Nuclear Imaging & Therapy of Thyroid Disease

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Thyroid Disease

- Hyperthyroidism
- Thyroid Nodules
- Thyroid Cancer
Thyroid Disease

- Hyperthyroidism
- Thyroid Nodules
- Thyroid Cancer
Hyperthyroidism: Symptoms

• Weight Loss
• Fatigue
• Muscle Weakness
• Palpitations
• Sweating and Heat Intolerance
• Irritability
• Hair Loss
Hyperthyroidism: Signs

- Neck Enlargement
- Tachycardia
- Tremor
- Lid Lag and Retraction
- Exophthalmus
- Pretibial Edema
- Thyroid Acropachy
Hyperthyroidism: Labs

• Suppressed Serum Thyroid Stimulating Hormone (TSH)
Hyperthyroidism: Etiology

- Graves’ Disease (Toxic Diffuse Goiter)
- Toxic Nodular Goiter
- Subacute, Silent or Post-partum Thyroiditis
- Factitious Hyperthyroidism
Graves’ Disease
Autoantibodies

Hypothalamus

TRH

Anterior Pituitary

TSH

T3 and T4

Iodine Uptake

Negative Feedback
Graves’ Disease

- Thyroid Stimulating Immunoglobulins Bind TSH Receptor and Augment Thyroid Trapping and Organification of Serum Iodine
- Radioiodine Uptake Value is Usually Markedly Elevated
Thyroid Regional Autonomy

TSH SUPPRESSED

T3 T4
Toxic Nodular Goiter

- Regional Thyroid Tissue Autonomy Escapes Pituitary Control
- Regional Increase of Trapping and Organification of Iodine
- Radioiodine Uptake is Mildly to Moderately Increased
Diffuse Inflammation
Thyroiditis

- Inflammatory Process Results in Thyroid Cell Damage With Leakage of Thyroid Hormone into the Circulation
- Thyroid Cell Injury Results in the Interruption of Trapping and Organification of Iodine
- Radioiodine Uptake is Markedly Reduced
Factitious Hyperthyroidism

- Exogenous Thyroid Hormone Inhibits Pituitary TSH secretion
- Radioiodine Thyroid Uptake is Markedly Reduced
Thyroid Uptake: Patient Preparation

- Dietary Restriction of High Iodine Foods (Shellfish, Seaweed)
- Cessation of Amiodarone, Thyroid Hormone, or Anti-Thyroid Medication
- No Recent Radiographic Contrast
Thyroid Uptake: Agents

- I-131
- I-123
Thyroid Uptake: Calculation

• \% Uptake = \frac{[(\text{net neck counts} - \text{net thigh counts}) \times 100]}{\text{net standard counts}}
Thyroid Uptake: 6 vs. 24-hour

• 6-h Uptake Requires One Day
• 6-h Uptake Occasionally Elevated with a Normal 24-h Uptake (Hyperthyroid with Rapid Iodine Turnover)
Thyroid Uptake: Interpretation

- 6-h Normal Range: 5 to 15%
- 24-h Normal Range: 10 to 30%
Thyroid Scan: Agents

• I-131
• I-123
• Tc-99m Pertechnetate
Thyroid Scan: Clinical Utility

- Aids in the Differentiation of Graves’ Disease from Toxic Nodular Goiter
Thyroid Scan: Graves’ Disease
Thyroid Scan: Toxic Multinodular Goiter
Thyroid Scan: Toxic Nodular Goiter
Hyperthyroidism: Radioiodine Therapy

- Thyroid Tissue Extracts Iodine
Hyperthyroidism: Radioiodine Therapy

- Thyroid Tissue Extracts Iodine
- Beta Particles from I-131 Destroy Follicular Cells in the Thyroid
Hyperthyroidism: Radioiodine Therapy

- Thyroid Tissue Extracts Iodine
- Beta Particles from I-131 Destroy Follicular Cells in the Thyroid
- Subsequent Thyroid Function is Normal or Subnormal
Radioiodine Therapy: Patient Preparation

• No Recent Radiocontrast
Radioiodine Therapy: Patient Preparation

- No Recent Radiocontrast
- Avoidance of Dietary Iodine
Radioiodine Therapy: Patient Preparation

- No Recent Radiocontrast
- Avoidance of Dietary Iodine
- Cessation of Anti-Thyroid Drugs (PTU, Methimazole) for at least 3 days
Radioiodine Therapy: Patient Preparation

- No Recent Radiocontrast
- Avoidance of Dietary Iodine
- Cessation of Anti-Thyroid Drugs (PTU, Methimazole) for at least 3 days
- Beta Blockade
Radioiodine Therapy: Patient Preparation

- No Recent Radiocontrast
- Avoidance of Dietary Iodine
- Cessation of Anti-Thyroid Drugs (PTU, Methimazole) for at least 3 days
- Beta Blockade
- Pregnancy Test
Radioiodine Therapy: Dose Determination

- Radioiodine Uptake
- Thyroid Gland Size
- Effective Half-Life in the Gland
- Thyroid Follicular Cell Radiosensitivity
Radioiodine Therapy: Dose Determination

- Fixed Dose
Radioiodine Therapy: Dose Determination

- Fixed Dose
- Microcuries/Gland Mass
Radioiodine Therapy: Dose Determination

- Fixed Dose
- Microcuries/Gland Mass
- Absorbed Radiation Dose
Radioiodine Therapy: Therapeutic Effect

- Thyroid Hormone Levels Increase in the First Several Weeks Following Therapy.
- Euthyroidism or Hypothyroidism Ensues Within Two to Four Months.
- Continued Hyperthyroidism at Four Months is a Treatment Failure.
Radioiodine Therapy: Therapeutic Response

- Lower Initial Doses Decrease Early Incidence of Hypothyroidism
- Treatment Failure is More Likely in Low Dose Therapy.
- No Significant Difference in Long Term Rates of Hypothyroidism Between High and Low Dosing Strategies. (Sridama et al, 1984)
Objective: Hypothyroidism?

