SPECT/CT in Parathyroid Disease

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Outline

- Pathophysiology
- Current guidelines
- SPECT/CT – the evidence
- SPECT/CT in clinical scenarios
  MGD, Nodular goitre
- Impact on surgery
- RFH protocol and data
Primary Hyperparathyroidism

- Sporadic: commonest cause hypercalceamia outpatient populations (F: 1/500, M: 1/2000)
- 80-85% adenoma
- 15-20% multiple glands (double adenomas or hyperplasia)
- 1% carcinoma
- Hereditary disorders ≈10% cases

Secondary hyperparathyroidism

**Compensatory** gland hypertrophy secondary to hypocalcaemia eg Chronic Kidney Disease

Tertiary hyperparathyroidism

**Autonomous function** of parathyroid tissue after longstanding secondary hyperparathyroidism
Parathyroid Embryology

Pharyngeal Pouches

Superior glands (4th pouch) minimal descent

Inferior glands (3rd pouch) descend further with thymus

Gland Location

Normal parathyroid gland

- **Superior** – posterior to upper 2/3 of thyroid.
- **Inferior** – anterior, lateral or posterior to inferior pole of thyroid

- 4 glands (2-6)

Ectopic

- 20%
- Any position above / below thyroid
- Sup PTH - lower 1/3 of thyroid
Superior Adenoma – located postero-inferiorly

Surgical Management

- Excision of hyper functioning glands
- Historically four gland exploration
- Move towards minimally invasive surgery
- IOPTH monitoring (cut off variable)

Other Techniques: eg radio-guided using gamma probe
Guidelines

EANM 2009

- Dual tracer planar subtraction
  - $^{99m}$Tc MIBI + $^{99m}$Tc pertechnetate/$^{123}$I
  - pinhole (LFOV view also needed)
- Dual tracer planar subtraction +SPECT $^{99m}$TcMIBI
- Dual phase planar with $^{99m}$Tc MIBI +/- SPECT
  - 10 mins and 120 mins ("washout")

Overall sensitivity variable: 80-90%

Guidelines 2

EANM 2009 SPECT/CT:

- Improves accuracy + reporter confidence
- ‘did not demonstrate a clear superiority or clinical impact of SPECT/CT over SPECT where the end point is success of surgery’
- Conclusion: SPECT/CT useful in ectopic glands and distorted neck anatomy
SNM Practice Guideline for Parathyroid Scintigraphy (2012)

- ‘SPECT and SPECT/CT have proven useful and provide more precise anatomical localization particularly for ectopic lesions’
- ‘The combination of anatomical and functional imaging, that is, SPECT/CT provides the optimal localization for surgical planning and additional diagnostic information’
- Does however state there is ‘still controversy of use in patients who have not had previous surgery’.

Greenspan et al, JNMT 2012;40:1-8

SPECT vs SPECT/CT

- 48 patients (32 surgery)
- MIBI Planar + SPECT/CT performed
- ‘Added value’ of CT component
  - ie SPECT vs SPECT/CT (2 reporters)
- Results:
  - CT: helpful in ectopic glands
  - no difference in identification rate of adenoma
  - better inter-observer agreement on location with SPECT /CT (29/48 vs 45/48)
- Conclusion:
  - SPECT /CT: no added value over SPECT
  - Reserve for ectopic glands

Gayed 2005 JNM46:248-251
Ectopic Gland – pre-vascular space

Comparison of Planar, SPECT and SPECT/CT

- 24 patients
- Planar (dual phase) and delayed SPECT/CT
- Surgical confirmation: 35 parathyroid adenomas/hyperplasia (all eutopic)
- Lesion by lesion: SPECT/CT detected 8 (23%) more lesions than SPECT alone and 11 more than planar
- SPECT/CT also correctly localised them (quadrant)

SPECT vs SPECT CT

- 16 patients (10 1° HPT, 6 2° HPT)
- Planar, SPECT and SPECT/CT
- Comparison with surgical findings

