Imaging outcomes in primary hyperparathyroidism (HPTH): Experience from a district general hospital

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Aims and objectives

Primary Hyperparathyroidism (HPTH) is a common endocrine disorder affecting upto 0.3% of the population\(^1\). 80-85% of HPTH is caused by a solitary or multiple parathyroid adenomas, 10-15% parathyroid hyperplasia and <1% parathyroid cancer\(^1\). Surgical resection of the hyperfunctioning parathyroid gland provides curative treatment, and over the past few decades there has been a trend towards minimally invasive surgical approaches that rely on accurate preoperative localisation of parathyroid lesions through increasingly innovative imaging techniques\(^2\).

Ultrasound (USS), radionuclide studies, computed tomography (CT) and magnetic resonance imaging (MRI) are some of the common imaging modalities used to image parathyroid glands. Although choice of modality varies according to local resources, expertise and ability, USS and \(^{99m}\)Tc-sestamibi scintigraphy (MIBI) are the dominant techniques currently used for preoperative localisation in HPTH\(^2\).

USS provides anatomical localisation of parathyroid lesions, and studies demonstrate a sensitivity ranging from 72-89%\(^3\) (Figure 1). Although highly user dependent, it is widely available, cost effective and there are subsequently studies proposing its use as the sole preoperative diagnostic procedure in HPTH\(^4,5\).

MIBI works on the physiological principle that hyperfunctioning parathyroid tissue demonstrates a higher and prolonged uptake of radionuclide tracer \(^3\) (Figure 2). A sensitivity of 68-95% has been reported in the literature\(^3\), especially in combination with SPECT, and although has limited efficacy detecting smaller adenomas, in many institutions it is used as first line imaging, with other techniques employed if negative.

Experienced radiologists at our institution currently use both USS and MIBI to localise adenomas preoperatively, as despite debate regarding first line imaging, studies demonstrate a higher sensitivity of 79-95% when used together\(^3\). Furthermore, there have been reports of improved MIBI and USS sensitivity with higher preoperative serum calcium and PTH, thus posing the question if there could potentially be a biochemical predictor of imaging accuracy\(^6,7\).

In this study, we therefore sought to firstly, identify if USS or MIBI was better at adenoma localisation, establish if current multiimaging preoperative imaging is optimal, and finally,
identify if there is a biochemical predictor of imaging concordance or discordance with surgical location.

**Images for this section:**

![Parathyroid Ultrasound (USS): USS demonstrating a right lobe parathyroid adenoma.](image)

**Fig. 1:** Parathyroid Ultrasound (USS): USS demonstrating a right lobe parathyroid adenoma.
Fig. 2: 99m Tc-sestamibi scintigraphy scan (MIBI): MIBI scan showing both early and late phase images, demonstrating right lower lobe parathyroid adenoma.
Methods and materials

We conducted a retrospective study of all patients with HPTH who underwent a parathyroidectomy between 2009 and 2012. Demographic (age & sex) and biochemical data (PTH, calcium, phosphate and magnesium) for each patient was collected, and the adenoma location identified from USS, MIBI and surgery documented. The result from USS or MIBI was then compared to surgical location and classed as 'concordant' or 'discordant' and results from USS and MIBI compared to each other, to identify if one modality was better.

PTH, Calcium, Phosphate and Magnesium values, within the concordant and discordant group for USS and MIBI, respectively, were summarised as mean or median and then compared using a two sample t-test or mann-whitney U test, to establish if there was a statistical difference in values between groups. Logistic regression was then used to examine the effect of each biochemical parameter on odds of surgical concordance or discordance for each imaging modality.

Results

100 HPTH patients, underwent a parathyroidectomy between 2009 - 2012. These patients were aged between 25 - 88 years (median 66), and 80% (80) were female.

The PTH adenomas were categorised as within the Right lobe (RL), Right Upper Lobe (RUL), Right Lower Lobe (RLL), Left Lobe (LL), Left Upper Lobe (LUL), Left Lower Lobe (LLL), isthmus or multiple (Figure 3). No adenoma was identified or no surgical documentation found for 7 patients. Multiple adenomas were identified among 3 patients. The most frequent adenoma location was the RLL 27% (n=93). (Figure 3)

Sonography(USS) vs Scintigraphy (MIBI)

Of the 93 patients with surgical findings, USS was not performed in 2 cases. Of the 91 scans performed, 82 (90%) were positive and 9 (10%) negative. USS correctly identified and correlated with surgical location in 69 cases (75%) (Figure 4a).

92 MIBI scans were performed, 71 (77%) were positive, 22 (23%) negative, and 67 (72%) correlated with surgical location (Figure 4b).

60 results (65%) from USS and MIBI agreed and demonstrated a similar surgical concordance as seen from Figure 4. Of those scans that agreed 51 (85%) correlated
accurately with surgical location. USS proved better in 18 cases (20%) and MIBI in 14 (15%), giving the combined accurate localisation rate of 90% (83/93) (Figure 5).

**Biochemistry**

A summary of the collated biochemical values (PTH, calcium, phosphate and magnesium), can be seen in Table 1.

A two sample t-test or mann-whitney u test was used to compare the biochemical parameters between concordant and discordant groups for USS and MIBI, and found no significant difference between groups (Table 2).

Furthermore using logistic regression, the effect of each biochemical parameter on the odds of surgical concordance for each modality was examined, and once again found no significant effect (Table 3).

