema, weight gain, hair loss, increased tissue around the eyes, lethargy, intellectual and motor slowing, cold intolerance, decreased sweating, constipation, menstrual irregularities, deep voice
  - Causes:
    - Primary = Intrinsic abnormality of thyroid gland (Hashimotos Disease #1)
    - Secondary (Central)= Hypothalamic or pituitary disease (tumors, irradiation, meds)
  - Treatment
    - Synthetic thyroid hormone can reverse the condition

http://pixabay.com

45

Thyroid Disease and Pregnancy

- 2nd most common endocrinopathy that affects women of reproductive age.
  - Increase TBG (Thyroid Binding Globulin)
  - Increased hCG
  - Inhibits Pituitary Gland
    - Decreased TSH weeks 8-14
  - Reduced plasma iodine (Fetal Use)
- Increased gland size in 15% women
- Post Partum Thyroiditis

46

Hashimoto's Disease

- Autoimmune – Genetic Predisposition (Family Clusters)
  - Chronic inflammation; diffuse enlargement
  - Usually Painless
  - Eventual hypothyroidism
  - Young – middle-aged females
  - A cause of non-endemic goiter in children
- Associated Risks
  - Malignant disease - B Cell lymphoma (non-Hodgkin)
  - May require an FNA
  - Nodules present may be benign or malignant
  - Definitive diagnosis with the presence of antithyroglobulin antibodies (blood test)

47

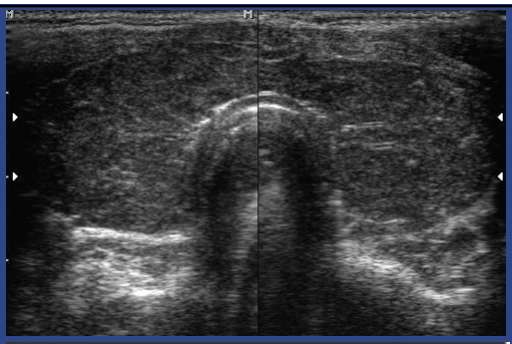
Case Study: Diagnosis

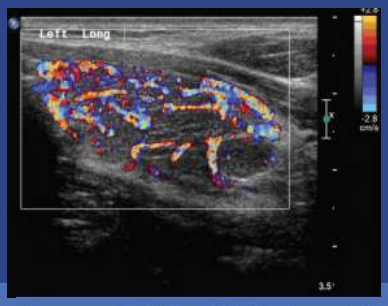
48

Hashimoto's Disease

Sonographic Features

1. Increased Vascularity with Color Doppler
2. Texture changes from homogenous/normal to coarse, fibrotic, and heterogenous with multiple ill-defined hypoechoic areas separated by thick fibrous strands. Diffusely abnormal!
3. Isthmus measures greater than 1 cm AP





Kawamura, D K, Nolan, T. (2018). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 4th ed. Philadelphia, PA: Wolters Kluwer

49

Case Study: Reaction to Diagnosis & Patient Education

50

Correlating Autoimmune: Celiac Disease

- Celiac Disease
  - Gluten-sensitive enteropathy is a permanent intolerance of dietary gluten leading to mucosal damage in the proximal small bowel.
- Characteristics
  - Inflammation
  - Crypt Hyperplasia and Villous Atrophy
- Diverse Manifestations
  - Diarrhea, bloating, gas, fatigue, weight loss, iron deficiency, constipation, depression, dermatitis
- Pathogenesis for Co-Existing Autoimmune Thyroid Disease
  - Genetic predisposition HLA-DQ2 and DQ8 haplotypes are over-represented & associated immunological phyotype

Ch'ng, C., Jones, M., & Kingham, G. (2007). Celiac Disease and Autoimmune Thyroid Disease. *Clinical Medicine & Research,* 5(3): 184-192.

51

Treatment – Size Decrease

Gluten free diet & supplements (including Glutathione)

52

De Quervain's or Subacute Thyroiditis

- Temporary Inflammatory Condition
- Proceeded by Viral Infection
- Symptoms
  - Radiating neck pain
  - Fever
  - Tenderness
  - Fatigue
  - Malaise
- Spontaneous recovery in 6-8 weeks

www.pexels.com

53

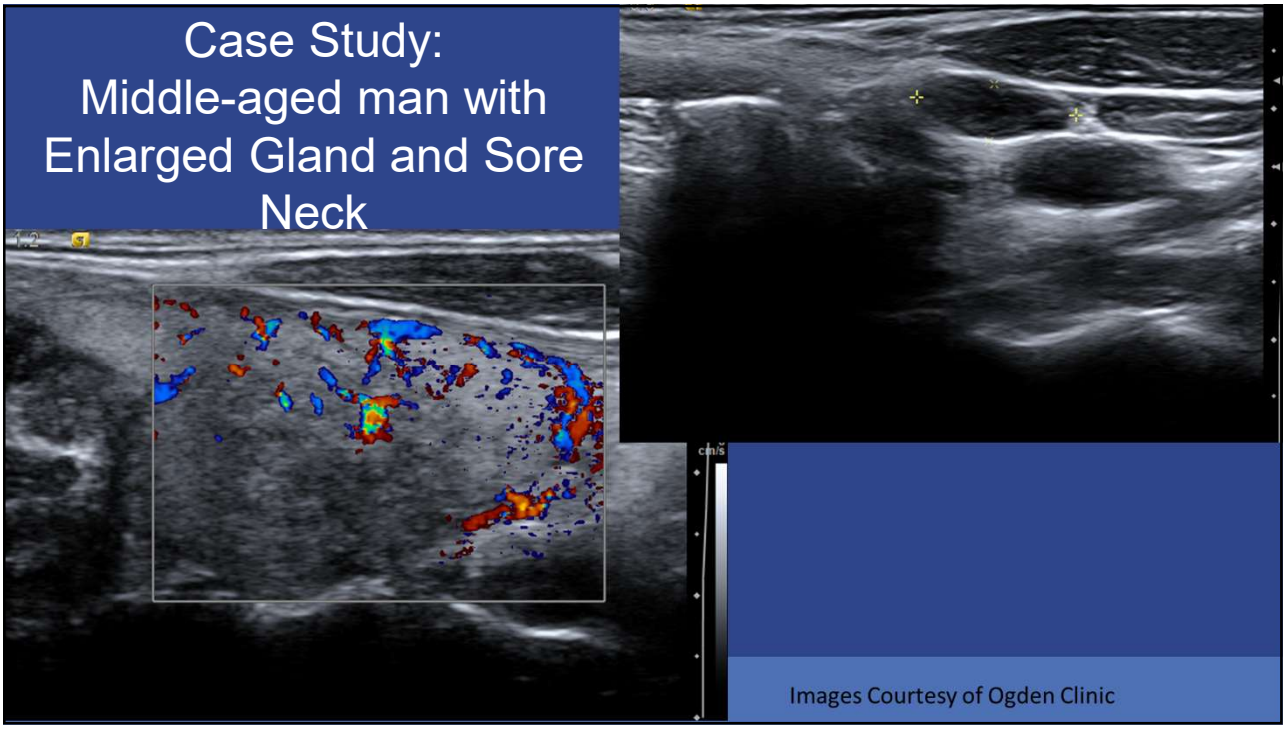
Subacute Thyroiditis

- Diffusely enlarged, hypoechoic gland with normal or decreased vascularity due to the presence of diffuse edema compressing the vessels.
- Presence of hypoechoic or hyperechoic nodules is not uncommon

