SPECT/CT in Parathyroid Localisation
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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 hypercalcaemia
  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

Primary Hyperparathyroidism
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  outpatient populations (F: 1/500, M: 1/2000)
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Secondary hyperparathyroidism
Compensatory gland hypertrophy secondary to hypocalcaemia e.g. Chronic Kidney Disease

Tertiary hyperparathyroidism
Autonomous function of parathyroid tissue after longstanding secondary hyperparathyroidism

Parathyroid Embryology
Pharyngeal Pouches

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

EANM Guidelines 2009

Dual tracer planar subtraction
- $^{99m}$Tc MIBI + $^{99m}$Tc pertechnetate /$^{123}$I
- pinhole (LFOV view also needed)

Dual tracer planar subtraction + SPECT MIBI

Dual phase planar with $^{99m}$Tc MIBI +/- SPECT
10 mins and 120 mins ("washout")
Overall sensitivity variable: 80-90%
EANM Guidelines 2

**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 is success of surgery'

- Conclusion: SPECT/CT useful in ectopic glands and distorted neck anatomy

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**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

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**Ectopic Gland – pre-vascular space**
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>Protocol</th>
<th>Sensitivity (per lesion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planar</td>
<td></td>
</tr>
<tr>
<td>Sensitivity 1° HPT</td>
<td>57%</td>
</tr>
<tr>
<td>Sensitivity 2° HPT</td>
<td>43%</td>
</tr>
<tr>
<td>Localization (1°)</td>
<td>-</td>
</tr>
<tr>
<td>SPECT</td>
<td>100%</td>
</tr>
<tr>
<td>SPECT/CT</td>
<td>100%</td>
</tr>
</tbody>
</table>

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

Serra et al 2006 Radiol Med 111:999-1008

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>

Results

- 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 99mTc MIBI subtraction SPECT vs SPECT/CT

- 61 patients: subtraction SPECT/CT
- SPECT vs SPECT/CT

<table>
<thead>
<tr>
<th></th>
<th>SPECT</th>
<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: not recommended (reduced sensitivity)
- Sensitivity per patient is higher (88% and 86%)

Neuman et al 2008 JNM 49: 2012-2117

123I and 99mTc 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)

Multiglandular Disease

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

Wimmer et al, 2010 SPECT vs SPECT/CT in MGD
  Retrospective review of pre-op imaging in 29 pts with MGD
  - 6 1° HPT, 23 with 2° or 3° HPT
  - SPECT, CT (post contrast), SPECT with CT fusion
• Results

<table>
<thead>
<tr>
<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>
</tr>
<tr>
<td>MGD detected</td>
<td>66%</td>
<td>17%</td>
</tr>
</tbody>
</table>

SPECT/CT more sensitive than SPECT overall
MGD (1° HPT): SPECT/CT - 5/6
SPECT - 6/6

• Conclusion
1° HPT: SPECT/CT useful for predicting MGD (pre-op planning)
2° and 3° HPT: SPECT/CT not useful

Wimmer et al 2010 Langenbecks Arch Surg 395: 73-80
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
  - SPECT/CT better quadrant localization
  - MGD: identified on SPECT/CT only

<table>
<thead>
<tr>
<th></th>
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<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>59% (96%)</td>
<td>86% (96%)</td>
</tr>
<tr>
<td>Mean op time</td>
<td>56 mins</td>
<td>38 mins</td>
</tr>
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</table>

Pata et al 2010 Thyroid 20: 1121-1127

Impact of MIBI SPECT/CT on Surgical Management
- 36 pts (1° HPT)
- Planar + SPECT/CT pre-op
- Compared with surgical findings
- 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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<tr>
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<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>
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</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
- 2mSv
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