4D-CT scoring and protocol optimization of parathyroid adenomas. Challenging diagnosis made simple.

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Background
Pre-operative localization of parathyroid adenomas has allowed for the development of successful minimally invasive parathyroid surgery. 4-dimensional computed tomography (4D-CT) of the neck has emerged as a highly sensitive imaging modality for detecting adenomas and is increasingly being used as an effective alternative to SPECT-CT and high resolution ultrasound. No standardized imaging protocol or scoring system exists for parathyroid CT scans.

Objective
1) To delineate a practical scoring system based on CT imaging signs and,
2) Derive the most effective 4D-CT imaging protocol to simplify this challenging diagnosis.

Methods
A retrospective analysis of patients who underwent 4D-CT for detection of parathyroid adenoma between July 2012 and July 2014 after inconclusive SPECT-CT and ultrasound. Patients included had clinically suspected primary hyperparathyroidism and underwent minimally invasive parathyroid surgery. Each 4D-CT study was reviewed separately by two neuroradiologists for parathyroid adenomas.

Imaging protocols included:
1) Single arterial phase CT,
2) Dual noncontrast and arterial phase CT, and
3) Triple phase noncontrast, arterial, and delayed phase CT.

Five imaging features were also analyzed: 1) Arterial phase enhancement and washout, 2) Shape of adenoma, 3) Size, 4) Location, and 5) Polar vessel sign. A five point scoring system was derived based on these five features. Data analysis was performed using Cohen's kappa and the exact binomial method.

Results
Twelve patients underwent pre-operative 4D-CT for primary hyperparathyroidism. Ten patients were confirmed by surgery and pathology to have parathyroid adenomas. The sensitivity of the triple phase sequence CT scan for accurately detecting the parathyroid adenoma was not significantly different from the single or dual phase sequences for either neuroradiologist.

Figure 1: Arterial enhancement and polar vessel sign (arrow)

Correctly identified parathyroid adenomas were all ovoid in shape, located behind the thyroid, between 0.5 and 1.5 centimeters in size, and exhibited arterial phase enhancement. A polar vessel sign was seen in 75%. The presence of 4 or more imaging characteristics was associated with 100% sensitivity and 80% specificity for correctly localizing parathyroid adenomas.

Table 1: Imaging characteristics.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Sens (95% CI)</th>
<th>Spec (95% CI)</th>
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<tbody>
<tr>
<td>Ovoid shape</td>
<td>100 (63-100)</td>
<td>0 (0-52)</td>
</tr>
<tr>
<td>Arterial enhancement</td>
<td>100 (63-100)</td>
<td>0 (0-52)</td>
</tr>
<tr>
<td>Polar vessel sign</td>
<td>75 (35-97)</td>
<td>100 (48-100)</td>
</tr>
<tr>
<td>Location behind</td>
<td>100 (63-100)</td>
<td>0 (0-52)</td>
</tr>
<tr>
<td>thyroid</td>
<td>Size 1 cm +/- 5 mm</td>
<td>100 (63-100)</td>
</tr>
<tr>
<td>4+ features</td>
<td>100 (63-100)</td>
<td>0 (0-52)</td>
</tr>
<tr>
<td>5 features</td>
<td>75 (35-97)</td>
<td>100 (48-100)</td>
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Figure 1: Arterial enhancement and polar vessel sign (arrow)

Conclusions
We have derived a practical 5 point scoring system for parathyroid CT scan imaging. If 4 out of 5 points are assigned to a lesion on 4D-CT, there is a high level of accuracy in localizing eutopic parathyroid adenomas. The majority are ovoid shaped, approximately one cm in size, and most frequently located posterior to the thyroid lobe with a fat plane separating the two glands. The diagnostic accuracy of triple phase parathyroid CT scan is not significantly different when compared to single or dual phase imaging.

References
1412.