Images Courtesy of Ogden Clinic

54

Case Study: Middle-aged man with Enlarged Gland and Sore Neck



Images Courtesy of Ogden Clinic

55

Ultrasound-Guided Fine Needle Aspiration

Primary evaluation method of a palpable thyroid nodule
- Diagnosis from cytologic evaluation of the thyroid follicular epithelial cells

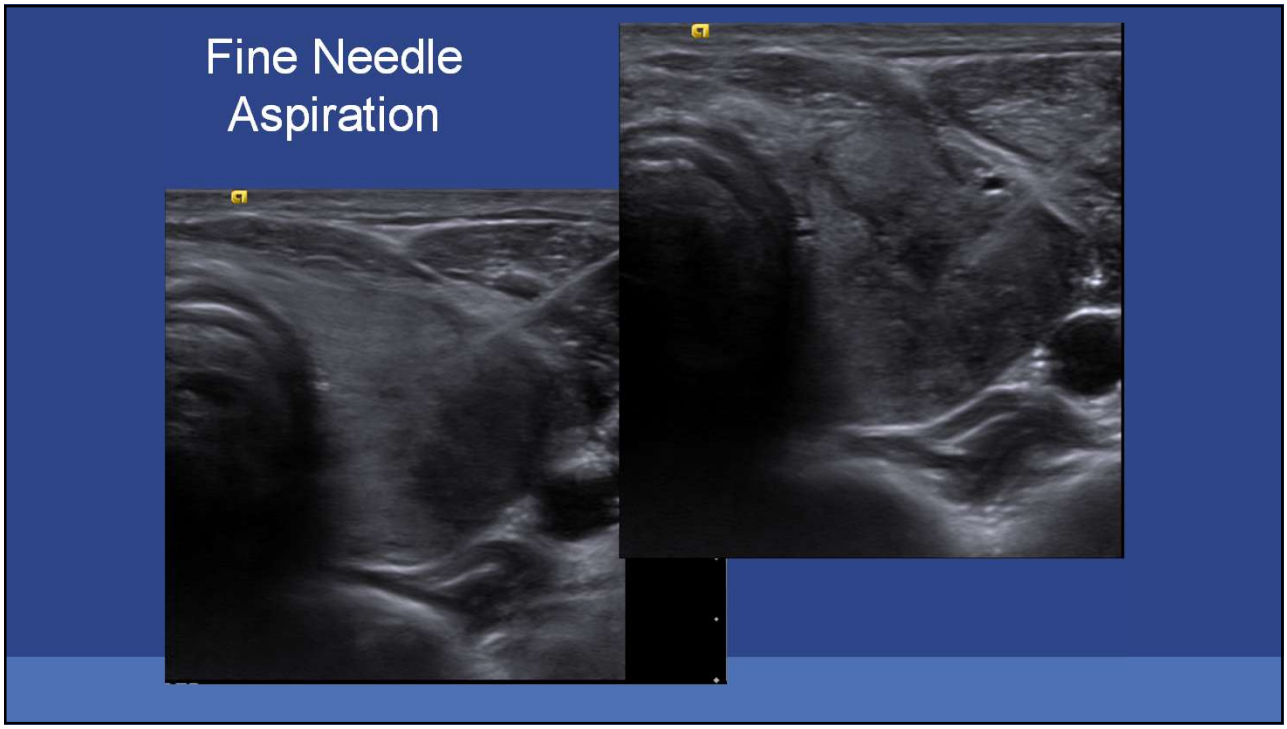
Recommendations for FNA
- Review TIRADS

Side Effects
- Bleeding, hoarseness, infection, cancer seeding

Protocol
- 25G needle, parallel to transducer
- Within the nodule, pull back on the syringe while collecting tissue, moving the needle within the area of interest

Limitations
- High repeat rate, Benign (7-10 biopsies), Cancer (1-20)
- Can diagnose papillary, medullary, and anaplastic carcinoma, but lacks specificity for follicular carcinoma, Hurthle cell carcinoma, and lymphomas

56



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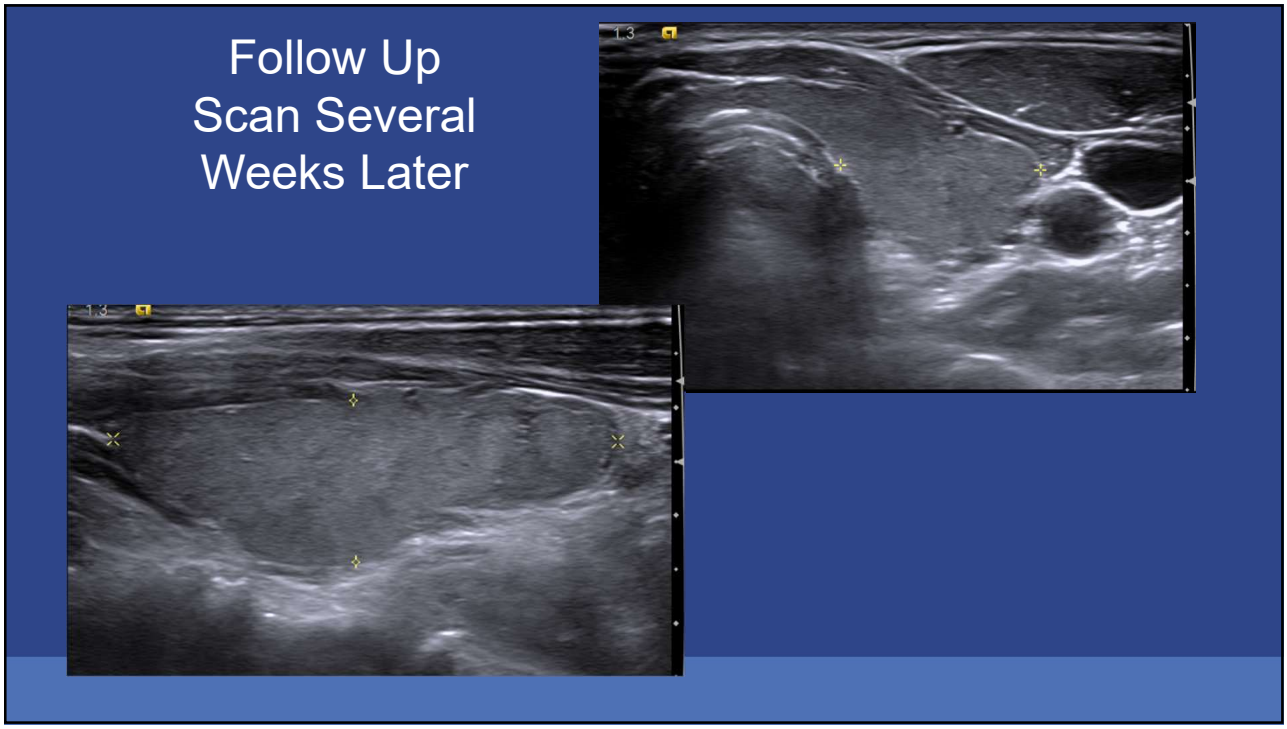

