Thyroid Parathyroid and SPECT/CT

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Management of Primary Hyperparathyroidism

- 80% of patients may be asymptomatic (serum calcium usually less than 11.5 mg/dl)
  - Lack of agreement on how to care for asymptomatic patients with hypercalcemia
- Of the patients with symptoms
  - Stones, bones, groans and moans
  - Psychiatric symptoms
When is Surgery Done?

- Controversial
- Most patients diagnosed are asymptomatic
  - Or are they?
  - Mild depression, etc.
When is Imaging Done?

- Controversial
- 90% of first surgeries are successful without imaging
- ~80% of patients in US get pre-op imaging
- Imaging is more likely to be helpful in limited surgical procedures (unilateral approach)
- Re-operation – Often unsuccessful without imaging
Pathology in Hyperparathyroidism

- 80 – 88% are solitary benign adenomas
- 5 – 12% have two or more adenomas
- 5 – 15% have diffuse hyperplasia
- 1 – 2% have carcinoma
Imaging Parathyroid Tumors

- When
- How
  - CT
  - MRI
  - Ultrasound
  - Angiography
  - Radioisotopic methods
Parathyroid Imaging

- Isotopes
  - Tc-99m pertechnetate and thallium-201 dual isotope technique
  - Tc-99m labeled sestamibi or tetrafosmin
  - I-123
  - Tc-99m thyroid scan
Parathyroid Imaging

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  - I-123
  - Tc-99m thyroid scan
Imaging Protocols

- **MIBI**
  - 20 mCi IV (~30 mSv to GB)
  - Images
    - 20 minutes
    - 2 hours
    - SPECT/CT
Case

- 54 year old female
- Calcium 11.1 – 11/8
- PTH 130 pg/mL
- Osteopenia
20 minutes
2 hours
SPECT/CT at 2 Hours
Case

- 20 year old woman s/p parathyroidectomy
- Calcium declined after parathyroidectomy, but remains elevated.
Comparison of SPECT/CT, SPECT, and Planar Imaging with Single- and Dual-Phase
$^{99m}$Tc-Sestamibi Parathyroid Scintigraphy

William C. Lavelly$^1$, Sibyll Goetze$^1$, Kent P. Friedman$^1$, Jeffrey P. Leal$^1$, Zhe Zhang$^2$, Elizabeth Garret-Mayer$^2$, Alan P. Dackiw$^3$, Ralph P. Tufano$^3$, Martha A. Zeiger$^3$, and Harvey A. Zieissman$^1$

$^1$Russell H. Morgan Department of Radiology and Radiological Sciences, Division of Nuclear Medicine, Johns Hopkins University, Baltimore, Maryland; $^2$Department of Oncology and Biostatistics, Johns Hopkins University, Baltimore, Maryland; and $^3$Department of Otolaryngology–Head and Neck Surgery, Johns Hopkins University, Baltimore, Maryland

Various methodologies for $^{99m}$Tc-sestamibi parathyroid scintigraphy are in clinical use. There are few direct comparisons between the different methods and even less evidence supporting the superiority of one over another. Some reports suggest that SPECT is superior to planar imaging. The addition of CT to SPECT may further improve parathyroid adenoma localization. The purpose of our investigation was to compare hybrid SPECT/CT, SPECT, and planar imaging and to determine phase $^{99m}$Tc-sestamibi scintigraphy for planar imaging, SPECT, and SPECT/CT.

Key Words: hyperparathyroidism; parathyroid adenoma; parathyroid scintigraphy; SPECT/CT; minimally invasive parathyroidectomy

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**TABLE 1**

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- Single adenomas only (98) of 110 patients scanned
- Early SPECT/CT and delayed anything showed superior sensitivity to dual-phase planar
- SPECT alone not as helpful
- Dual phase planar very good
Preoperative $^{123}\text{I}/^{99}\text{Tc}$-Sestamibi Subtraction SPECT and SPECT/CT in Primary Hyperparathyroidism

