Nuclear Endocrinology
Board Review 2009

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New York, N.Y.
Nuclear Medicine Board Review: Endocrinology

- Thyroid Nodules
  - 24 hr Thyroid uptake, TFTs; Thyroid Scanning; $^{131}$I Therapy-Hyperthyroidism
  - Thyroid Cancer
    - Whole Body $^{131}$I Scanning
    - $^{131}$I Therapy-Thyroid Ca
- Hyperthyroidism
- Thyroid Cancer
  - Parathyroid Scintigraphy
  - MIBG Scintigraphy [Adrenal medullary tumors; pheochromocytoma, neuroblastoma; medullary ca thyroid]

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Nuclear Endocrinology

Tyrosine on Tgb

\[ \text{MIT} \quad \{ \text{DIT} \} \]

\[ \begin{align*}
\text{I}^- & \rightarrow \text{I}^0 + \text{R} \\
\text{I}^- & \rightarrow \text{X} \\
\text{KClO}_4 & \\
\text{123I, 131I} & \\
\text{123I, 131I} & \\
\text{99mTcO}_4 & \\
\text{99mTcO}_4 & \\
\end{align*} \]

Organification Defect

Anti-thyroid Drugs: PTU, Tapazole, etc

\[ \text{Bound to TBG} \]

\[ \text{Intracellular} \]

\[ \text{T}_3, \text{T}_4 \]

on Thyrogblobulin

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Perchlorate Washout Test for Organification Defect

Normal response to KClO₄ (blocks further trapping but previously trapped radioiodine has been organified and remains in the thyroid)

Organification Defect: 50% decrease in counts in 30 minutes; non-organified iodine washes out

123I, 131I

Time

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Factors that Affect $^{131}$I uptake

• Decreased Uptake - I
  – Thyroid hormones
  – Increased Iodine Intake
    • ssKI
    • Mineral Supplements including multi-vitamin prep
    • Iodine supplemented foods [salt; commercial bakery products. red dyes]
    • Drugs [Amiodorone (arrhythmia med)]; skin lotions, ointments
    • X-ray Contrast Agents
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Factors that Affect $^{131}$I uptake

• Decreased Uptake - II
  – Increased iodine retention [expanded iodine pool]
    • Renal Failure; Congestive Heart Failure
  – Non-iodinated Drugs that affect uptake
    • Anti-thyroid drugs: PTU, Methimazole
    • Steroids; Zoloft; Penicillin; Bromides
  – Acquired defects
    • Thyroiditis, [sub] acute painful; auto-immune
Nuclear Endocrinology

Factors that Affect $^{131}I$ uptake

• Increased Uptake
  – Iodine Deficiency
    • Endemic goiter regions; dietary deficiency
  – Physiologic and Pharmacologic
    • Pregnancy
    • Lithium
    • Rebound after discontinuing thyroid suppression medication
Thyroid Scintigraphy $^{99m}$Tc pertechnetate

Euthyroid

Hyperthyroid

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### Differential Diagnosis of Enlarged Thyroid

<table>
<thead>
<tr>
<th>Hyperthyroid</th>
<th>Euthyroid</th>
<th>Hypothyroid</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Clinical features of hyperthyroidism</td>
<td>- Clinically euthyroid [normal]</td>
<td>- Clinical features of hypothyroidism</td>
</tr>
<tr>
<td>- $\downarrow$ TSH; $\uparrow$ $T_4$, $T_3$</td>
<td>- Normal TSH</td>
<td>- $\uparrow$TSH; $\downarrow$ $T_4$, $T_3$</td>
</tr>
<tr>
<td>- $\uparrow$ iodine uptake</td>
<td>- Normal $T_4$, $T_3$</td>
<td>- $\downarrow$ iodine uptake</td>
</tr>
<tr>
<td>- diffuse increase size or hyper nodule</td>
<td>- $\uparrowT_4$, consider estrogens, familial, pregnancy</td>
<td>- diffuse increase size or small; if large, congenital or acquired synthesis defect or antithyroid drugs (blocking synthesis); if small, consider chronic thyroiditis [Hashimoto’s], surgery or radiation</td>
</tr>
<tr>
<td>- If iodine uptake $\downarrow$, consider thyroiditis (subacute) or $T_4$, $T_3$ intake or true hyper $+$ $\uparrow$ iodine intake</td>
<td>- If $\uparrowT_4$, consider estrogens, familial, pregnancy</td>
<td>- If $\downarrow$TSH; preclinical hypothyroidism</td>
</tr>
<tr>
<td>- If TSH is $\uparrow$, consider TSH producing pituitary tumor</td>
<td>- If $\downarrow$TSH, preclinical hypothyroidism</td>
<td>- If TSH is $\downarrow$, consider nonfunctioning pituitary [tumor]</td>
</tr>
</tbody>
</table>
Published Guideline: Nodule Evaluation