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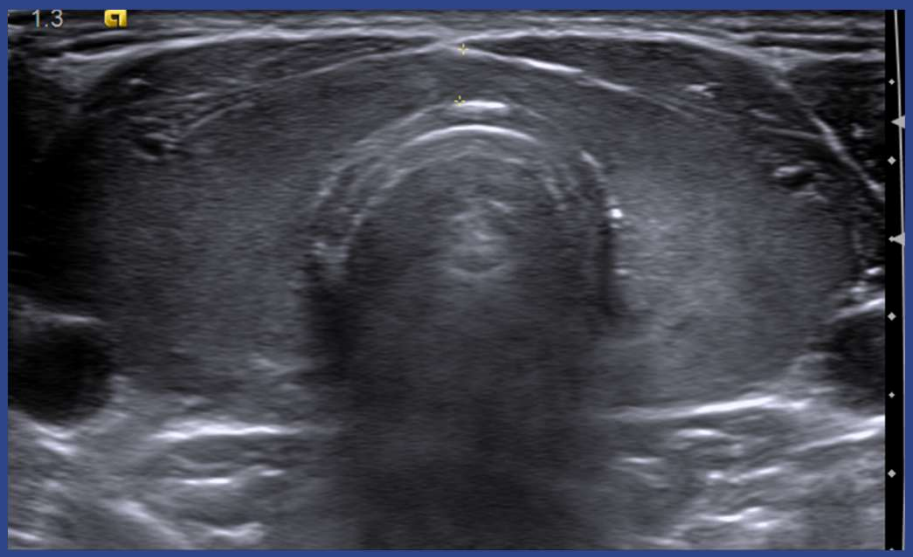


59

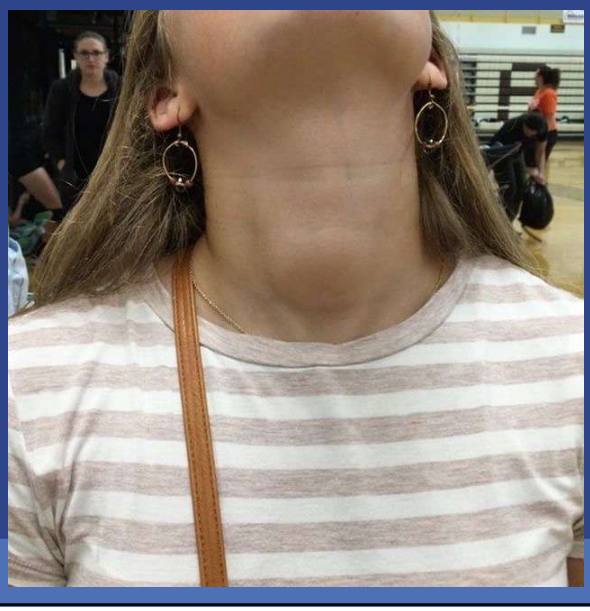
Case Study – Back to our Hashimoto's Patient

A new concern:

- **Hard Anterior Lump**

When:

- **Senior Year**
- **Age 17**

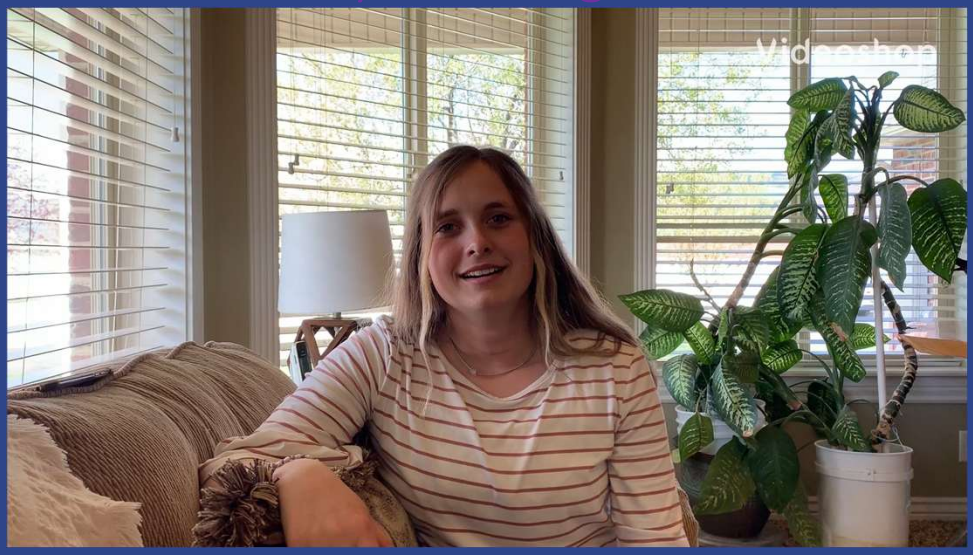


60

Case Study: Fine Needle Aspiration

61

Case Study: 2nd Diagnosis

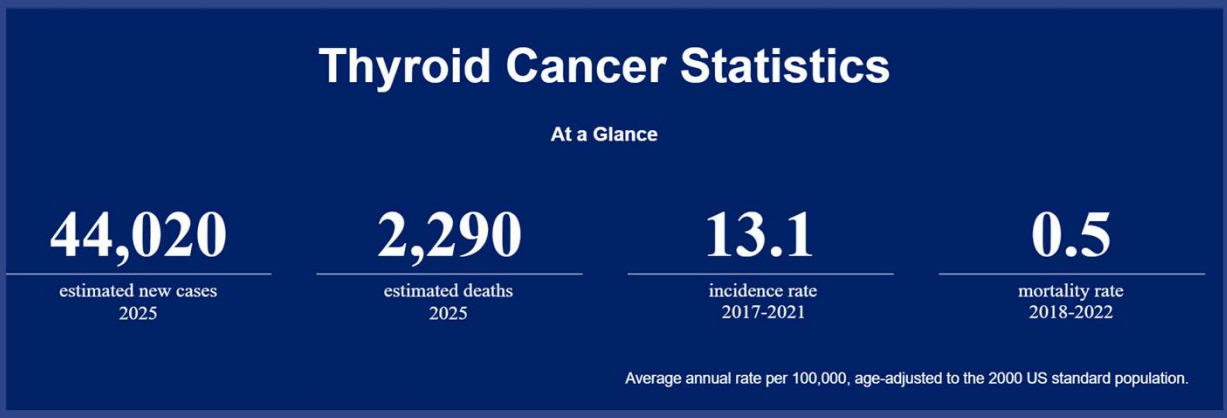


62

THYROID MASSES MALIGNANT

63

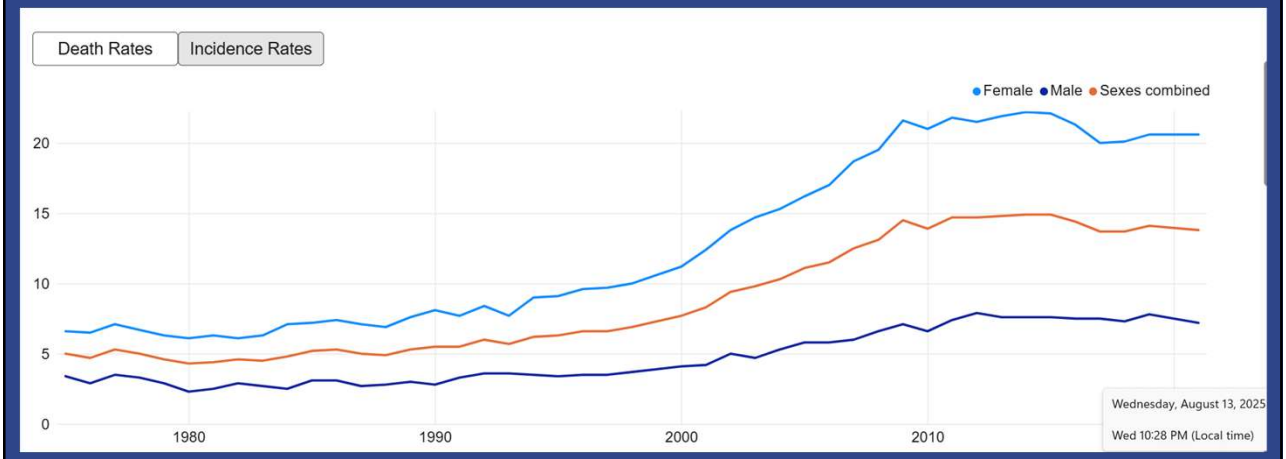
Thyroid Cancer – National Statistics



American Cancer Society retrieved from cancerstatisticscenter.cancer.org

64

Thyroid Cancer – National Statistics



American Cancer Society retrieved from cancerstatisticscenter.cancer.org

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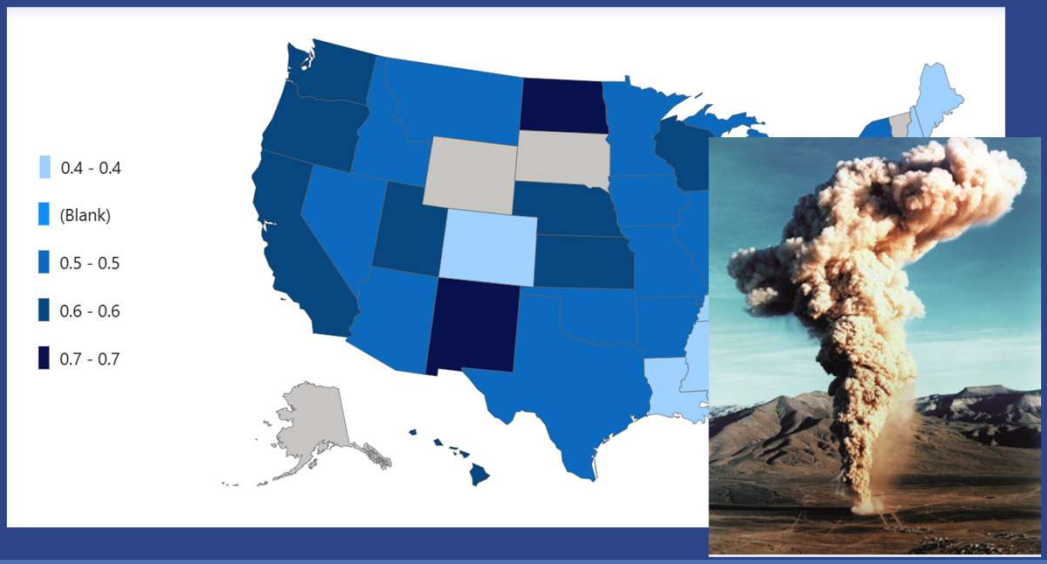
Thyroid Cancer – National Statistics

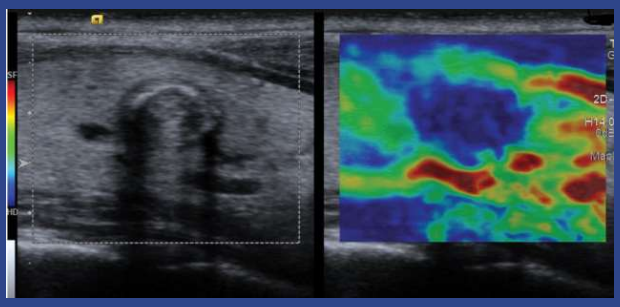


American Cancer Society retrieved from cancerstatisticscenter.cancer.org

66

Malignant Thyroid Nodules

- Risk of malignancy
  - Solitary vs. Multiple
  - Younger vs. Older patients
  - Male vs. Female
  - History Radiation Exposure



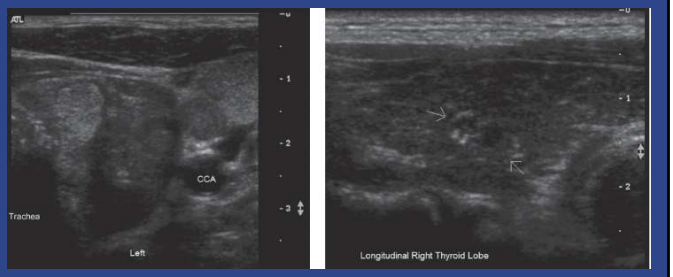
- Clinical Findings
  - Asymptomatic
  - Hoarseness
  - Solitary fixed, rapidly enlarging nodule

- Kawamura, D K, Nolan, T. (2023). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 5th ed. Philadelphia, PA: Wolters Kluwer

67

Papillary Carcinoma

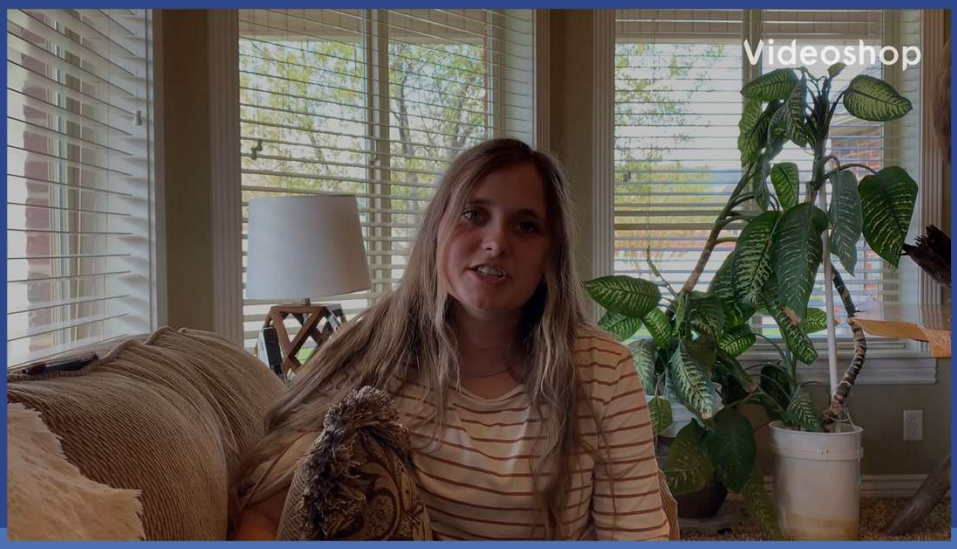
- **Most common thyroid malignancy & least aggressive**
  - 20-50 years
  - Painless, Palpable Lump that moves with swallow
  - Enlarged Cervical Lymph Nodes
  - Cervical Lymphadenopathy
  - Cancer more aggressive in >50 yrs and men.



- 5 Year Suvival Rate
  - 99% if localized. 98%
  - 75% with lung mets
- Sonographic Findings
  - Hypoechoic
  - Microcalcifications
  - Hypervascularity
  - Possible cervical lymph node metastasis

68

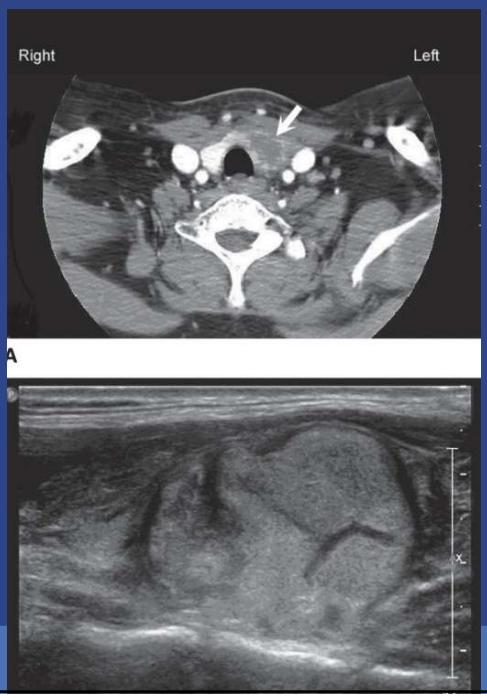
Case Study: Treatment



69

Follicular Carcinoma

- **2nd most common**
  - Increased incidence in areas of endemic goiter – dietary iodine deficiency
  - Slow-growing, painless nodule
  - 2 Types: Minimally and Widely Invasive
  - Does not spread to lymphatics like papillary. Spreads hematogenously, especially bone, lungs, and liver
- Sonographic Appearance
  - Similar to follicular adenomas
- Treatment
  - Lobectomy
  - Subtotal thyroidectomy
  - F/U radioactive Iodine

