Imaging in Pediatric Thyroid disorders: US and Radionuclide imaging

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Imaging in Pediatric Thyroid disorders: Outline

• Imaging modalities
• ACR-SNM-SPR guidelines for thyroid scintigraphy
• Imaging in:
  1. Congenital hypothyroidism
  2. Thyrotoxicosis
  3. Thyroid nodules
  4. Radioiodine whole body scan in differentiated thyroid cancers.
Pediatric Thyroid disorders: Imaging modalities

1. Ultrasound with Color Doppler: Provides anatomic and perfusion information.

2. Thyroid Scintigraphy: Provides functional information. RAIU measurement is the only direct test of thyroid function.

US and Scintigraphy are complimentary.

Serum assays: T3, T4, TSH and thyroglobulin have to be correlated.
ACR-SPR-SNM guidelines for Thyroid Scintigraphy: Indications and contraindications

A. Thyroid imaging is useful in but not limited to:

1. Evaluation of the size and location of thyroid tissue.
2. Evaluation of hyperthyroidism.
3. Evaluation of suspected focal (i.e., masses) or diffuse thyroid disease.
4. Evaluation of clinical laboratory tests suggestive of abnormal thyroid function.
5. Evaluation of patients at risk for thyroid neoplasm (e.g., post neck irradiation).
6. Assessment of the function of thyroid nodules identified on clinical examination or ultrasound or by other diagnostic imaging.
7. Evaluation of congenital thyroid abnormalities.
Thyroid Scintigraphy: Indications and contraindications

B. Thyroid uptake is useful for:

1. Differentiating hyperthyroidism from other forms of thyrotoxicosis (e.g., thyroiditis and thyrotoxicosis factitia).
2. Calculating iodine-131 administered activity for patients to be treated for hyperthyroidism or ablative therapy.
Thyroid Scintigraphy: Indications and contraindications

C. Whole-body imaging for thyroid carcinoma is useful for:
1. Determining the presence and location of residual functioning thyroid tissue after surgery for thyroid cancer or after ablative therapy with radioactive iodine.
2. Determining the presence and location of metastases from iodine-avid forms of thyroid cancer.
Thyroid Scintigraphy: Indications and contraindications

D. Contraindications:
Administration of iodine-131 sodium iodide to pregnant or lactating patients (whether currently nursing or not) is contraindicated.
Thyroid Scintigraphy: Radiopharmaceuticals

1. Routinely employed:
   - I-131
   - I-123
   - Tc-99m pertechnetate

2. Others:
   - Thallium-201, Tc-99m-sestamibi, Tc-99m-teatrafosmin
   - and F-18- FDG

   Imaging of differentiated thyroid cancer who have measurable Tg levels but negative radioiodine scans with these agents is under investigation.
Thyroid Scintigraphy: Radiopharmaceuticals

- **I-131** (physical half life 8.1 days; gamma emission 364 kev)
  - **Advantages:** Wide availability and relative low cost
  - **Disadvantages:** High radiation absorbed dose

- **I-123** (physical half life of 0.55 days; gamma emission 159 kev)
  - **Adv:** Short half life and absent beta radiation
  - **Disadv:** Limited availability and expensive
Thyroid Scintigraphy: Radiopharmaceuticals

- **Tc 99m-pertechnetate** (physical half life 6 hours; gamma emission 140 kev)

Advantages:

1. Wide availability, low cost and low radiation.
2. Short time interval for scintigraphy
3. Scan can be performed during antithyroid treatments with thionamides.
Congenital Hypothyroidism: Causes

- **Transient:**
  P/o maternal antibodies due to a thyrotropin receptor blocking antibody; maternal ingestion of antithyroid medication or iodine overload caused by exposure to iodine containing antiseptics.

- **Permanent:**
  80% of them are caused by: Aplasia, hypoplasia, hemiplasia or ectopy
  15-20% results from dyshormonogenesis.
Congenital Hypothyroidism: Imaging

• Should we image?
• If so what should we start with? US/Scintigraphy or both
• Which radiopharmaceutical is preferred: Tc 99m pertechnetate or I 123?
Congenital Hypothyroidism: Imaging

• Controversial
• Lot of clinicians believe that presence, absence, or abnormal location of a thyroid does not alter management of CH.
• Thyroid scintigraphy in combination with ultrasound however gives the clinician maximal information on the anatomic status of the thyroid.
Imaging in Congenital Hypothyroidism

• Ultrasound: Less sensitive in detecting ectopic thyroid (although has high specificity)
• NM thyroid scintigraphy: Tc 99m pertechnetate or I-123

The Key Role of Newborn Thyroid Scintigraphy With Isotopic Iodide ($^{123}$I) in Defining and Managing Congenital Hypothyroidism

Edgar J. Schoen, MD* et al. Pediatrics Vol. 114 No. 6 December 1, 2004
Congenital hypothyroidism: Ultrasound

Aplasia

Hemiagenesis

Lingual thyroid
Congenital hypothyroidism: Scintigraphy

Normal

Aplasia

Hemiagenesis

Lingual thyroid
Congenital hypothyroidism: Dyshormonogenesis

D/D: antithyroid medication ingestion; iodine excess; maternal antithyroid antibodies
Congenital Hypothyroidism: Imaging

- Scintigraphy and US discordance:
  No functioning thyroid tissue at scintigraphy but gland seen by US.