Thyroid Nodule [palpation/imaging] > 1.0-1.5 cm

Hx & Phys Serum TSH

Low TSH

NI or Hi TSH

Dx U/S

<50% cyst

50% cyst posterior

Other nodule 1.0-1.5 cm

No nodule

Eval/Rx

Hyper

Not

123I, 99mTc scan

<50% cyst

> 50% cyst or posterior

Surgically Guided FNA

Malignant

Inadequate

Repeat U/S FNA

Inadequate

Benign

No Rx; Follow

Elevated TSH

123I scan

Warm

Cold

Consider 123I scan

No Rx; Follow

? Hypo

Elevated TSH

Normal TSH

No Rx; Follow

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Thyroid Scintigraphy \(-^{99m}\text{Tc} \text{ pertechnetate}\)

- anterior
- with marker
- LAO
- RAO
Thyroid Scintigraphy - $^{99m}$Tc pertechnetate
Patient may or may not present with clinical hyperthyroidism; low or normal TSH at that time. I-131 etc is not performed during pregnancy or while nursing; evaluate later even if clinically normal.
Hyperthyroidism

- Therapeutic Choices
  - Anti-thyroid drugs
  - Surgery
  - I-131 therapy

- Fixed dose; Low: 4.5 mCi, High: 7.5 mCi
- Dose adjusted for size & uptake \([\mu\text{Ci/gm}]\)
  - Low: 80 \(\mu\text{Ci/gm}\), High: 160 \(\mu\text{Ci/gm}\) [or more]
- Patient specific dosimetry: adjusted for size, uptake, turnover

  - Graves 7000 rads
  - TMNG 10,000 – 12,000 rads
  - Age; Prior Rx 10,000 – 12,000 rads
  - Atrial Fibrillation 12,000 - 15,000 rads
  - Combinations 12,000 – 15,000 rads
  - Toxic Nodule 15,000 rads

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\[ ^{131}I \text{ Therapy of Hyperthyroidism} \]

**Calculation of Radiation Absorbed Dose**

- Can use computer program based on Quimby-Marinelli or MIRD
- Can use simplified formula that assumes uniform geometry [Zanzonico]

\[
\text{Radiation Absorbed Dose} = \frac{\text{Admin Activity [uCi]} \times \% \text{ uptake}}{\text{gland weight [gm]}} \times T_{1/2\text{eff}} \times \text{Constant}
\]

\[
\text{Admin Activity} = \frac{\text{cGy desired} \times \text{gland wt [gm]}}{T_{1/2\text{eff [days]}} \times 24 \text{ hr uptake [\%]}} \times 6.67
\]

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Therapy of Hyperthyroidism

- Risks
  - Recurrent/ persistent hyperthyroidism [under treated]
  - Hypothyroidism [over treated]
  - No increased risk of malignancy, thyroid carcinoma, leukemia
$^{131}$I Therapy of Euthyroid Goiter

- **Issues:**
  - rTSH preparation
  - $^{131}$I dose:
    - Fixed dose [< 30 mCi]
    - Dosimetry [20,000-30,000 rads to thyroid; normal thyroid is more resistant than Graves Disease Thyroid]
Thyroid Carcinoma
Role of $^{131}$Iodine

