ADVANCED IMAGING FOR LOCALIZATION OF PARATHYROID ADENOMA

Salman Alsafran. MD
Endocrine Surgery Fellow
9.21.2017
ADVANCED IMAGING FOR LOCALIZATION OF PARATHYROID ADENOMA

• Objectives:
  1. 4D CT for localization of pathological Parathyroid gland
  2. Cost-utility analysis for use of 4D CT vs Sestamibi
  3. New imaging for localization of pHPTH
CASE 1 PM 3679909

- CC: Kidney stone/ Osteopenia
- HPI:
  - 71 y.o F with persistent Primary hyperparathyroidism (PHPT)
    - Came to see us in clinic after failed parathyroid exploration 2009.
  - 2009: elevated CA/PTH
    - Hx nephrolithiasis/ osteopenia
    - Pre-op localization study
      - US: **possible Right and Left upper pole adenoma**
      - Sestamibi: **Negative for localization**
    - 9/2009 for gland exploration with intra-operative PTH monitoring
Case 1 PM

- 9/2009
  - Left upper gland was removed initially
    - PTH remained elevated
  - Identified both right upper/lower
  - Removed the right upper
    - PTH elevated
  - Unable to identify the left lower.
    - Left thyroid lobectomy (suspicious for intra-thyroidal PT gland)
    - PTH elevated
CASE 1 PM

Right upper parathyroidectomy

Left upper parathyroidectomy

PTH remained Elevated

Left thyroid lobectomy
CASE 1 PM

• HPI (con’t)
  – Post-op continue to have elevated Ca and PTH
    • Ca in the 11 mg/dl range
  – Patient started on Sensipar
    • Her current Ca 10.5 and PTH 106
    • Sx of Tiredness/Bone pain/Kidney stone/constipation
    • Medication cost
      – Reoperative parathyroidectomy.
Case 1 PM

- **PMHx:**
  - Factor V leiden
  - HTN
  - Osteoarthritis/Osteopenia
  - Hyperparathyroidism
  - Hypothyroidism
  - DVT x2/PE > 15 years ago
  - Anxiety

- **PSHx:**
  - C-section
  - Hip replacement
  - Parathyroidectomy/Hemithyroidectomy

- **Family hx:**
  - Father: PHPTH
  - Son: PHPTH

- **Medication:**
  - Synthroid 75mcg
  - Sensipar 30mg
  - Valsartan 320mg
  - Xarelto 20mg
  - Xanax/ Temazepam
  - Nortiptyline
Physical Exam: Noncontributory
Case 1 PM

- OR
  - Parathyroidectomy
  - Intra-operative PTH
  - Possible Autotransplant.
4D CT SCAN

• Similar to CT angiography
• 3-D CT scanning with added dimension from change in perfusion of contrast over time.
• Allows visualization of differences in the perfusion characteristics of hyper-functioning parathyroid glands
  – Rapid uptake and washout
• Provides both anatomical and functional information
• Issues:
  – Availability
  – Radiation exposure
  – Contrast
4D CT SCAN
Purpose:
  – Compare 4D CT with Sestamibi and US for pre-op localization of pHPTH.

Methods:
  – 75 pts W pHPTH; US, Sestamibi, 4D CT performed in all pts pre-op
  – Results of imaging studies compared with operative finding.
• Results:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sensitivity (%)</th>
<th>95% CI</th>
<th>Specificity (%)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side of the neck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4D-CT</td>
<td>88</td>
<td>81-95</td>
<td>88</td>
<td>80-96</td>
</tr>
<tr>
<td>Ultrasonography</td>
<td>57</td>
<td>47-67</td>
<td>94</td>
<td>88-99</td>
</tr>
<tr>
<td>Sestamibi</td>
<td>65</td>
<td>55-75</td>
<td>88</td>
<td>80-96</td>
</tr>
<tr>
<td>Precise location in the neck</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4D-CT</td>
<td>70</td>
<td>59-81</td>
<td>89</td>
<td>85-93</td>
</tr>
<tr>
<td>Ultrasonography</td>
<td>29</td>
<td>20-38</td>
<td>86</td>
<td>82-90</td>
</tr>
<tr>
<td>Sestamibi</td>
<td>33</td>
<td>24-42</td>
<td>83</td>
<td>79-87</td>
</tr>
</tbody>
</table>

• Conclusion:

– 4D CT provides significantly greater sensitivity than US/Sestamibi for Precise localization of pHPTH.
A Meta-analysis of Preoperative Localization Techniques for Patients with Primary Hyperparathyroidism

Kevin Cheung, MSc, MD,
Tracy S. Wang, MD, MPH,
Forough Farrokhhyar, MPhil, PhD,
Sanziana A. Roman, MD,
and
Julie A. Sosa, MD, MA

• Purpose:
  – Determine the accuracy of US, Sestamibi-Spect, 4D CT as pre operative localization strategies
• Methods:
  – Meta-analysis: studies Ix accuracy of pre-op localization studies in pHPTH.
• Result:
  – 43 studies met criteria
    • 19 US
    • 9 Sestamibi-SPECT
    • 4 4D CT
A Meta-analysis of Preoperative Localization Techniques for Patients with Primary Hyperparathyroidism

Kevin Cheung, MSc, MD1, Tracy S. Wang, MD, MPH2, Forough Farrokhyar, MPhil, PhD1, Sanziana A. Roman, MD3, and Julie A. Sosa, MD, MA4

• Result con’t:
  – Us: pooled sensitivity & PPV of
    • 76.1% & 93.2%
  – Sestamibi:
    • 78.9% & 90.7%
  – 4D CT:
    • 89.4% & 93.5%

• Conclusion:
  – US & Sestamibi similar in ability to preop localized abnormal parathyroid glands.
  – 4D CT: improved Accuracy.
Purpose:
- Sensitivity and PPV of 4D CT
- Compare different protocols (contrast) and their performance in different pts group.

