Complementary sestamibi scintigraphy and ultrasound for primary hyperparathyroidism

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Abstract

Background: With the increasing adoption of minimally invasive parathyroidectomy techniques, the dual use of sestamibi scintigraphy (MIBI) and Ultrasound (US) has become more important in the preoperative evaluation of primary hyperparathyroidism. The results presented here arose from a Practice Quality Improvement project (PQI) at our institution, which demonstrated that when compared against surgical outcomes, the use of both MIBI and US enhanced the detection of enlarged parathyroid glands. This project corroborates the complementary nature of these two imaging modalities in the preoperative localization of enlarged parathyroid glands.

Methods: Fifty-six consecutive cases that coupled the usage of MIBI and US were included during the duration of our PQI project from January to November of 2014. Patients in every case were diagnosed with typical Primary Hyperparathyroidism (PHPT) accompanied by the elevation of Parathyroid Hormone (PTH) and calcium levels, with the exception of one case.

Results: In 34 out of 56 cases, the parallel use of preoperative MIBI and US resulted in consistent findings between the two modalities. The remaining 22 cases demonstrated that the limitations of one modality can be overcome by the advantages of the alternate modality.

Conclusion: MIBI provides guidance for the interpretation of US data, especially in the context of ectopic parathyroid glands, small parathyroid adenomas, and concurrent thyroid nodules. US offers detailed anatomic information and supports the diagnostic confidence of interpreting MIBI scans. US can be especially helpful in patients with more than one enlarged parathyroid gland. In the majority of cases, the dual utilization of MIBI and US was able to successfully overcome the inherent limitations of each modality when employed alone.

Introduction

With the development of minimally invasive parathyroidectomy (MIP) procedures, sestamibi scintigraphy (MIBI) and ultrasound (US) have emerged as the predominant techniques in the preoperative evaluation of primary hyperparathyroidism (PHP). Not only are MIBI and US the most informative modalities for the detection of abnormal parathyroid glands, but they are potentially complementary [1-3]. The precise localization of enlarged parathyroid glands before embarking on major neck surgery has become indispensable to the management of PHPT. This article presents the results from a Practice Quality Improvement project (PQI) at our institution, which demonstrated that when compared against surgical outcomes, the use of both MIBI and US enhanced the detection of enlarged parathyroid glands. This project improved our diagnostic confidence and accuracy and supported the proposed complementary nature of these two imaging modalities in the visualization of the etiology of PHPT.

Methods

Fifty-six consecutive cases that coupled the usage of MIBI and US were included for the duration of our PQI project from January to November of 2014. Patients in every case were diagnosed with typical PHPT accompanied by the elevation of PTH and calcium levels, with the exception of one case (Figure 1). To improve the correlation between MIBI and US in the preoperative localization of parathyroid adenomas, we held a consultation session between the nuclear medicine physicians, US radiologists, and US technologists on each case prior to patient discharge. A repeat US scan was performed if the results from both scans were inconsistent with each other.

Results

In 34 of the 56 cases, the parallel use of preoperative MIBI and US resulted in consistent findings between the two imaging modalities. A typical feature of parathyroid adenomas on MIBI is a focal area of persistently increased uptake in the region of the thyroid gland. On US, the characteristic appearance of parathyroid adenomas is a homogeneously hypoechoic focal area with a feeding vessel and a peripheral distribution of vascularity (Figure 2A). The remaining 22 cases demonstrate that the limitations of one modality can be overcome.

Key words: sestamibi scintigraphy (MIBI), ultrasound (US), primary hyperparathyroidism (PHPT), parathyroid hormone (PTH), enlarged parathyroid glands, parathyroid adenoma, minimally invasive parathyroidectomy

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The limitations of MIBI include: 1) false-positive findings due to thyroid nodules (Figure 1); 2) false-negative or low confidence results due to the relatively small size of enlarged parathyroid gland(s) (Figure 3); 3) suboptimal results due to body habitus, motion, patient intolerance to lengthy procedures, or an adverse tracer reaction (Figure 2B); 4) information arising from a predominant, hyperfunctioning parathyroid gland that overwhelms the uptake activity from the other non-dominant, enlarged parathyroid glands (Figure 4); 5) the inability to portray an accurate relationship between an enlarged parathyroid gland and its surrounding structures (Figure 5); and 6) the inability to detail concurrent thyroid nodules (Figure 6).