• Ablation of Remnant
  – Range of Doses: Select Dose based upon assessment of risk factors and surgical and histopathology findings

• Treatment of Residual Thyroid Cancer
  – Thyroid Bed; Regional Lymph Nodes

• Treatment of Thyroid Cancer Metastases
  – Mediastinal Lymph Nodes
  – Lungs
  – Bones
  – Other
Effect of Administered $^{131}$I Activity on Success of Initial Ablation of Thyroid Remnant in 70 Patients

<table>
<thead>
<tr>
<th>mCi (MBq)</th>
<th>Successful</th>
<th>Failed</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 30 (&lt;1110)</td>
<td>20/26 (77%)</td>
<td>6/26 (23%)</td>
</tr>
<tr>
<td>≥30 (≥1110)</td>
<td>37/44 (84%)</td>
<td>7/44 (16%)</td>
</tr>
<tr>
<td>&lt;45 (&lt;1665)</td>
<td>28/33 (79%)</td>
<td>7/33 (21%)</td>
</tr>
<tr>
<td>≥45 (≥1665)</td>
<td>31/37 (84%)</td>
<td>6/37 (16%)</td>
</tr>
</tbody>
</table>

Maxon, H et al JNM 1992
## Thyroid Cancer – Remnant Ablation

<table>
<thead>
<tr>
<th>Group [n= 149]</th>
<th>25 - 35 mCi</th>
<th>35 - 64 mCi</th>
<th>65 -119 mCi</th>
<th>120 - 200 mCi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity (mCi)</td>
<td>30.0 ± 1.5</td>
<td>50.6 ± 5.4</td>
<td>88.6 ± 14.0</td>
<td>155.0 ± 28.7</td>
</tr>
<tr>
<td>Radiation Absorbed Dose (cGy)</td>
<td>19,800 ± 992</td>
<td>31,372 ±3,355</td>
<td>49,616 ± 7,858</td>
<td>130,200 ± 24,162</td>
</tr>
<tr>
<td># Success (%)</td>
<td>17/27 (63.0)</td>
<td>42/54 (77.8)</td>
<td>28/38 (73.7)</td>
<td>23/30 (76.7)</td>
</tr>
</tbody>
</table>

Bal et al; Cancer, 1996
Thyroid Cancer
Patient Release following I-131

• In May 1997, the US Nuclear Regulatory Commission revised its patient release regulations.
  – Previously, medical confinement required until exposure rate was < 5 mR/h at 1 meter or until patient contained < 30 mCi.
• New rule allows release if exposure to any other individual is not likely to exceed 5.0 mSv based on a patient-specific calculation.
  – Release also permitted < 7 mR/h at 1 meter.

JAMA 2000

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Thyroid Cancer Patient Release

Figure. Radiation Exposure

Measured radiation exposure to 30 children (younger than 19 years), 35 adults, and 17 pets living in the households of 30 patients treated as outpatients with 2.8 to 5.6 GBq of sodium iodide I 131 for thyroid carcinoma. The maximum radiation exposure to household members, mandated by new Nuclear Regulatory Commission regulations, is 5.0 mSv.

75-150 mCi

JAMA 2000
Comparison of Procedure Guidelines for I-131 Therapy of Patients with Thyroid Carcinoma

<table>
<thead>
<tr>
<th>SNM Guideline:</th>
<th>EANM Guideline:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• For postoperative ablation of thyroid bed remnants: activity in the range of</td>
<td>• For patients undergoing ablation of thyroid remnant: administered activities in</td>
</tr>
<tr>
<td>2.75–5.5 GBq (75–150 mCi) is typically administered, depending on the RAIU</td>
<td>the range of 3700–5500 MBq (100–150 mCi) are usually given.</td>
</tr>
<tr>
<td>and amount of residual functioning tissue present</td>
<td></td>
</tr>
</tbody>
</table>

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131I Ablation (Therapy) in Patients with Thyroid Cancer