Methods:
- Meta-analysis 2000-20016 Ix diagnostic value of CT for Parathyroid localization.
Outcome

– 34 studies (2563 pts)
– Localization: Pooled sensitivity of 73% PPV 81% (quadrant)
– Lateralization: pooled sensitivity increase 81%
– Subgroup analysis
  • Only pt with inconclusive imaging and/or previous PTH surgery
    – Sensitivity: 62-76%
  • Number of contrast phases
    – 2 phase contrast 76%

• Conclusion:
  – CT performs well in localizing pathological glands in patients with pHPT.
  – 2 contrast phases seems to offer a good balance of acceptable performance with limitation of radiation exposure.
Purpose: compare comprehensive costs associated with common localization strategies.

Methods:
- Decision-analytic model evaluate comprehensive, short-term cost of localization strategies for pt with pHPTH.
- 8 strategies were compared
Preoperative Localization Strategies for Primary Hyperparathyroidism: An Economic Analysis

Carrie C. Lubitz, MD, MPH¹, Antonia E. Stephen, MD¹, Richard A. Hodin, MD¹, and Pari Pandharipande, MD, MPH²

<table>
<thead>
<tr>
<th>Rank</th>
<th>Strategy</th>
<th>Cost ($)</th>
<th>Incremental cost ($) (compared with US → 4D-CT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>US → 4D-CT (if US indeterminate)</td>
<td>5,901</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>US</td>
<td>6,028</td>
<td>127</td>
</tr>
<tr>
<td>3</td>
<td>4D-CT</td>
<td>6,110</td>
<td>209</td>
</tr>
<tr>
<td>4</td>
<td>SM → 4D-CT (if SM indeterminate)</td>
<td>6,266</td>
<td>365</td>
</tr>
<tr>
<td>5</td>
<td>US + SM → 4D-CT (if US and SM indeterminate or discordant)</td>
<td>6,319</td>
<td>418</td>
</tr>
<tr>
<td>6</td>
<td>US/SM</td>
<td>6,329</td>
<td>428</td>
</tr>
<tr>
<td>7</td>
<td>SM</td>
<td>6,374</td>
<td>473</td>
</tr>
<tr>
<td>8</td>
<td>BNE</td>
<td>6,824</td>
<td>923</td>
</tr>
</tbody>
</table>

*US ultrasound, SM sestamibi-SPECT, BNE four-gland, bilateral neck exploration

DOI 10.1245/s10434-012-2512-2
Preoperative Localization Strategies for Primary Hyperparathyroidism: An Economic Analysis

Conclusions:
- US followed by selective 4D-CT is the least expensive.
CASE 2

- CC: Kidney stones
- HPI:
  - 66 y.o F with pHPTH.
  - Initially px with sx kidney stone was found to have pHPTH.
    - Osteoporosis
    - Previous hx of left thyroid lobectomy (toxic nodule) 2000
- PMH: CAD, HTN, Nephrolithiasis, Osteoporosis.
- PSH:
  - L thyroid lobectomy
  - Cervical laminectomy
CASE 2

• Physical Examination:
  – None contributory

• Lab:
  – CA: 10.4 mg/dl
  – PTH: 81 pg/ml
  – Vit D: 52 ng/ml
CASE 2

4D CT SESTAMIBI
CASE 2

• Localization Study:
  – US: -ve
  – Sestamibi: -ve
  – 4D CT: -ve
  – Selective venous sampling: -ve

• What is the next step?
  – Surgery ?
  – Further Imaging ?
• **Purpose:**
  – Evaluate the usefulness of 18F-flourocholine PET/CT for preoperative localization of pHPTH

• **Method:** Pilot study
  – PET/CT and SESTAMIBI performed in 24 pts
  – Diagnostic performance compared with histopath/Ca/iPTH
<table>
<thead>
<tr>
<th></th>
<th>PET/CT</th>
<th>SPECT/CT</th>
<th>Subtraction</th>
<th>Dual-phase</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All patients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>92</td>
<td>49***</td>
<td>46***</td>
<td>44***</td>
<td>64***</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Accuracy (%)</td>
<td>98</td>
<td>83</td>
<td>82</td>
<td>82</td>
<td>88</td>
</tr>
<tr>
<td>PPV (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>NPV (%)</td>
<td>96</td>
<td>80</td>
<td>79</td>
<td>79</td>
<td>85</td>
</tr>
<tr>
<td><strong>Solitary parathyroid adenoma</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>94</td>
<td>70</td>
<td>65</td>
<td>59*</td>
<td>82</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Accuracy (%)</td>
<td>99</td>
<td>94</td>
<td>93</td>
<td>92</td>
<td>96</td>
</tr>
<tr>
<td>PPV (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>NPV (%)</td>
<td>99</td>
<td>93</td>
<td>92</td>
<td>91</td>
<td>96</td>
</tr>
<tr>
<td><strong>Multiple parathyroid adenomata and parathyroid hyperplasia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity (%)</td>
<td>91</td>
<td>32***</td>
<td>32***</td>
<td>32***</td>
<td>50**</td>
</tr>
<tr>
<td>Specificity (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Accuracy (%)</td>
<td>94</td>
<td>57</td>
<td>57</td>
<td>57</td>
<td>57</td>
</tr>
<tr>
<td>PPV (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>NPV (%)</td>
<td>87</td>
<td>46</td>
<td>46</td>
<td>46</td>
<td>46</td>
</tr>
</tbody>
</table>