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Shear wave elastography and parathyroid adenoma: A new tool for diagnosing parathyroid adenomas

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ABSTRACT

Objectives: This study prospectively determines the shear wave elastography characteristics of parathyroid adenomas using virtual touch imaging quantification, a non-invasive ultrasound based shear wave elastography method.
Methods: This prospective study examined 57 consecutive patients with biochemically proven primary hyperparathyroidism and solitary parathyroid adenoma identified by ultrasound and confirmed by at least one of the following: surgical resection, positive Technetium–99 m Sestamibi Scintigraphy (MIBI) scan, or fine needle aspiration biopsy with positive PTH washout (performed only in MIBI negative patients). Vascularity and shear wave elastography were performed for all patients. Parathyroid adenoma stiffness was measured as shear wave velocity in meters per second.
Results: The median (range) pre-surgical value for PTH and calcium were 58 pg/mL (19, 427) and 10.8 mg/dL (9.5, 12.1), respectively. 37 patients had positive MIBI scan. 20 patients had negative MIBI scan but diagnosis was confirmed with positive PTH washout. 42 patients underwent parathyroidectomy, and an adenoma was confirmed in all. The median (range) shear wave velocity for all parathyroid adenomas enrolled in this study was 2.02 m/s (1.53, 2.50). The median (range) shear wave velocity for thyroid tissue was 2.77 m/s (1.89, 3.70). The shear wave velocity of the adenomas was independent of adenoma size, serum parathyroid hormone concentration, or plasma parathyroid hormone concentration.
Conclusions: Tissue elasticity of parathyroid adenoma is significantly lower than thyroid tissue. B-mode features and distinct vascularity pattern are helpful tools in diagnosing parathyroid adenoma with ultrasound. Shear wave elastography may provide valuable information in diagnosing parathyroid adenoma.

1. Introduction

Primary hyperparathyroidism is the most common cause of hypercalcemia [1,2]. Most patients with primary hyperparathyroidism have a solitary parathyroid adenoma. Other causes include glandular hyperplasia, multiple adenomas, and parathyroid carcinoma [3,4]. Many patients with primary hyperparathyroidism have a solitary adenoma that can be treated with unilateral minimally invasive surgical techniques following accurate preoperative localization [5].

The two most widely used imaging modalities for preoperative localization are ultrasound (US) and Technetium–99 m Sestamibi Scintigraphy (MIBI) scan.In the past decade, the role of US technology has become prominent in diagnosing head and neck malignancy due to improved image quality. Adding color and power Doppler to US exam improved detection of parathyroid adenomas [6,7]. The diagnostic accuracy of MIBI scan is limited [8]. Several publications reported a sensitivity of 50% to 85% for MIBI scan for primary hyperparathyroidism [9–13]. Adding B-mode US and fine

Abbreviation: US, ultrasound; FNAB, fine needle aspiration biopsy; PTH, parathyroid hormone; SWE, shear wave elastography; VTIQ, virtual touch imaging quantification; m/s, meters per second; SWV, s hear wave velocity; LN, lymph nodes.

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needle aspiration biopsy (FNAB) with parathyroid hormone (PTH) washout to MIBI scan has improved localization of parathyroid adenoma [14].

Another recent modality is 4D CT scan. A recent publication reported that 4D CT scan was able to show a distinct vascularity pattern, polar vessel sign, in nearly two-thirds of surgically confirmed parathyroid adenoma [6].

The role of strain elastography in parathyroid localization was examined by Ünlütürk et al. between 2009 and 2010 [15]. The main limitation of this study was the use of strain elastography, which does not perform tissue quantification. Since this study was published, shear wave elastography (SWE), an improved method form measuring tissue stiffness, has become available. We were unable to find any published articles employing SWE to localize parathyroid adenomas.

The use of SWE in diagnosing malignancy in thyroid, breast and prostate has been established [16–19]. Virtual Touch Imaging Quantification (VTIQ) is a recently available 2D-shear wave technology generated by acoustic radiation force impulse. VTIQ is capable of creating shear wave image and subsequent tissue quantification in one display and allows for identification of regions for measurement of tissue stiffness [20]. Based on our prior experience with elastography and neck pathology, we propose that SWE may be a useful tool in diagnosing parathyroid adenoma since parathyroid adenoma has a different tissue composition, vascularity pattern, and subsequent tissue stiffness.

2. Objective

The aim of this study was to prospectively determine the SWE characteristics of parathyroid adenomas using the VTIQ technology.