- Based upon assessment of risk of residual disease and likelihood of recurrence, 50-150 mCi of 131I is pre-selected as an ablative/therapeutic dose for patients not known to have metastatic disease.
- Nevertheless, a pre-Rx WB scan with 2 mCi of 123I is performed to “exclude surprises”.
- Post-Rx scan is performed at 7-10 days.
Thyroid Cancer

- hu rTSH [Thyrogen®] was approved over a decade ago as a means to prepare thyroid cancer patients for $^{131}$I whole body scan and surveillance in place of thyroid hormone withdrawal
  - Concordant scans [compared with Thyroid hormone withdrawal]: 195/220 (89%).
  - Discordant scans:
    - 8/220 (4%) rTSH > THWD
    - 17/220 (8%) rTSH < THWD [$p = 0.11$]
  - Overall diagnostic equivalence for detection of remnant thyroid and thyroid carcinoma metastases
rTSH in Thyroid Carcinoma

Thyroid Hormone Therapy Maintained

0.9 mg rhTSH

0.9 mg rhTSH

2–5 mCi $^{131}$I

Scan

Day # 1 2 3 4

Serum Tgb; pre rTSH & Day 4

• rTSH is viewed as an acceptable (even preferred method to prepare Thyroid Ca pts for assessment with WB imaging and serum thyroglobulin measurement

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rhTSH Testing: Metastases Detection Rate

- rhTSH whole-body scan and Tg
- rhTSH Tg
- Tg on thyroid hormone therapy

![Bar chart showing detection rates for rhTSH based on serum thyroglobulin cut-offs of ≥2, ≥5, and ≥10 ng/mL.]

- For serum thyroglobulin cut-offs of ≥2 ng/mL, the detection rates are 100% for both rhTSH whole-body scan and Tg, and rhTSH Tg.
- For serum thyroglobulin cut-offs of ≥5 ng/mL, the detection rates are 100% for rhTSH whole-body scan and Tg, and 97% for rhTSH Tg.
- For serum thyroglobulin cut-offs of ≥10 ng/mL, the detection rates are 88% for rhTSH whole-body scan and Tg, and 80% for rhTSH Tg.

Data on file, Genzyme Corporation.

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rTSH as preparation for Thyroid Remnant Ablation *Robbins RJ et al JNM 2002*

**Thyroid Hormone Withdrawal**

**rhTSH**
Modern Approach to $^{131}$I Therapy: Remnant Ablation, Rx Local Disease

Maintain Thyroid Hormone Therapy

- Tgb
  - 0.9 mg rhTSH
  - 0.9 mg rhTSH

4 hrs later 2–4 mCi $^{123}$I

50-150 mCi $^{131}$I ablation or Rx cervical LN

Day # 1 2 3 10

Post-Rx WB Scan

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Pre $^{131}$I Rx

1 year

Post $^{131}$I Rx
Comparison of Procedure Guidelines for I-131 Therapy of Patients with Thyroid Carcinoma

SNM Guideline:
• For treatment of presumed thyroid cancer in the neck or mediastinal lymph nodes: activity in the range of 5.55–7.4 GBq (150–200 mCi) is typically administered.

EANM Guideline:
• For patients undergoing re-treatment for residual disease or local recurrence, somewhat larger administered activities (in the range of 5500 MBq (150 mCi) are often used.

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Comparison of Procedure Guidelines for I-131 Therapy of Patients with Thyroid Carcinoma

SNM Guideline:
• For treatment of distant metastases, >7.4 GBq (>200 mCi) is often given.
• Retention of radiiodine in the body at 48 hr should be <4.44 GBq (120 mCi) to reduce the risk of myelosuppression or <2.96 GBq (80 mCi) if diffuse lung metastases are present to reduce the risk of radiation pneumonitis.

EANM Guideline:
• For patients with distant metastases: administered activities of 7400 MBq (200 mCi) or more may be used.
• Caution is recommended in patients with diffuse lung metastases in view of the potential risk of radiation fibrosis.

