Incorporating Nuclear Medicine Into An Endocrine Office

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Prior to a radioidine administration, a patient with a history of a severe reaction to contrast should be treated with:

- nothing
- diphenhydramine 50 mg p.o. 1 h prior
- prednisone 50 mg p.o. 1 h prior
- prednisone 50 mg p.o. 13, 7, and 1 h prior

Iodine Allergy

Minimum daily allowance of iodine

\[ 150 \text{ mg} = 150,000 \text{ ngm} \]

1 mCi of I-123 = 0.51 ngm

\[ 1 \text{ mCi} \times 37 \text{ MBq/mCi} = 3.7 \times 10^7 \text{ d/s} \]

\[ N = A \times \frac{1}{\lambda}, \text{ where } \frac{1}{\lambda} = T_{\text{mean}} \]

\[ 3.7 \times 10^7 \text{ d/s} \times 19 \text{ h (} T_{\text{mean}}) \times 3600 \text{ s/h} = 2.5 \times 10^{12} \text{ atoms} \]

\[ 2.5 \times 10^{12} \text{ atoms} / 6.022 \times 10^{23} \text{ atoms/mole} = 4.1 \times 10^{-12} \text{ moles} \]

\[ 4.1 \times 10^{-12} \text{ moles} \times 123 \text{ gm/mole} = 5.1 \times 10^{-10} \text{ gm} \]

\[ 5.1 \times 10^{-10} \text{ gm} = 0.51 \text{ ngm} \]

The best diagnosis for a 36-year-old woman with thyrotoxicosis:

- normal
- Graves’ disease
- autonomous nodule
- subacute thyroiditis

The best diagnosis for a 38-year-old woman with subclinical thyrotoxicosis:

- normal
- Graves’ disease
- autonomous nodule
- subacute thyroiditis

The best diagnosis for a 56-year-old woman with thyrotoxicosis:

- normal
- Graves’ disease
- autonomous nodule
- subacute thyroiditis
The best next step in this 46-year-old euthyroid woman with is:

- follow thyroid function ultrasound
- fine needle aspiration surgery

5 y later initial follow thyroid function ultrasound fine needle aspiration surgery

**RECOMMENDATION 2**

(A) Serum thyrotropin (TSH) should be measured during the initial evaluation of a patient with a thyroid nodule. 

(Strong recommendation, Moderate-quality evidence)

(B) If the serum TSH is subnormal, a radionuclide (preferably ¹³¹I) thyroid scan should be performed. (Strong recommendation, Moderate-quality evidence)

(C) If the serum TSH is normal or elevated, a radionuclide scan should not be performed as the initial imaging evaluation. (Strong recommendation, Moderate-quality evidence)

Since hyperfunctioning nodules rarely harbor malignancy, if one is found that corresponds to the nodule in question, no cytologic evaluation is necessary.

The best diagnosis in this 54-year-old man with thyrotoxicosis is:

- Graves'
- Graves' + MNG
- Graves' + Ca toxic MNG

**Toxic Multinodular Goiter**

**Thyrotoxicosis, TSH 0.15,**

Dominant Left Lower Pole Nodule

RAO Ant LAO

24-hour Uptake 46%
TSH 0.15, left lower pole nodule. What is the BEST next step?

- Rx with methimazole
- Rx with $^{131}I$
- FNA Nodule
- Ultrasound

**Predominantly Cystic Autonomous Nodule**

- 40-year-old woman with a 3.1 cm right and a 1.5 cm left thyroid nodule. What should be done next:
  - follow up
  - Rx with methimazole
  - FNA

**40-year-old woman with a 3.1 cm right and a 1.5 cm left thyroid nodule. What should be done next:**

- Left papillary thyroid carcinoma

**The best diagnosis in this 67-year-old woman with thyrotoxicosis is:**

- Graves'
- Graves' + MNG
- Graves' + Ca toxic MNG
Dx in a 46-year-old woman with minimal heterogeneity on ultrasound is:

- Graves'
- Graves' + MNG
- Graves' + Ca
toxic MNG

Thyroid Scan in Thyrotoxicosis: Big Three Diagnoses

- Uniform, very high uptake
  - Graves' disease
- Focal, moderately high uptake
  - Autonomous nodule
- No uptake
  - Subacute thyroiditis
  - Factitious hyperthyroidism