3. Materials and methods

This single center prospective study was approved by the Institutional Review Board. A subject population of 64 consecutive patients was evaluated in this Health Insurance Portability and Accountability Act (HIPAA) compliant study from March 28, 2013 to October 12, 2015. All patients gave written informed consent. We evaluated patients with US confirmed solitary parathyroid adenoma and biochemically confirmed primary hyperparathyroidism. Patients were studied both before and after the VTIQ technology was approved by the FDA. All patients were evaluated clinically and with US by a single practitioner with more than 16 years of experience in thyroid, parathyroid, and neck US, and 8 months experience using SWE routinely prior to study.

3.1. Inclusion criteria

Patients included in this study were 18 years and older, had biochemically confirmed primary hyperparathyroidism, and a parathyroid adenoma candidate seen with US. Patients with positive neck US and negative MIBI scan underwent FNAB with PTH washout.

3.2. Exclusion criteria

Patients were excluded from this study for the following reasons: (1) A candidate for parathyroid adenoma was not found with US. (2) Despite negative MIBI scan patients declined FNAB with PTH washout. (3) FNAB with PTH washout failed to confirm a diagnosis of parathyroid adenoma.

A total of 7 patients were excluded. In 4 patients we were unable to find a candidate for parathyroid adenoma. 3 patients with negative MIBI scan were excluded, of those, 2 patients refused FNAB with PTH washout and in one patient FNAB failed to confirm the diagnosis of parathyroid adenoma.

In this study, parathyroid adenoma localization was confirmed by at least one of three end points. In group one, a positive MIBI scan confirmed the US finding. In group two, the MIBI scan was negative or discordant with positive US findings and FNAB for PTH washout confirmed the diagnosis and US localization. Finally, in group three, the location of the parathyroid adenoma was confirmed by surgical resection.

3.3. Conventional ultrasound

All patients in this study had a candidate for solitary parathyroid adenoma seen on initial US exam. MIBI scan was performed subsequently. US exam of the neck included B-mode information related to thyroid gland: homogenous versus heterogeneous; presence or absence of thyroid nodules. Patients were also evaluated for the following B-mode characteristics of parathyroid adenoma: size (length and height) and location in the neck (posterior/superior versus posterior/inferior versus ectopic location). The presence of polar vessels was examined with color Doppler and power Doppler.

3.3.1. Principle of acoustic radiation force impulse elastography

VTIQ is based on the principle of acoustic radiation force impulse technology. In tissue, shear waves travel at a velocity of around 1–10 m per second (m/s) [20]. Using image based localization and proprietary implementation of acoustic radiation force impulse technology, the shear wave speed may be quantified in a precise anatomical region focused on a region of interest (ROI) with a predefined 1.5 mm size provided by the system [21]. The VTIQ image is a color-coded display of relative shear wave velocities within the user defined ROI superimposed onto a conventional B-mode US image. VTIQ is capable of four discrete shear wave display maps: velocity, quality, travel time, and displacement [20].

3.3.2. Elastography exam

Conventional US exam and SWE were performed with Siemens ACUSON S3000 US system (SIEMENS Medical Solution, Mountain View, CA, USA). The B-mode features and vascularity pattern were recorded with 18LHD probe. The shear wave image was created and reproduced twice with a 9L4 Multi-D probe. Shear wave velocity (SWV) measurement was performed using VTIQ. A small ROI box was used to measure parathyroid tissue velocity. Two areas within the parathyroid were measured, Read 1 and 2, because the ROI box is relatively small (1.5 mm in diameter).The size of ROI box is predetermined by manufacturer and cannot be modified. Velocity mean was defined as the average of the two parathyroid velocity measurements. The elastography exam was the last part of the US exam.

3.4. External observer evaluation

The US images were additionally reviewed by 2 independent outside sonographers with >10 years experience in thyroid and neck US. The reviewers were only informed that patients had hyperparathyroidism.

3.5. Biochemical assays

At the time of initial visit, each patient had blood drawn for the following measurements: calcium (reference range 8.5–10.2 mg/dL), PTH (15–65 pg/mL), phosphorus (2.5–4.5 mg/dL), ionized calcium (4.5–5.6 mg/dL), and vitamin D (30–100 ng/mL). They were also asked to collect 24-h urine for calcium and creatinine. Post-operative calcium and PTH levels were also measured. All measurements were performed by LabCorp (LabCorp Research