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Comparison of Procedure Guidelines for I-131 Therapy of Patients with Thyroid Carcinoma

- **SNM Guideline:**
- For treatment of distant metastases, activity > 7.4 GBq (200 mCi) is often given.
- Radiation dose to the bone marrow is typically the limiting factor.
- Most experts recommend limiting the estimated radiation dose to the bone marrow to < 200 cGy (200 rads).
- Detailed dosimetry may be indicated to determine the $^{131}$I dose that can be safely administered.
Summary
Radioactive Iodine Therapy of Thyroid Carcinoma

- $^{131}$I ablative doses from 50-150 mCi can be selected based upon assessment of risk of recurrence, based on clinical factors including surgical-path findings.

- Extra-thyroidal disease is treated with >250 mCi depending on age and extent of disease.

- Dosimetry is appropriate > 40-45 yo using the Quimby-Marinelli formulation [also depends on renal functional status].
FIGURE 1: MTA distribution for the 328 patients. Mean MTA is $15.3 \pm 6.4$ GBq (414 ± 173 mCi).

\[ \text{MTA (GBq)} \]

\[ \text{Number of patients} \]

\[ \text{~200 mCi} \]
% of patients (by decade) in whom MTA exceeded empiric dosing. Empiric dose > 200 mCi (7.4 GBq) exceeded MTA in 14% from 60-69 yo* and 22% from 70-79 yo.* Empiric dose of 250 mCi (9.25 GBq) exceeds MTA in 20% from 60-69 yo* and 50% ≥ 70 yo.*

Tuttle M et al JNM 2006
Effect of Clearance Rate on Radiation Absorbed Dose (cGy)

Individuals with a rapid clearance rate tolerate a higher administered dose (mCi) than those with a slow clearance rate. Individuals with a slow clearance rate only tolerate a lower administered dose (mCi).

Rapid Clearance: 200 cGy
Slow Clearance: 200 cGy
Radiation Dosimetry in Thyroid Cancer Therapy

• Patient specific dosimetry is most relevant in treating metastatic disease [\(^{131}\text{I} \text{doses} \geq 200 \text{ mCi}\)]

• Patient differences due to renal function; age; body iodine pool

• 200 cGy to marrow is used as the maximal radiation absorbed dose [Maximum Tolerated Activity (MTA)] (some latitude exists)

• Allows administration of largest safe dose
Radiation Dosimetry in Thyroid Cancer Therapy

• Treatment of metastatic thyroid carcinoma
  – Determination of the Maximal Tolerated Activity
  – Organ at risk: Bone Marrow
  – Clinical observations at MSKCC years ago [Benua & Leeper]: No adverse bone marrow effects if dose to blood does not exceed 200 cGy [per year]
  – Estimate Bone Marrow radiation absorbed dose by calculating rads to Blood [Quimby-Marinelli]
    • Since I-131 is NOT deposited in bone marrow:
    • Bone marrow receives β-radiation from blood within marrow
    • Additional radiation received from activity throughout the body [g]
$^{131}$I Therapy of Thyroid Cancer

$^{131}$Iodine

$\beta$ Blood Activity $\rightarrow$ Bone Marrow

$\gamma$ Whole Body $\rightarrow$ Bone Marrow

(illustrative purpose only: not $^{131}$I biodistribution)
Radiation Dosimetry in Thyroid Cancer Therapy

Data Points obtained following 2 mCi I-131 Tracer Dose

Blood data is principal source of radiation absorbed dose to blood from $\beta$ radiation

Total body data is principal source of radiation absorbed dose to blood from $\gamma$ radiation

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Radiation Dosimetry in Thyroid Cancer Therapy

Quimby-Marinelli Formulation:

• Dose $b_{\text{blood}} = 51.2$ (constant) $\times E_b \times C(t)$

• Dose $g_{\text{whole body}} = 0.024$ (constant) $\times g_T \times p$ (density $= 1$) $\times G$ (geometric constant)

• Total Blood Dose [per mCi] =

  \[
  \text{Dose } b_{\text{blood}} \rightarrow \text{blood} + \text{Dose } g_{\text{whole body}} \rightarrow \text{blood}
  \]