• Ensure Hypothyroidism with Sufficient Dose
• Institute Thyroid Hormone Replacement on a Permanent Basis
Radioiodine Therapy: Toxic Nodular Goiter

- Higher Radioiodine Dose As Thyroid Tissue is More Radioresistant
Radioiodine Therapy: Toxic Nodular Goiter

• Higher Radioiodine Dose As Thyroid Tissue is More Radioresistant
• Subsequent Hypothyroidism Much Less Common Than in Graves’ Disease
Radiodine Therapy: Early Complications

• Early Elevation of Thyroid Hormones
Radiodine Therapy: Early Complications

- Early Elevation of Thyroid Hormones
- Thyroid Storm (High Fever and Tachycardia)
Radiodine Therapy: Early Complications

- Early Elevation of Thyroid Hormones
- Thyroid Storm (High Fever and Tachycardia)
- Radiation Thyroiditis
Radioiodine Therapy: Late Complications

- Hypothyroidism
Radioiodine Therapy: Late Complications

- Hypothyroidism
- No Increased Risk of Thyroid Cancer (Anno et al, 1970)
Thyroid Disease

- Hyperthyroidism
- Thyroid Nodules
- Thyroid Cancer
Thyroid Nodules

• Definition: Discrete Lesion that is Palpable and/or Sonographically Distinct from Surrounding Thyroid Parenchyma (Cooper et al, 2006)
Thyroid Nodules

- Common Clinical Problem: Random Sonographic Surveys Indicate 19 to 67% of Population (Tan et al, 1997)
- Higher Frequency in Women and Elderly Populations.
Thyroid Nodules

• 5 to 10% Are Malignant
• Differentiated Thyroid Cancer Comprises 90% of these Tumors. (Papillary and Follicular Subtypes)
Thyroid Nodules

• Nonpalpable Nodules Discovered by Imaging Modalities (Incidentalomas) Have the Same Risk of Malignancy as Palpable Nodules of the Same Size. (Hagag et al, 1998)

• One Centimeter is the Generally Accepted Size Threshold For Further Evaluation
Thyroid Nodules: Laboratories

• Serum Thyrotropin (TSH)
Thyroid Nodules: Labs

• Subnormal TSH: Obtain Radionuclide Thyroid Scan
Hyperfunctioning Nodule: Requirements

- Region of Increased Activity Must Be Significantly Greater Than Surrounding Thyroid Tissue.
- Surrounding Thyroid Tissue Must Be Suppressed Indicating that the Hot Nodule is Autonomous.
- Malignancy is Not Excluded in “Warm” or Isointense Thyroid Nodules
Hyperfunctioning Nodule
Hyperfunctioning Nodule

- Malignancy is Extremely Rare
- Refer for Ablative Therapy with I-131
Thyroid Nodule: Labs

• Serum TSH Normal or > Normal: Obtain Thyroid Sonogram
Thyroid Sonogram

- Does the Palpable Finding Correspond to a Thyroid Nodule?
- Is the Nodule > 50% Cystic?
- Is the Nodule Located Posteriorly
- Are There Other Nodules?
Fine Needle Aspiration

- Most Accurate Method for Evaluating Thyroid Nodules
- Most Laboratories Utilize Sonographic Guidance
Fine Needle Aspiration

- Nondiagnostic
- Malignant
- Indeterminate
- Benign
Fine Needle Aspiration: Nondiagnostic Aspirate

- Fails to Make Specified Criteria for Adequacy
- Cystic Nodules Can Consistently Yield Nondiagnostic Aspirates. Malignancy Cannot Be Excluded
- Surgery Should Be Considered in Nondiagnostic Aspirates Especially in Solid Nodules
Fine Needle Aspiration: Indeterminate Cytology

- Other Terms Include “Suspicious” or “Follicular Neoplasm”
- Surgery Should Be Considered
Multinodular Goiters

- Each Nodule Within a Multinodular Gland Has the Same Risk of Malignancy as a Solitary Nodule in a Thyroid Gland
- If Only the “Dominant Nodule” is Aspirated, Thyroid Cancer May Be Missed in Other Nodules
Multinodular Goiter

• Given Two or More Thyroid Nodules Larger Than One Centimeter, Aspirate Those Nodules With a Suspicious Sonographic Appearance (Microcalcification, Hypoechogenicity or Intranodular Hypervascularity)
Multinodular Goiter

• If None of the Nodules Demonstrate a “Suspicious” Appearance or If Coalescent Nodularity is the General Appearance, Then Aspirate the Largest Nodule
Thyroid Nodules: Follow-Up

• Nodules Deemed Benign by FNA or Size Criteria: Repeat Sonography Within 6 to 18 Months