Thyroid Scan in Thyrotoxicosis: More Complex Diagnosis

- Uniform, normal uptake: current TSH
  - Normal TSH: recovering thyroiditis
  - Low TSH: Graves'
- Focal with defect
  - Involution of autonomous nodule
- Irregular, high uptake
  - Graves'
  - Graves' plus MNG: cold foci
  - Toxic MNG: hot foci

Whole Body Scans

<table>
<thead>
<tr>
<th>Diagnostic</th>
<th>Post-Rx 131I, 7 days later</th>
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<tbody>
<tr>
<td>123I</td>
<td></td>
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</table>

The difference between scans is due to:

- Biological variability
- False positive post-Rx
- Photon energy
- Resolution
- Post-Rx is more sensitive

Pre-therapy Scan: Old Guidelines

**RECOMMENDATION 35**

Pretherapy scans and/or measurement of thyroid bed uptake may be useful when the extent of the thyroid remnant cannot be accurately ascertained from the surgical report or neck ultrasonography, or when the results would alter either the decision to treat or the activity of RAI that is administered. If performed, pretherapy scans should utilize $^{123}$I (1.5-3 mCi) or low-activity $^{131}$I (1.5-3 mCi), with the therapeutic activity optimally administered within 72 hours of the diagnostic activity. Recommendation rating C.

Thyroid 2009; 19:1167-1214
**RECOMMENDATION 33**

(A) Preoperative use of cross-sectional imaging studies (CT, MRI) with intravenous (IV) contrast is recommended as an adjunct to US for patients with clinical suspicion for advanced disease, including invasive primary tumor, or clinically apparent multiple or bulky lymph node involvement.

*(Strong recommendation, Low-quality evidence)*

(B) Routine preoperative $^{18}$FDG-PET scanning is not recommended.

*(Strong recommendation, Low-quality evidence)*

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**Differentiated Thyroid Cancer**

- **40-year-old woman**
- **1.9 cm multi-focal**
- **Papillary carcinoma, follicular variant**
- **No lymphovascular invasion**
- **Extends to margin focally**
- **2 negative lymph nodes**

**TSH 53 (0.27-4.2) µIU/mL**

**Anti-Thyroglobulin Ab 242 (0-40) IU/mL**

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**Diagnostic $^{123}$I Scan**

**24-hour uptake 10%**

**Transmission Ant Post**

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**What is the BEST next step?**

- Therapy with 1.85 GBq (50 mCi)
- Therapy with 3.7 GBq (100 mCi)
- Re-image after at day 3
- SPECT/CT
- Repeat TSH measurement

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**$^{123}$I SPECT/CT**
Post 7.4 GBq (200 mCi) $^{131}$I

Papillary Thyroid Carcinoma

- 79-year-old man
- Thyroidectomy for goiter 10 y previously
- Incidental 2.5 cm papillary carcinoma
- Presents for hip pain
- Destructive lytic metastasis
- Biopsy: papillary carcinoma

The most likely diagnosis (arrow) is?

Liver metastasis
Adrenal metastasis
Gastric activity
Contamination
Duodenal diverticulum

Contrast CT

Large Remnant with 40% Uptake
Diffuse Liver Uptake

$^{131}$I 1 day diagnostic
$^{131}$I 7 days post therapy
The liver uptake is related to:
- diffuse liver metastasis
- NaI symporter
- labeling of plasma proteins
- remnant thyroid
- cirrhosis

Large Remnant with 40% Uptake
Diffuse Liver Uptake - Not Metastases!
- 123I - 7 days post therapy

Differentiated Thyroid Cancer Metastasis
- Regional lymph nodes
- Lung
- Bone
- Liver (focal)
- Central nervous system

49-year-old woman s/p surgery for papillary cancer. The focus is:
- remnant tissue
- salivary tissue
- level II LN metastasis
- level VI LN metastasis

Hemiagenesis
I-123 Withdrawal Scan
- S/P R thyroidectomy for Ca
- Hemiagenesis by US & at bx

Post-Rx 131I Scan (3.7 GBq, 100 mCi)
- Maker: abdominal wall nodule
The MOST likely diagnosis (arrow) is:
- contamination
- furuncle
- diverticulum
- abdominal wall metastasis
- rib metastasis

FDG-PET/CT
At time of $^{131}$I post-Rx scan. Path papillary thyroid.