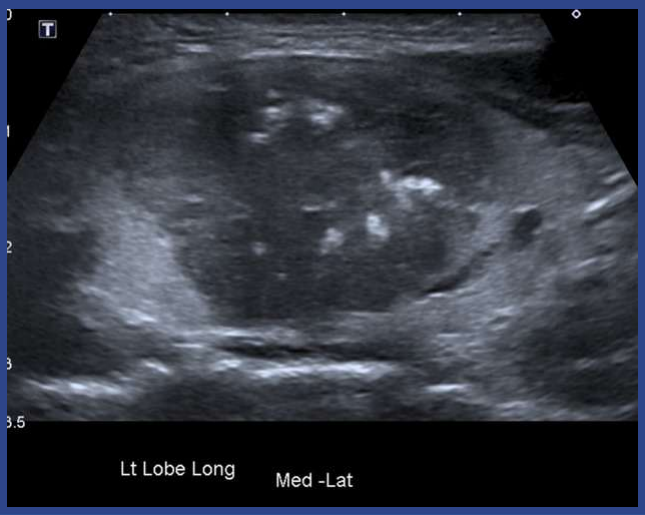


- Kawamura, D K, Nolan, T. (2023). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 5th ed. Philadelphia, PA: Wolters Kluwer

70

Medullary Carcinoma

- 5% of thyroid carcinoma
- Neuroendocrine neoplasm derived from parafollicular cells (C cells)
- Risk Factor: GLP-1
- Clinical Findings
  - Hard, bulky mass
  - Abnormal serum calcitonin levels
  - Associated with Carcinoid Syndrome, Cushing syndrome, and Diarrhea
- Sonographic Findings
  - Solid mass with calcifications
  - Lymphadenopathy



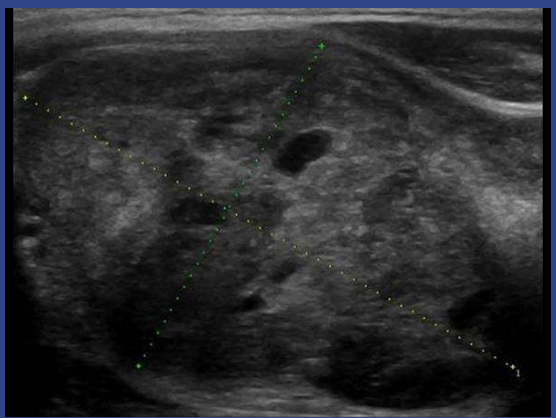
https://radiopaedia.org/articles/medullary-thyroid-carcinoma-1

71

Anaplastic (Undifferentiated) Carcinoma

- Less than 5% - MOST aggressive
- Clinical signs
  - After age 50
  - Hard, fixed
  - Rapid growth
  - Pain, pressure, tenderness
  - Invasive

  Poor Prognosis (10% for 5 yrs survival)
  No effective therapies
- Sonographic Findings
  - Hypoechoic huge mass, possibly irregular
  - Diffuse glandular involvement
  - Invasion of surrounding structures