The limitations of US scans include: 1) operator-dependent analyses and 2) the inability to detect ectopic parathyroid glands (Figure 7).

**Discussion**

PHTP is a common disease that is characterized by a destructive and progressive process involving multiple organ systems, for which the only cure is surgery [3]. The traditional surgical therapy, bilateral four-gland exploration, has been gradually replaced by unilateral and more focused surgical approaches such as MIP techniques at most medical centers, including our institution [1]. A successful MIP requires accurate localization of enlarged parathyroid glands by imaging modalities prior to surgery. MIBI scans are the most commonly used imaging technique. The sensitivity of MIBI for detecting parathyroid adenomas ranges widely, from 54 to 96%, mainly as a result of discrepancies in imaging protocols [2]. The significant limitations of MIBI are its low resolution and poor anatomic localization. Conversely, US is an imaging modality with high resolution, which can yield adequate visualization of anatomic details. However, US is limited by its operator-dependent image acquisition and analysis as well as the inability to detect ectopic parathyroid glands. Through our PQI project, we noted our implementation of the following methods to be helpful in overcoming the deficiencies of US: 1) placement of the American Institute of Ultrasound (AIUM) practice guidelines for performing thyroid and parathyroid ultrasound examinations in US scan rooms; 2) incorporation of educational lectures along with this written guide for US technologists, US physicians, and residents; 3) designation of experienced US physicians and technologists to guide the performance of US when warranted; 4) communication with clinicians on the benefits of carrying out (and thus ordering) US and MIBI scans on the same day; 5) acquisition of the MIBI scan following ultrasonography for every patient with PHPT; 6) consultation between the NM physician(s) and US radiologist(s) to reach a consensus on the diagnosis before the patient is discharged; and 7) performance of a repeat US if results from the MIBI and US scans were inconsistent with each other.
Yang Z (2017) Complementary sestamibi scintigraphy and ultrasound for primary hyperparathyroidism

Figure 2. 49-year-old female presented with a PTH level of 1123.5 pg/ml and a calcium level of 12.8 mg/dl.

Figure 3. A 49-year-old female presented with a PTH level of 192.5 pg/ml and a calcium level of 11.1 mg/dl.
A 72-year-old female presented with a PTH level of 141 pg/ml and a calcium level of 10.3 mg/dl.

Figure 4. A 72-year-old female presented with a PTH level of 141 pg/ml and a calcium level of 10.3 mg/dl.

A 57-year-old female presented with a PTH level of 500 pg/ml and a calcium level of 10.9 mg/dl.

Figure 5. A 57-year-old female presented with a PTH level of 500 pg/ml and a calcium level of 10.9 mg/dl.
Yang Z (2017) Complementary sestamibi scintigraphy and ultrasound for primary hyperparathyroidism

Figure 6. A 59-year-old female presented with a PTH level of 344.5 pg/ml and a calcium level of 11.5 mg/dl.

Figure 7. A 63-year-old female presented with a PTH level of 90.2 pg/ml and a calcium level of 10.2 mg/dl.
Conclusion

MIBI provides guidance for the interpretation of US data, especially in the context of ectopic parathyroid adenomas. US offers detailed anatomic information and supports the diagnostic confidence of MIBI in localizing ectopic parathyroid glands, small abnormal parathyroid glands, or concurrent thyroid nodules. US can be particularly helpful in patients with more than one enlarged parathyroid gland. In the majority of cases, the dual utilization of MIBI and US was able to successfully overcome the inherent limitations of each modality.

Authorship and contributorship

Dr. Yang performed the main study design, and Drs. Yang, Alexander, and Chadha conducted the data collection and analyses. Dr. Yang prepared the manuscript drafts with significant intellectual contribution and critical revisions from Anna Li. All authors have approved the final manuscript.

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