Donald R. Neumann¹, Nancy A. Obuchowski², and Frank P. DiFilippo¹

¹Department of Nuclear Medicine, Cleveland Clinic Imaging Institute, Cleveland, Ohio; and ²Department of Diagnostic Radiology, Cleveland Clinic Imaging Institute, Cleveland, Ohio
61 surgical patients with primary hyperparathyroidism

4 hours after I-123, Tc-99m MIBI
- Imaging 10 minutes after MIBI

I-123/Tc-99m MIBI subtraction for both SPECT and SPECT/CT

Subtracted SPECT and SPECT/CT images read separately by the same physician

Sensitivities
- SPECT – (50/70) - 71%
- SPECT/CT – (49/70) - 70%

Specificity
- SPECT – (13/27) – 48%
- SPECT/CT – (26/27) – 96%
Visualization of Brown Adipose Tissue with \(^{99m}\text{Tc-Methoxyisobutylisonitrile}\) on SPECT/CT

Sibyll Goetze, William C. Lavelle, Harvey A. Zissman, and Richard L. Wahl

Division of Nuclear Medicine, The Russell H. Morgan Department of Radiology and Radiological Science, Johns Hopkins University, Baltimore, Maryland

Brown adipose tissue (BAT) is retained into adulthood in some patients. It has been imaged using several radiopharmaceuticals, including \(^{18}\text{F-FDG}\). Using SPECT/CT, we assessed whether and how frequently uptake of \(^{99m}\text{Tc-Methoxyisobutylisonitrile}\) was present in expected locations of BAT. Methods: A total of 205 SPECT/CT scans using \(^{99m}\text{Tc-MIBI}\) for parathyroid imaging were reviewed for the presence of \(^{99m}\text{Tc-MIBI}\) uptake in expected locations of BAT. Results: We detected \(^{99m}\text{Tc-MIBI}\) uptake in BAT in 13 of 205 patients (6.3%). When BAT was visualized, it was detected on both early and delayed scans. The patients with \(^{99m}\text{Tc-MIBI}\) uptake in BAT were younger than the patients with no \(^{99m}\text{Tc-MIBI}\) uptake \((P = 0.044)\). Conclusion: Uptake of \(^{99m}\text{Tc-MIBI}\) in BAT is relatively common in this adult patient population and should not be confused with \(^{99m}\text{Tc-MIBI-avid}\) tumors. SPECT/CT can be useful for defining such tracer uptake as a normal physiologic variant.

Key Words: brown adipose tissue; hybrid imaging; \(^{99m}\text{Tc-Methoxyisobutylisonitrile}\); SPECT/CT

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exclude incidental incremental tumor involvement, which may be \(^{99m}\text{Tc-MIBI-avid}\). This is particularly important in instances when \(^{99m}\text{Tc-MIBI}\) is used for tumor imaging. We suspected that \(^{99m}\text{Tc-MIBI}\) might accumulate in BAT and evaluated this possibility, reviewing consecutive SPECT/CT scans.

MATERIALS AND METHODS

Patient Population

We retrospectively reviewed scintigrams of consecutive patients who were evaluated for parathyroid adenomas from May 2004 to July 2005, using dual-phase (early and late) planar imaging and SPECT/CT. We identified 205 patients (153 female, 52 male; mean age, 59.7 ± 13.1 y, range, 23–94 y). Our retrospective study was approved by the Institutional Review Board, and informed consent was waived.

Imaging Protocol and Analysis

All patients were injected intravenously with 925–1110 MBq of \(^{99m}\text{Tc-MIBI}\).
Case

- Prior parathyroid scan showed inferior pole of right lobe focus
- Surgery removed 3 hyperplastic parathyroid glands
- Calcium remained elevated
- 2 months later repeat scan with SPECT/CT showed mediastinal focus more clearly.
One more
Elevated calcium and PTH

Blind neck exploration – all 4 parathyroid glands found in expected locations.

3 of 4 parathyroid glands removed – all were normal.