  \textbf{MIRD}

• MIRD formulation can also be used

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Thyroid Cancer

• Papillary and Follicular Carcinoma
  – Newly Diagnosed Patients
    • Frequently post-op when 1st seen by nuclear medicine or endocrinology
    • Likely on Thyroid hormone replacement
      • Characterize Risk: Age, Gender, Tumor Size, Local Invasion, Lymph Node Mets; Distal Mets
Thyroid Cancer

• Papillary and Follicular Carcinoma
  • Low Risk of Recurrence
    – Less than 40-45 yrs; Female; Tumor < 2.5 cm; no capsular invasion; no lympho-vascular invasion; negative margins; negative lymph nodes; appropriate thyroglobulin

• T4 replacement and observe thyroglobulin levels at intervals
Thyroid Cancer

• Papillary and Follicular Carcinoma

• Increased Risk
  – If either > 45 yrs, male, tumor > 2.0-.2.5 cm; multifocal or evidence of local invasion of thyroid, lympho-vascular invasion or extrathyroidal tissue; + lymph nodes
Thyroid Cancer
Is “stunning” real?

If the surgical history is known, and the ablative $^{131}$I dose is based on risk factors for residual or metastatic thyroid cancer, imaging may not be needed before ablation.

If imaging is considered necessary before ablation, as some have argued (9), use of $^{123}$I instead of $^{131}$I will avoid stunning.

If $^{131}$I imaging is performed before ablation, a 74-MBq dose is unlikely to cause significant stunning. A 185-MBq dose may cause stunning of remnant tissue, although satisfactory ablation is likely to be achieved anyway.

2 mCi

James Woolfenden
Sept 2006
<table>
<thead>
<tr>
<th>Workspace</th>
<th>I131 WB POST RX</th>
<th>VARICAM</th>
<th>NEW YORK PRESBYTERIAN</th>
</tr>
</thead>
</table>

48 yo woman; papillary carcinoma; no angio-lymphatic invasion; negative margins; lymph nodes negative.

Elevated Tgb [residual thyroid]; $^{131}$I WB scan revealed 2 vertebral metastases. Patient underwent WB dosimetry and was Rx with 360 mCi $^{131}$I.

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18F-FDG PET scans before and after 360 mCi I-131 Rx of thyroid Ca metastasis to lumbar vertebrae

Pre I-131 Rx

2 years post Rx

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Thyroid Cancer Management Based on Risk Assessment

<table>
<thead>
<tr>
<th>Low Risk Patient</th>
<th>Medium Risk Patient</th>
<th>High Risk Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>• $^{123}$I scan; Tgb</td>
<td>• $^{123}$I scan; Tgb</td>
<td>• $^{131}$I dosimetry → determine MTD</td>
</tr>
<tr>
<td>• If no “surprise”, Rx $^{131}$I 50 - 75 mCi</td>
<td>• If no “surprise”, Rx $^{131}$I 150 mCi</td>
<td>• Rx MTD $^{131}$I *</td>
</tr>
<tr>
<td>• WB scan 1 week post Rx</td>
<td>• WB scan 1 week post Rx</td>
<td>• WB scan 1 week post Rx</td>
</tr>
<tr>
<td>• Monitor Tgb</td>
<td>• Monitor Tgb</td>
<td>• Monitor Tgb</td>
</tr>
<tr>
<td>• At 1 yr, follow-up w. rTSH Tgb &amp; $^{123}$I or $^{131}$I scan</td>
<td>• At 1 yr, follow-up w. rTSH Tgb &amp; $^{123}$I or $^{131}$I scan</td>
<td>• At 6 -12 months:</td>
</tr>
<tr>
<td>• If negative, continue to monitor rTSH stimulated Tgb q year; scan prn</td>
<td>• If negative, continue to monitor rTSH stimulated Tgb q year; scan at increasing intervals</td>
<td></td>
</tr>
</tbody>
</table>

* Should not exceed 150 mCi without WB dosimetry if >40 yo or decreased renal function; 250 mCi safe in young
POST OP; PRE $^{131}$I Rx