https://www.ultrasoundcases.info/anaplasic-thyroid-carcinoma-5375/

72

Case Study: Metastasis

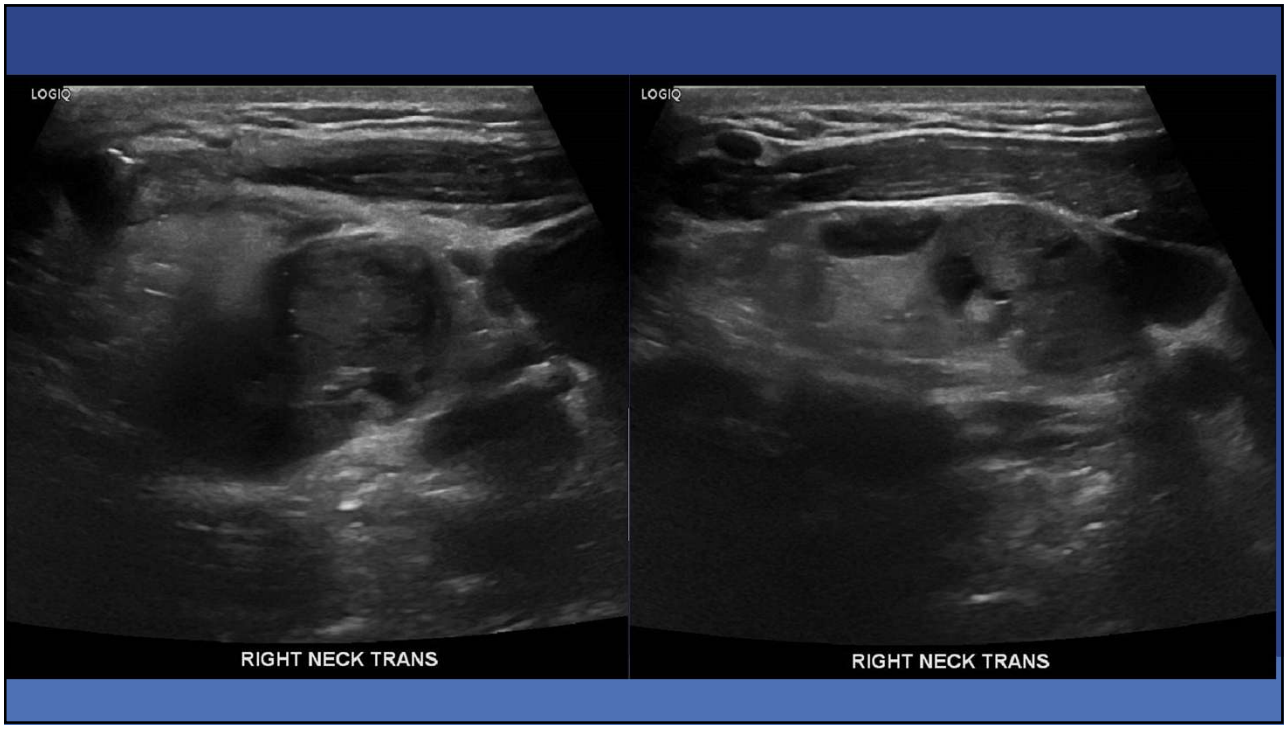
73

Case Study: 2nd Family Case

74

Case 2: 48 Year Old Male

75



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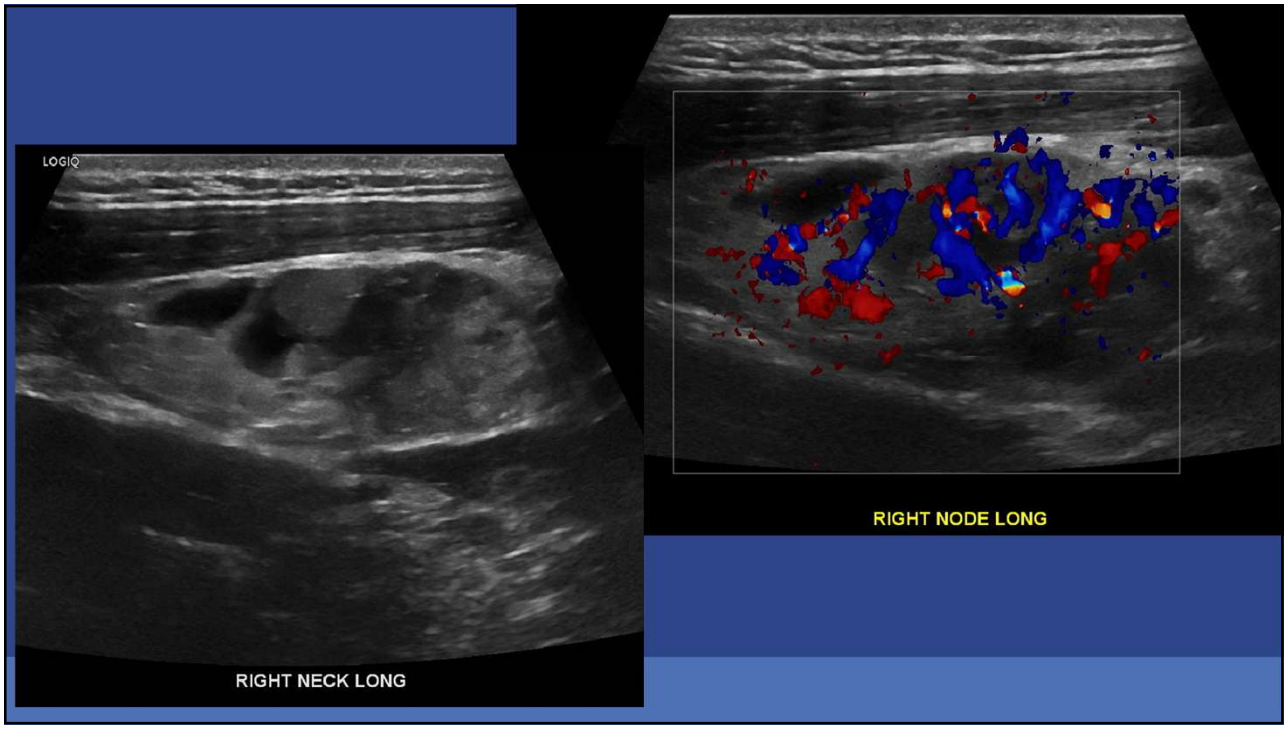

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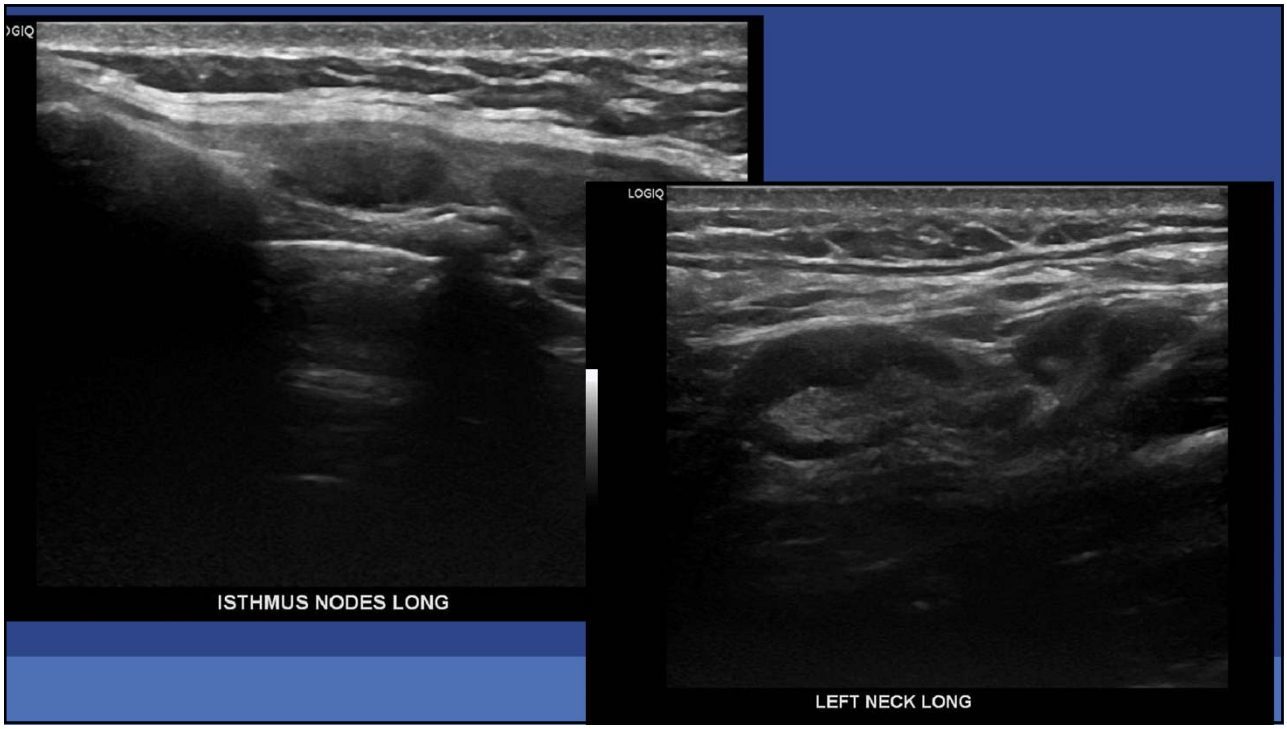

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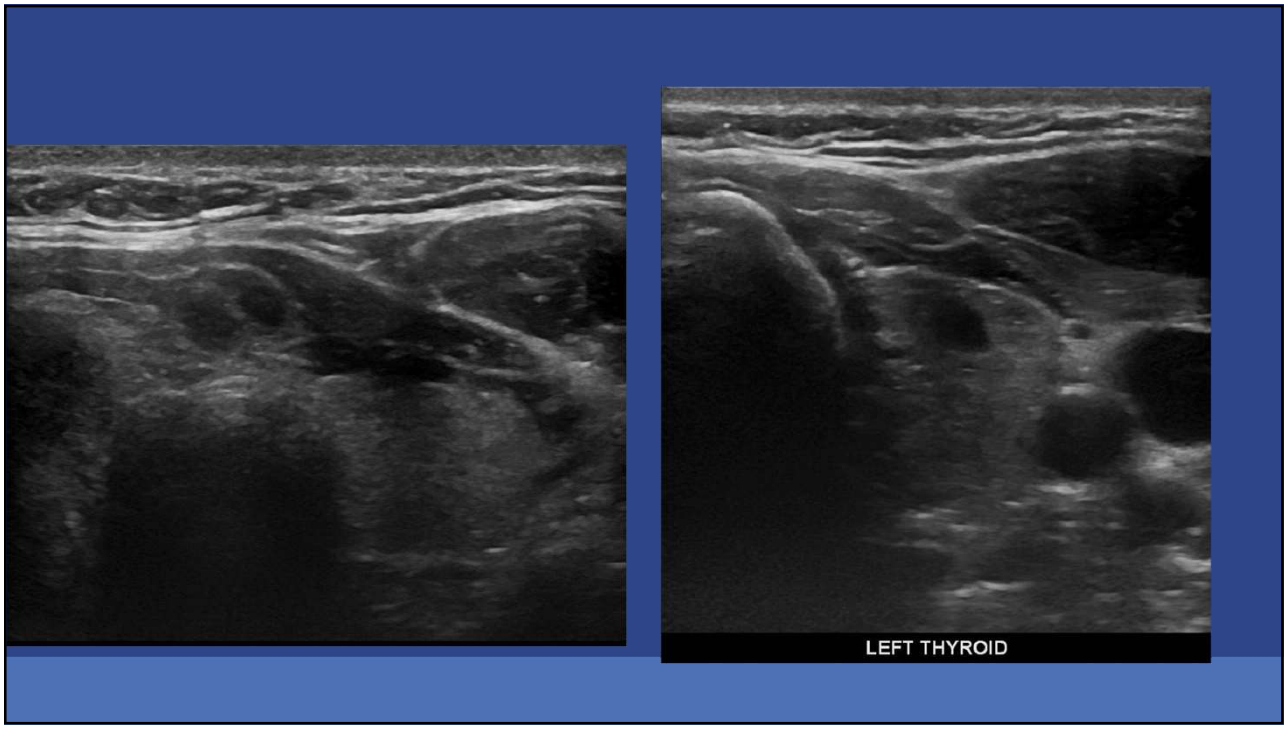