No decline in PTH

MIBI scan done.
Fifth Parathyroid

- 80% of people have 4 parathyroid glands
  - One posterior to each upper lobe of the thyroid
  - One adjacent to each inferior pole
- Rarely only 3 parathyroid glands
- 20 to 30% of people have a 5th parathyroid
- 5th parathyroid is hyperfunctioning in 1 - 3% of cases of hyperparathyroidism
- Young female with hyperparathyroidism
- SPECT/CT performed for localization
Personalized Medicine!

- Limit field of view of SPECT/CT as needed
- Low dose CT for anatomic localization
Thyroid Cancer and SPECT/CT
Recent Literature


“The therapeutic strategy was changed in 8 (47.1%) of 17 patients”

“The result was a change in risk stratification in 14/57 patients (25%)”

“Globally, SPECT/CT modified therapeutic management in 35.6% of positive cases, and avoided unnecessary treatment in 20.3%”

“Reconsider therapy in 22/94 patients”
Case

- 62 year old male with chronic MNG
- FNA inconclusive
- 2\textsuperscript{nd} FNA “suspicious”
- Thyroidectomy showed multi-focal papillary carcinoma (follicular variant)
- Treated with radioiodine 6 months later because of CTA in ED 2 months after cancer diagnosis
Thyroid Gland (2)

- Node categories revised
  - N0  No regional lymph node metastasis
  - N1  Regional lymph node metastasis
  - N1a Metastasis to Level VI (pretracheal, paratracheal, and prelaryngeal/Delphian lymph nodes)
  - N1b Metastasis to unilateral, bilateral, or contralateral cervical or superior mediastinal lymph nodes
Case

- 34 year-old male had thyroid nodule noted on routine exam.
- Thyroidectomy showed:
  - Less than 2 cm primary
  - No capsular invasion
  - Follicular variant
- 2 cervical lymph nodes negative by FNA
- Stage I papillary thyroid cancer
- Whole body I-123 scan read as thyroid bed uptake only. Uptake 2.9%
- Treated with 30 mCi
WB I-123 Scan
Post-therapy scan – 30 mCi
Case

- 61 year old female with 2.5 cm multifocal variant papillary thyroid cancer resected in 1991.
- 7/30/07 – WB I-123 scan read as negative, but thyroglobulin was elevated.
- 11/1/07 Neck US and bx were positive. –
  - 4/10 nodes (+)
  - Vascular invasion
  - Pulmonary nodules on PET/CT at BWH
  - L3 lytic lesion
12/21/07 post-therapy scan - 175 mCi I-131
Case

- 26 year old female
  - 0.8 cm papillary carcinoma, follicular variant
  - 8/10 nodes positive
I-123 pre-therapy scan
Post I-131 scan 7/25/07
Post I-131 Rx

- Repeat I-123 scan 8 months later – negative.
- FDG PET/CT - negative
- Repeat I-131 therapy (200 mCi) shown here
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<thead>
<tr>
<th>Definition</th>
<th>Description</th>
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<tbody>
<tr>
<td>T1</td>
<td>Tumor diameter 2 cm or smaller</td>
</tr>
<tr>
<td>T2</td>
<td>Primary tumor diameter &gt; 2 cm</td>
</tr>
<tr>
<td>T3</td>
<td>Primary tumor diameter &gt; 4 cm limited to the thyroid or with minimal extrathyroidal extension</td>
</tr>
<tr>
<td>T4a</td>
<td>Tumor of any size extending beyond the thyroid capsule to invade subcutaneous soft tissues, larynx, trachea, esophagus, or recurrent laryngeal nerve</td>
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<tr>
<td>T4b</td>
<td>Tumor invades prevertebral fascia or encases carotid artery or mediastinal vessels</td>
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<tr>
<td>TX</td>
<td>Primary tumor size unknown, but without extrathyroidal invasion</td>
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<tr>
<td>NO</td>
<td>No metastatic nodes</td>
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<tr>
<td>NX</td>
<td>Nodes not assessed at surgery</td>
</tr>
<tr>
<td>MO</td>
<td>No distant metastases</td>
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<tr>
<td>M1</td>
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<td>MX</td>
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<th>Stages</th>
<th>Patient age &lt; 45 years</th>
<th>Patient aged 45 years or older</th>
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<td>T3, N1c, MO</td>
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