Results

<table>
<thead>
<tr>
<th>Planar</th>
<th>SPECT</th>
<th>SPECT/CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity 1° HPT</td>
<td>57%</td>
<td>100%</td>
</tr>
<tr>
<td>Sensitivity 2° HPT</td>
<td>43%</td>
<td>64%</td>
</tr>
<tr>
<td>Localization (1°)</td>
<td>-</td>
<td>61%</td>
</tr>
</tbody>
</table>

- 3/16 cases SPECT/CT changed management:
  - retro-tracheal location detected on SPECT/CT only

Serra et al, Radiol Med 2006; 111:999-1008

Patients with pre-op +ve MIBI and -ve USS more likely to have PLUGS (posteriorly located upper glands)
- retro-pharyngeal
- retro-oesophageal

Which Protocol?

Single v Dual Phase?
Planar, SPECT or SPECT/CT?

- 98 pts surgical follow-up (1° HPT)
- Planar + SPECT/CT (both early and late)
- Sensitivity of correct localization per patient

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Sensitivity per lesion</th>
</tr>
</thead>
<tbody>
<tr>
<td>single phase early planar</td>
<td>34%</td>
</tr>
<tr>
<td>single phase delayed planar</td>
<td>45%</td>
</tr>
<tr>
<td>dual phase planar</td>
<td>57%</td>
</tr>
<tr>
<td>early SPECT</td>
<td>54%</td>
</tr>
<tr>
<td>dual phase SPECT</td>
<td>64%</td>
</tr>
<tr>
<td>73% early phase SPECT/CT with any delayed phase (planar, SPECT or SPECT/CT)</td>
<td>73%</td>
</tr>
</tbody>
</table>

• Early SPECT/CT combined with any delayed imaging most sensitive

• SPECT CT localized superior glands within tracheo-oesophageal groove (near to RLN)

Lavley et al 2009,   JNM  38 1084-1089
123I and 99m Tc MIBI subtraction SPECT vs SPECT/CT

- 61 patients: subtraction SPECT/CT vs SPECT

**Results**

<table>
<thead>
<tr>
<th></th>
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<th>SPECT/CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity*</td>
<td>71%</td>
<td>70%</td>
</tr>
<tr>
<td>Specificity*</td>
<td>48%</td>
<td>96%</td>
</tr>
</tbody>
</table>

* per lesion

- Less false positives with SPECT/CT
- EANM guidelines: technique not recommended (reduced sensitivity)
- However, sensitivity/specificity *per patient* is higher (88% and 86%)

*Neumann et al 2008 JNM 49: 2012-2117*

123I and 99m Tc MIBI subtraction SPECT vs SPECT/CT (2)

**EANM 2011**

- 40 patients
  - Sensitivity 90%, Specificity 82%, PPV 93%

*Low et al 2011 EJNM 38 (suppl 2: S167)*

- 54 patients
  - Sensitivity 92%, Specificity 83%

*Ciappuccini et al 2011, EJNM 38 (suppl 2: S167)*

*Image courtesy of Dr C Low*
Multiglandular Disease

- MGD: 2 (or more) glands affected
- 1° HPT: minimally invasive surgery
- 2° /3° PTH: 4 gland exploration still standard

SPECT vs SPECT/CT in MGD
Retrospective review of pre-op imaging in 29 pts with MGD
- 6 with 1° HPT,
- 23 with 2° or 3° HPT

- SPECT, CT (post contrast), SPECT with CT fusion

Wimmer et al, 2010

Results

<table>
<thead>
<tr>
<th></th>
<th>CT</th>
<th>SPECT</th>
<th>SPECT/CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Locating all glands</td>
<td>37%</td>
<td>13%</td>
<td>47%</td>
</tr>
<tr>
<td>MGD detected</td>
<td>66%</td>
<td>17%</td>
<td>66%</td>
</tr>
</tbody>
</table>