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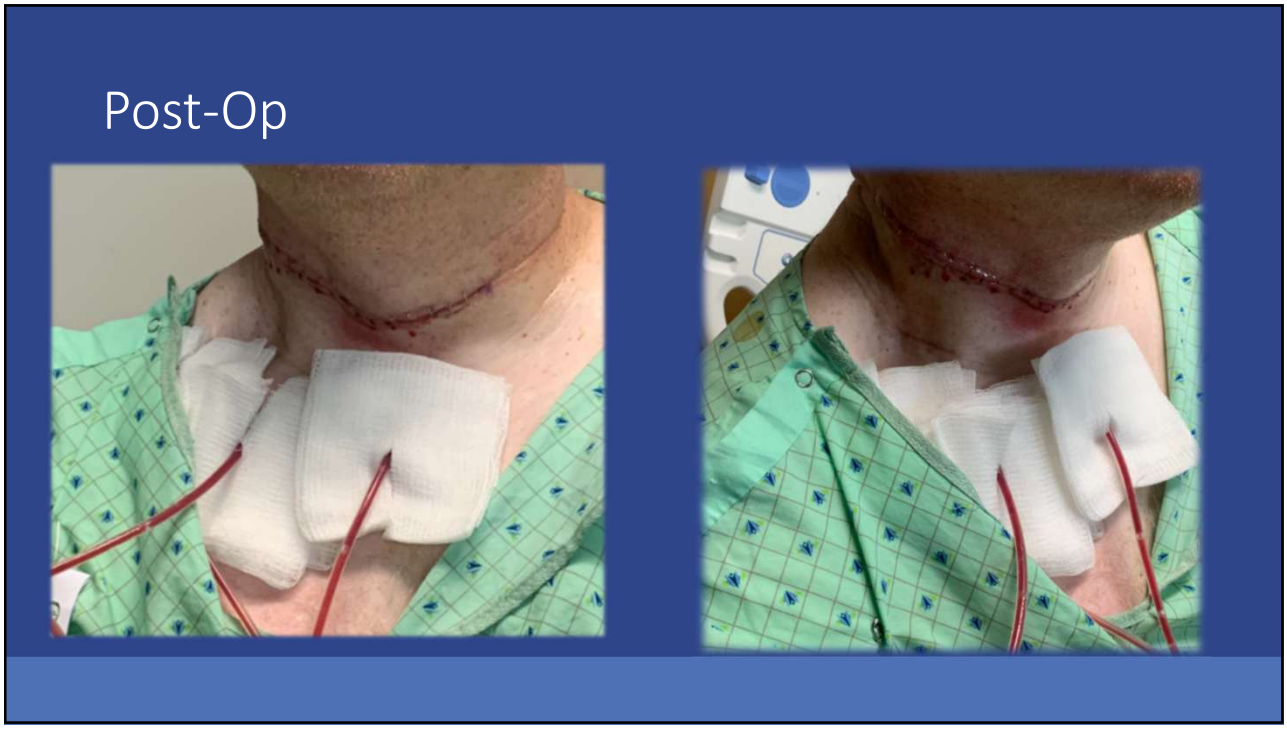
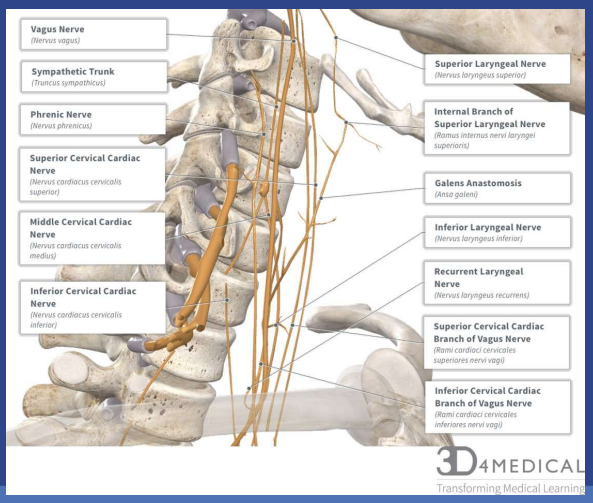


80

Surgical Nerve Damage

- Laryngeal Nerve Damage
  - Paralysis of the vocal cord
  - Weak/Raspy Breathing
  - Dysphagia
- Additional Damage = I131 Nuclear Medicine Treatment