1 year POST $^{131}$I Rx

↑ Tgb
$^{18}$F-FDG Scan in a patient with a Negative $^{131}$I WB scan and elevated serum Thyroglobulin

Surgical resection of lymph nodes:
Thyroid carcinoma confirmed histologically
\[^{131}\text{I}\text{ Negative; Thyroglobulin Positive}\text{ Thyroid Carcinoma: Treatment Options}\]

- \[^{18}\text{FDG PET scan: If +, evaluate for surgical resection; EBRT}\]
  - If inoperable, \[^{131}\text{I therapy: 100-150 mCi or MTD [> 150 mCi requires dosimetry]}\]
- \[^{18}\text{FDG PET scan: If-, maintain T}_4\text{ suppression of TSH; Observe}\]
Nuclear Medicine Board Review: Endocrinology

- **Thyroid Nodules**: 24 hr Thyroid uptake, TFTs; Thyroid Scanning; $^{131}$I Therapy-Hyperthyroidism
- **Hyperthyroidism**: 24 hr Thyroid uptake, TFTs; Thyroid Scanning; $^{131}$I Therapy-Hyperthyroidism
- **Thyroid Cancer**: Whole Body $^{131}$I Scanning; $^{131}$I Therapy-Thyroid Ca

- **Parathyroid Scintigraphy**
- **MIBG Scintigraphy** [Adrenal medullary tumors; pheochromocytoma, neuroblastoma; medullary ca thyroid]
Nuclear Medicine Board Review: Endocrinology

• Parathyroid Scintigraphy
  – Localization of parathyroid tissue in patients with hyperparathyroidism following demonstration of elevated Pth levels
  – Hyperparathyroidism, primary
    • Parathyroid adenoma: 80%
      – Scintigraphy ~90% sensitive for detection of adenoma > 1gm; has detected as small as 0.3 gm; SPECT & SPECT/CT may improve performance
      – Include parallel hole collimator view of thorax to detect ectopic and/or recurrent adenoma
    • Parathyroid hyperplasia: 20%
      – Generally non-visualized or multiple sites
      – If seen, difficult to differentiate from multiple adenomata

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Parathyroid Scintigraphy

- Thyroid & Parathyroid - Thyroid = Parathyroid

- Dual phase

- \( ^{123} \text{I} \) - \( ^{201} \text{Thallium} \)
- \( ^{99m} \text{Tc MIBI} \) - \( ^{99m} \text{TcO}_4 \)
- \( ^{123} \text{I} \) - \( ^{201} \text{Thallium} \)
- \( ^{99m} \text{Tc MIBI} \) - \( ^{99m} \text{Tc O}_4 \)

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Admin $^{123}$I orally. Pt returns at 4 or 24 hrs; image; follow with $^{99m}$Tc MIBI


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\[ {^{99m}Tc}\text{-Sestamibi} \]

15 min

2.5 hr

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Although there are differences in the $^{99m}$TcO$_4$ & $^{99m}$TcMIBI image, the subtraction image is well defined. Dual phase is not helpful. SPECT shows retro-thyroid location.
Ectopic Parathyroid Adenoma

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Adrenal Medullary Imaging
Pheochromocytoma

- Paroxysmal or sustained hypertension, headaches, palpitation, sweating, chest pain, anxiety
- MEN II may be asymptomatic
- Unilateral 90%; Bilateral 10%
- Malignant 2 - 10%
- Localization: I-131 MIBG  N = 1,900
  - Sensitivity 86%; Specificity 99%
  - Sensitivity: CT/ MRI > MIBG
  - Specificity: CT/MRI < MIBG

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Adrenal Medulla Imaging: Pheochromocytoma

Adrenergic pre-synaptic region

Secretory granules: epinephrine

Uptake: stimulation

Re-uptake

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Nuclear Medicine Board Review: Endocrinology

Adrenal Medulla Imaging: Pheochromocytoma

Adrenergic pre-synaptic region

MIBG

MIBG is recognized and taken up by pre-synaptic re-uptake mechanism: no effect at post-synaptic junction

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