SPECT/CT: more sensitive than SPECT overall

MGD (1° HPT): - SPECT/CT - 5/6
- SPECT - 0/6

1° HPT: SPECT/CT useful for predicting MGD (pre-op planning)

2° and 3° HPT: SPECT/CT less useful

Four Gland Hyperplasia

Double Adenoma MEN1

Axial upper

Axial lower
Double Adenoma

SPECT vs SPECT CT with Nodular Goitre

- 33 pts
  - 18 planar + SPECT
  - 13 planar + SPECT/CT
- Compared pre-op imaging with surgical findings

### Results

<table>
<thead>
<tr>
<th></th>
<th>SPECT</th>
<th>SPECT/CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>lateralization</td>
<td>80% (88%)</td>
<td>94% (93%)</td>
</tr>
<tr>
<td>quadrant</td>
<td>56% (86%)</td>
<td>86% (96%)</td>
</tr>
<tr>
<td>Mean op time</td>
<td>56 mins</td>
<td>38 mins</td>
</tr>
</tbody>
</table>

- SPECT/CT better quadrant localization
- MGD: identified on SPECT/CT only

*Pata et al 2010 Thyroid 20: 1121-1127*
Pre-Op 99mTc MIBI in MNG

- 50 patients nodular goitre
- Early planar + SPECT/CT early, delayed planar
- Surgery: 49 glands resected
- Sensitivity and specificity higher with SPECT/CT but not sig
- **Accuracy** better (85% vs 75%)
  - SPECT/CT Fewer false +ve and false –ve
- **Localisation better** in 9 pts (3 in TO groove)

Shafiei et al, NMC 2012; 33:1070-1076

Impact of MIBI SPECT/CT on Surgical Management

- 36 pts (1° HPT)
- Planar + SPECT/CT pre-op
- Compared with surgical findings
- Results
  - No additional lesions found on SPECT/CT (sensitivity 92%)
  - SPECT/CT had **impact on surgery** in 39%
    - (10 ectopic, 4 cervical)
      - Ease of accessibility (6 avoided sternotomy)
      - Decreased op time
      - Smaller incision

Krausz et al 2006 World J Surg 30: 76-83
Financial implications of SPECT/CT

- **55 patients**: 27 SPECT, 28 SPECT/CT

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</thead>
<tbody>
<tr>
<td>lateralization</td>
<td>79% (82%)</td>
<td>97% (96%)</td>
</tr>
<tr>
<td>quadrant</td>
<td>61% (90%)</td>
<td>87% (97%)</td>
</tr>
<tr>
<td>Mean op time</td>
<td>62 mins</td>
<td>36 mins</td>
</tr>
</tbody>
</table>

- **Ectopic glands**: 4 in SPECT, 3 in SPECT/CT
  - SPECT: 2 incorrectly lateralized
  - 2 aberrant position not detected
  - SPECT/CT: 3/3 correctly localized

- **Saving per patient**: €98 (95% CI €48-150)

*Pata et al, 2011 Ann Surg Oncol 18: 2555-2563*
Technique at RFH

- 855 MBq MIBI
- SPECT at 15 mins
- SPECT/CT at 120 mins
- 7.6 mSv
- CT neck/thorax
- 130 KeV, 40mAs
- 2 mSv

1.2 mSv

2 mSv
RFH DATA

Adenoma (histologically confirmed)
- 41/47 detected on MIBI
- Sensitivity 87%
- 36/38 correctly localized

Glandular Hyperplasia
- Detected 1/6

Begum et al, 2011 EANM

Conclusion
- SPECT/CT higher sensitivity than SPECT for ectopic, re-explorations and MGD (1° PTH) than SPECT
- No consensus over sensitivity of SPECT vs SPECT/CT in eutopic glands
- Superior localization with SPECT/CT
- SPECT/CT has positive impact on surgery
Thank You