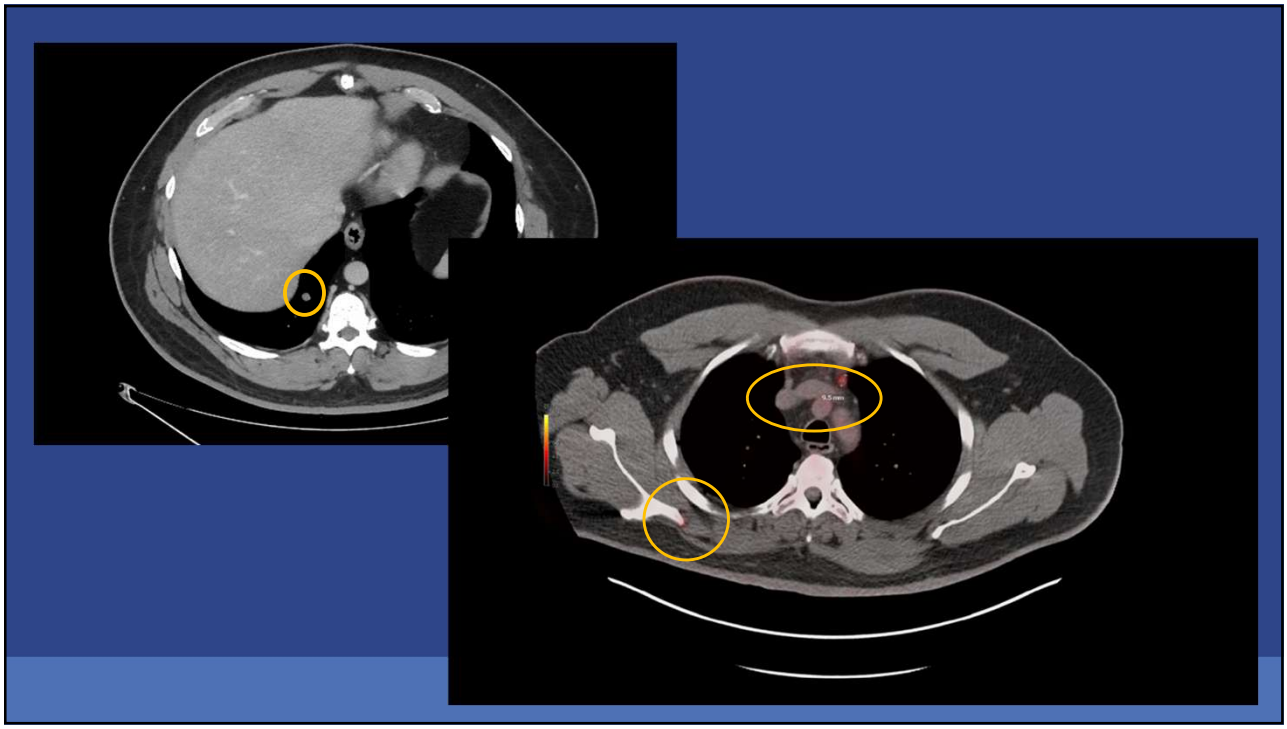


81

I131 Treatment Unsuccessful: Genetic Analysis

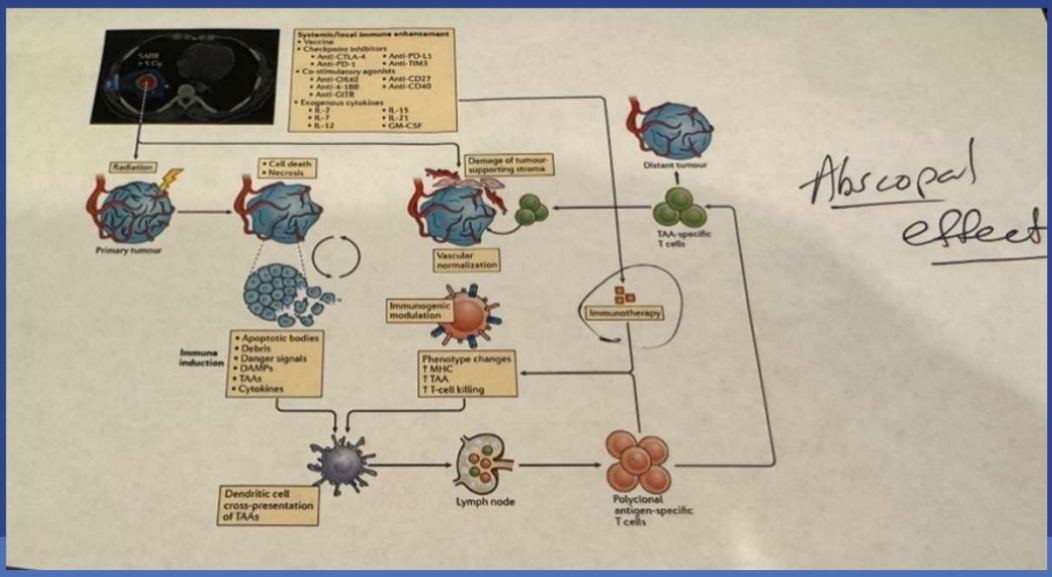
- Thyroid cancer is often associated with genetic mutations, with the most common being in the BRAF, RAS, and RET genes. These mutations can be found in various types of thyroid cancer.
- BRAF and TERT Mutation

82



83

Abscopal Effect (Dr. Evans)



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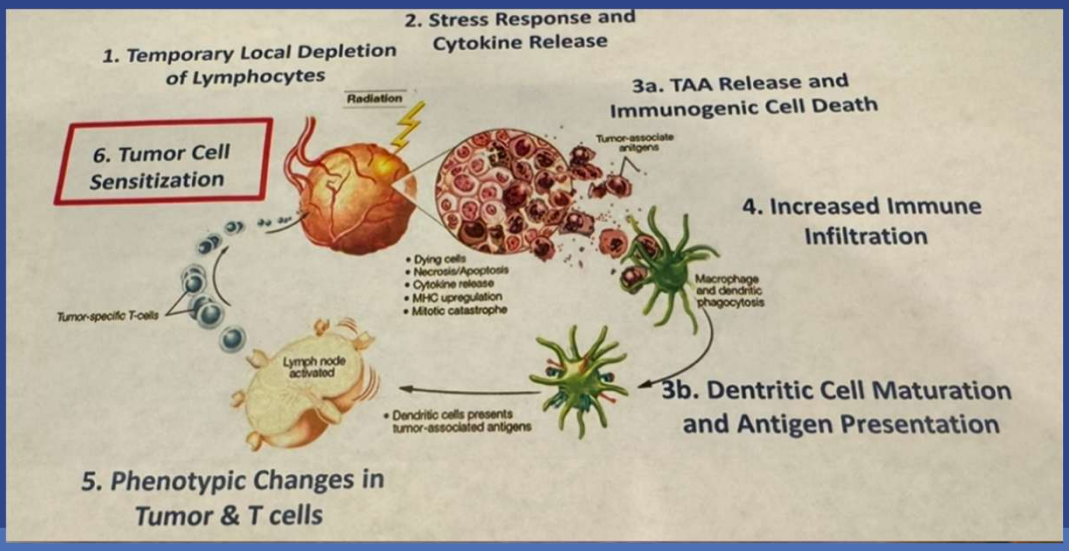
Abscopal Effect (Dr. Evans)



85

Case Study: Patient Expectations

86

References

- American Cancer Society (2025). Statistics retrieved from CancerStatisticsCenter.cancer.org
- Assem, Hussein M., et al. "Duplex Hemodynamic Parameters of both Superior and Inferior Thyroid Arteries in Evaluation of Thyroid Hyperfunction Disorders." *International Journal of General Medicine* 15 (2022): 7131-44. *ProQuest.* Web. 31 Aug. 2025.
- Banaka, I., Thomas, D., Kaltsas, G. (2013). Value of the left inferior thyroid artery peak systolic velocity in diagnosing autoimmune thyroid disease. *Journal of Ultrasound Medicine,* 32: 1969-1978.
- Ch'ng, C., Jones, M., & Kingham, G. (2007). Celiac Disease and Autoimmune Thyroid Disease. *Clinical Medicine & Research*, 5(3): 184-192.
- Google. (2025). Gemini (Version) [Large language model]. https://gemini.google.com/ .
- Lin JD, Huang BY, Hsueh C. Application of ultrasonography in thyroid cysts. J Med Ultrasound. 2007;15:91–102.
- Lisco G, De Tullio A, Disoteo O, Piazzolla G, Guastamacchia E, Sabbà C, De Geronimo V, Papini E, Triggiani V. Glucagon-like peptide 1 receptor agonists and thyroid cancer: is it the time to be concerned? Endocr Connect. 2023 Sep 27;12(11):e230257. doi: 10.1530/EC-23-0257. PMID: 37656509; PMCID: PMC10563602.
- Middleton WD, Kurtz AB, Hertzberg BS, Ultrasound: The requisites. 3rd ed. Elsevier, Mosby; 2015
- OpenAI. (2025). *ChatGPT* (Aug 25 version) [Large language model]. https://chat.openai.com/chat.
- Penrod, A. (2023) The Thyroid Gland, Parathyroid Glands, and Neck in Kawamura, D K, Nolan, T. (2023). Diagnostic Medical Sonography: Abdomen and Superficial Structures, 4th ed. Philadelphia, PA: Wolters Kluwer
- Viduetsky, A. & Herrejon, C. (2019). Sonographic Evaluation of Thyroid Size: A Review of Important Measurement Parameters
- Xiang P, Chu X, Chen G, et al. Nodules with nonspecific ultrasound pattern according to the 2015 American Thyroid Association malignancy risk stratification system: A comparison to the Thyroid Imaging Reporting and Data System (TIRADS-Na). Medicine (Baltimore). 2019;98:e17657-e17657.
- Ying M, Ahuja A, Wong KT. Ultrasound evaluation of neck lymph nodes. ASUM Ultrasound Bulletin. 2003;6:9–17.
- Ying M, Ahuja AT. Ultrasound of neck lymph nodes: how to do it and how do they look? Radiography. 2006;12:105–117.