Causes:

1. Suppression of TSH by thyroxine treatment
2. Transfer of maternal blocking antibodies
3. TSH receptor defect has been postulated.

Congenital hypothyroidism: How does imaging help?

- Parents can be counseled on either the certainty of lifetime therapy (for dysplastic thyroid) or the possibility of later discontinuing therapy (for eutopic thyroid, because CH may be transient in these children).
- If the dysplastic thyroid gland is absent or ectopic (usually a small sublingual gland), parents can be told that the infant will need lifetime thyroid therapy.
- If the thyroid gland is present in the normal position (eutopic) and the condition is transient (as shown by controlled withdrawal of thyroid in older children), lifelong treatment may not be needed.

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Thyrotoxicosis: Imaging

• Thyrotoxicosis refers to the manifestation of excessive quantities of circulating thyroid hormone.

• Hyperthyroidism refers only to the subset of thyrotoxic diseases caused by the overproduction of the thyroid hormone by the gland itself.

• Prior to scintigraphy biochemical thyrotoxicosis (Elevated T4 and low TSH) must be confirmed.
Graves disease:
Role of scintigraphy

- Pre-therapeutic measurement in anticipating dose of radioiodine therapy
- Will indicate the presence of a solid cold nodule which will need further evaluation to exclude malignancy.
Graves disease:
Scintigraphy

4 hour uptake 42%
Graves disease:
Classic US appearance

Diffusely enlarged, hypoechoic, increased vascularity (thyroid inferno)
Normal thyroid gland: US
Hashimotos Thyroiditis: Scintigraphy

4 hr uptake: 1.5%
Hashimotos thyroiditis (late stage): US

- Heterogeneous and coarse parenchyma
- Multiple small hypoechoic nodules surrounded by an echogenic rim of fibrosis
- Vascularity: Variable; increased early in the disease and decreased later in the disease course
Nodular Hashimotos thyroiditis US

Homogeneously echogenic nodule with a hypoechoic rim: “white knight”
Graves disease / Hashimotos thyroiditis?

Thyroid inferno

Graves disease: 4 hour uptake of 40%
Hashimoto’s thyroiditis

- Preclinical stage: Scintigraphy may show increased uptake
- Difficult to distinguish Hashitoxicosis from Graves disease by US or scintigraphy.
B. Evaluation of thyroid nodules

- Thyroid nodules are rare in children (estimated frequency of 0.05% to 1.8 %)
- However, prevalence of cancer in pediatric thyroid nodules is higher (5-33%)
- Challenge to determine which nodules are malignant
- Primary imaging modalities: US and rarely scintigraphy
- CT and MRI have very limited role
Evaluation of thyroid nodules
Radioisotope imaging for thyroid nodules

• Not as frequently used
• Can be utilized in a hyperthyroid patient with a palpable nodule.
• Less reliable if nodules are < 1cm
• Almost all malignant nodules are hypo functioning
• However 80% of hypo functioning nodules are benign and only 1% of hyperfunctioning nodules are malignant.
Thyroid nodules and Ultrasound

Most widely used imaging modality.

Findings concerning for malignancy:
- Size > 1cm
- Microcalcifications
- Hypoechogenicity
- Central intranodular vascular pattern
- Absent or irregular “halo”
- Irregular margin
- Extraglandular extension
- Local lymph node abnormalities
Thyroid nodules and Ultrasound

• Fine-Needle Aspiration Biopsy (FNAB)
• “Gold Standard” for the evaluation of a thyroid nodule
• Quick safe procedure, few complications and does not require radiation exposure
Benign degenerating nodule
Degenerating cystic nodules
Colloid cysts
Papillary thyroid cancer: US
Follicular carcinoma: US
Multinodular goiter
Toxic nodular goiter

4 hour uptake was 25%
Differentiated thyroid cancer: Radioiodine Whole Body Scan pre-ablation

- Radioiodine scanning remains the mainstay of staging for differentiated thyroid cancer.
- Thyroid cancer surveys are possible only after near-total thyroidectomy and are not appropriate for patients who have only undergone hemithyroidectomy.
- Star artifact due to substantial thyroid remnant
- I\(^{123}\) or I\(^{131}\)
Differentiated thyroid cancer: Radioiodine Whole Body Scan pre-ablation
Differentiated thyroid cancer: Radioiodine Whole Body Scan Post-ablation
Differentiated thyroid cancer:
Follow up post therapy scan about 4 months later
Imaging in Pediatric Thyroid disorders: Conclusion

• Thyroid scintigraphy and ultrasound are complimentary.

• Scintigraphy gives functional information of the thyroid gland or that of a clinically palpable thyroid nodule.

• In DTC, thyroid scintigraphy is often standard of care for post thyroidectomy remnant evaluation and in subsequent thyroid cancer surveillance.
Thank you