7-years later

In a 45-year-old woman with an incidental 0.8 cm FDG-avid nodule, the BEST next step is:
- follow up
- $^{123}$I thyroid scan
- FNA with cytology
- FNA with molecular testing

RECOMMENDATION 5
Haugen: Thyroid 2016; 26:1

(A) Focal $^{18}$FDG uptake within a sonographically confirmed thyroid nodule conveys an increased risk of thyroid cancer, and FNA is recommended for those nodules $\geq 1$ cm.

(Strong recommendation, Moderate-quality evidence)

B) Diffuse $^{18}$FDG-PET uptake, in conjunction with sonographic and clinical evidence of chronic lymphocytic thyroiditis, does not require further imaging or FNA.

(Strong recommendation, Moderate-quality evidence)

2-Fluoro 2-Dexoy-D-glucose (FDG)

Blood $\rightarrow$ Glut

Cell

FDG $\rightarrow$ Hexokinase

Phosphatase (Liver)

FDG-6-P
FDG-PET/CT is MOST useful for:

- Initial staging in stage III with tall cell variant
- Initial staging in stage IVa with incomplete resection
- Evaluation of lung metastases in papillary ca
- Rising thyroglobulin with a negative post-Rx scan
- Evaluation of iodine-avid CNS metastases

**RECOMMENDATION 68**

Haugen: Thyroid 2016; 26:1

(A) 

(Strong recommendation, Moderate-quality evidence)

(B) 

(Weak recommendation, Low-quality evidence)

Post Rx Scan 5/23/02

FDG-PET 7/01/03

Utility of Surgery in Localized Disease

FDG-PET/CT
2-Fluoro 2-DeoxyGlucose (FDG)

Cancer ferments glucose
- Otto Warburg, 1931 Nobel Prize

Higher FDG-SUV
- high overall metabolic rate
- less FFA metabolism
- hypoxia / non-TCA cycle
- proliferation
22 y/o Man Papillary Thyroid Cancer

- 22-year-old man
- Multifocal, left, papillary thyroid cancer
  - largest focus 3.9 x 3.5 x 2.5 cm
- 8/12 lymph central nodes positive
- 1 mm from margin
- Suspicious for lymphatic invasion
- Chronic thyroiditis
- 24-hour iodine uptake 5%

131I therapy
dosimetry
$^{123}\text{I}$ Diagnostic Whole Body Scan

$^{123}\text{I}$ SPECT/CT
downlow-dose tidal-breathing CT negative

$^{123}\text{I}$ Better Resolution
$^{131}\text{I}$ Better Biodistribution

$^{123}\text{I}$ Better Resolution
$^{131}\text{I}$ Better Biodistribution
Of the following locations, which is the most common site of differentiated thyroid metastasis?

- Adrenal glands
- Muscle
- Liver
- Spleen
- Salivary glands

Which test is BEST for detection of differentiated thyroid Ca metastasis?

- Diagnostic scan 1 day post 37 MBq (1 mCi) $^{123}$I
- Diagnostic scan 3 days post 185 MBq (5 mCi) $^{123}$I
- Diagnostic scan 3 days post 74 MBq (2 mCi) $^{131}$I
- Diagnostic scan 7 days post 370 MBq (10 mCi) $^{131}$I
- Post-Rx scan 7 days after $^{131}$I Rx

The MOST sensitive technique for diagnostic radioiodine imaging is:

- whole body
- dedicated lung
- dedicated abdomen
- pinhole neck
- SPECT/CT

Pre-Therapy $^{123}$I Diagnostic Scan

- 24 h uptake 37%
- TSH > 100
- free T4 0.28

Pre-Therapy $^{123}$I Diagnostic Scan

- 24 h uptake 40%
- TSH 36
- free T4 0.54

Iodine Uptake > Hormone Production

Examples
- Graves’ disease compared with toxic MNG
- Remnant versus intact gland

Common factor
- High level TSH receptor stimulation