**Images for this section:**
**Fig. 3:** Adenoma Location: Pie chart demonstrating the distribution of parathyroid adenoma locations found at surgery.
**Fig. 4:** Surgical Concordance of Imaging: a) Ultrasound (USS): pie chart demonstrating rate of USS concordance and discordance with surgical location. b) 99m Tc-sestamibi scintigraphy (MIBI): pie chart demonstrating rate of concordance and discordance with surgical location of PTH lesion.
Fig. 5: Comparison of imaging modalities: pie chart demonstrating the distribution of PTH adenomas detected by USS and MIBI separately and accurately and inaccurately detected by USS and MIBI together.

Table 1: Statistical summary of Biochemistry: Non normal data (PTH, calcium, magnesium) was summarised as median (interquartile range), and normally distributed data (Phosphate) using mean (standard deviation).
**Table 2:** Comparison of biochemical values between concordant and discordant groups for a. USS and b. MIBI.

<table>
<thead>
<tr>
<th></th>
<th>PTH (mmol/L)</th>
<th>Calcium (mmol/L)</th>
<th>Magnesium (mmol/L)</th>
<th>Phosphate (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concordant</td>
<td>124</td>
<td>2.69</td>
<td>0.87</td>
<td>0.87</td>
</tr>
<tr>
<td>Discordant</td>
<td>113</td>
<td>2.70</td>
<td>0.89</td>
<td>0.88</td>
</tr>
<tr>
<td>P value</td>
<td>0.690</td>
<td>0.691</td>
<td>0.451</td>
<td>0.955</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>PTH (mmol/L)</th>
<th>Calcium (mmol/L)</th>
<th>Magnesium (mmol/L)</th>
<th>Phosphate (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concordant</td>
<td>122</td>
<td>2.69</td>
<td>0.90</td>
<td>0.87</td>
</tr>
<tr>
<td>Discordant</td>
<td>116</td>
<td>2.70</td>
<td>0.89</td>
<td>0.88</td>
</tr>
<tr>
<td>P value</td>
<td>0.507</td>
<td>0.337</td>
<td>0.748</td>
<td>0.930</td>
</tr>
</tbody>
</table>

**Table 3:** Effect of biochemistry on odds of imaging concordance with surgical location using logistic regression for a. USS and b. MIBI.

<table>
<thead>
<tr>
<th></th>
<th>Odds Ratio</th>
<th>P value</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a. Ultrasound (USS)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTH</td>
<td>1.00</td>
<td>0.341</td>
<td>0.99 - 1.00</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.38</td>
<td>0.467</td>
<td>0.29 - 5.01</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.03</td>
<td>0.239</td>
<td>0.00 - 9.77</td>
</tr>
<tr>
<td>Phosphate</td>
<td>0.93</td>
<td>0.954</td>
<td>0.07 - 12.93</td>
</tr>
<tr>
<td><strong>b. 99m Tc-Sestamibi (MIBI)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PTH</td>
<td>1.00</td>
<td>0.142</td>
<td>0.99 - 1.00</td>
</tr>
<tr>
<td>Calcium</td>
<td>7.59</td>
<td>0.180</td>
<td>0.39 - 146.88</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.28</td>
<td>0.625</td>
<td>0.00 - 46.00</td>
</tr>
<tr>
<td>Phosphate</td>
<td>1.12</td>
<td>0.929</td>
<td>0.09 - 14.20</td>
</tr>
</tbody>
</table>
Conclusion

This study demonstrates that USS and MIBI are comparable in identifying parathyroid lesions, with a similar surgical concordance rate (Figure 4). Although USS was slightly higher (75%), this may be related to the higher proportion of solitary (90%) and inferior lesions (48%) within our study (more easily detected on USS), and our use of experienced radiologists. It is notable that MIBI was better at detecting the ectopic parathyroid lesion. The accuracy of MIBI can also be improved by reviewing early phase images and employing SPECT, (a technique adopted midway through our study period). Considering the small study size and this change in practice, it is therefore not possible to conclude that USS is significantly superior to MIBI.

Together, USS and MIBI demonstrated a sensitivity of 90%. This is in keeping with the quoted values in the literature, and supports current preoperative HPTH imaging practice. Although USS and MIBI are established, cost effective and readily available imaging modalities, there are however, emerging imaging modalities e.g. SPECT/CT with sensitivities approaching 100% and 4-dimensional CT with a reported sensitivity of 93.3%, therefore there is potentially huge scope for improvement to current practice.

Finally, no biochemical predictor of surgical concordance or discordance could be identified, as statistical analysis, demonstrated no significant relationship between preoperative serum PTH, calcium, phosphate or magnesium and imaging accuracy.

Limitations

There were several limitations to this study. The small study size limited the amount of data collected, and the significance of our conclusions, while the retrospective design resulted in missing data. PTH adenoma size, weight and histopathology have all been shown in previous studies to affect imaging accuracy, in addition to biochemistry, but were not included in the study. If we were to repeat this study we would therefore, include these factors in the design, as the relationship between imaging and PTH adenoma structure and biochemistry is still unclear and could influence preoperative PTH management.

Personal information
References

8. Gawrychowski J. Grzegorz B. Imaging diagnostics for primary hyperparathyroidism. Endokrynologia Polska 2013 64(5) 404