The American Journal of Surgery (2016) 211, 839-845

The American Journal of Surgery®

North Pacific Surgical Association

Dual-energy computed tomography: a promising novel preoperative localization study for treatment of primary hyperparathyroidism

Nazgol Seyednejad, M.D.[a], Ciaran Healy, M.D.[b], Pari Tiwari, M.D.[b], Patrick Vos, M.D.[b], George Sexsmith, M.D.[c], Adrienne Melck, M.D., F.R.C.S.C.[a], Cameron Hague, M.D.[b], Sam M. Wiseman, M.D., F.R.C.S.C.[a,*]

[a]*Department of Surgery, St. Paul's Hospital & University of British Columbia, 1081 Burrard Street, Vancouver, British Columbia, V6Z 1Y6, Canada; Departments of* [b]*Radiology, and* [c]*Nuclear Medicine, St. Paul's Hospital & University of British Columbia, Vancouver, British Columbia, Canada*

KEYWORDS:
Primary hyperparathyroidism;
Dual-energy computed tomography;
Parathyroid localization;
Parathyroidectomy;
Adenoma

Abstract

BACKGROUND: The objective of this study was to evaluate dual-energy computed tomography (DE-CT) for preoperative parathyroid tumor (PT) localization in individuals undergoing parathyroidectomy for treatment of primary hyperparathyroidism (PHP).

METHODS: DE-CT was evaluated by retrospective review of the clinical and biochemical characteristics, imaging, operative findings, and outcomes for PHP cases undergoing an initial operation at a single center.

RESULTS: The accuracy of each preoperative imaging test, based on operative findings and pathological confirmation of removal of a PT from the localized site was: 58% for ultrasound, 75% Tc-99m sestamibi noncontrast single photon emission noncontrast CT, and 75% for DE-CT. DE-CT was able to correctly localize a PT in a 3rd of cases that were nonlocalized. All study patients had normalization of serum calcium and parathyroid hormone levels postoperatively.

CONCLUSIONS: DE-CT shows promise for the preoperative PT localization, especially in nonlocalized PHP cases, and warrants further investigation.

Primary hyperparathyroidism (PHP) is the 3rd most common endocrine disorder and is caused by one or more of the 4 parathyroid glands secreting excessive amounts of parathyroid hormone (PTH), leading to hypercalcemia. PHP affects .1% to 2% of the adult population and has a 3:1 female preponderance.[1–3] The most common cause of PHP is a solitary adenoma (75% to 85%), but it may also be caused by multigland hyperplasia (10%), double adenomas (4%), and parathyroid carcinoma (1%).[1–5] Parathyroidectomy (PTx) is currently the only curative treatment for PHP.[1–5] Twenty years ago, the traditional surgical approach was a bilateral neck exploration with identification of all 4 parathyroid glands, and removal of the parathyroid adenoma or adenomas, or subtotal

There were no relevant financial relationships or any sources of support in the form of grants, equipment, or drugs.

The authors declare no conflicts of interest.

* Corresponding author. Tel.: +1-604-806-9108; fax: +1-604-806-9957.

E-mail address: smwiseman@providencehealth.bc.ca

Manuscript received November 10, 2015; revised manuscript January 22, 2016

0002-9610/$ - see front matter © 2016 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.amjsurg.2016.01.003

resection of 3½ glands in patients diagnosed with 4-gland hyperplasia.[3] However, more recently, largely due to the utilization of intraoperative PTH (IPTH) measurement, and increasingly accurate preoperative localization imaging studies, parathyroid operations have become more focused. This has allowed for a more precise and less invasive targeted surgical approach to PTx, through a small incision, and in most cases has eliminated the need for a bilateral neck exploration along with its associated morbidity.[6–8] Today, commonly used imaging tests used for preoperative parathyroid tumor (PT) localization include ultrasound (US) and technetium-99m sestamibi imaging (with planar and single photon emission computed tomography (CT); SPECT) with noncontrast CT (CT-MIBI). Accuracy rates for preoperative parathyroid localization as high as 80% for US, and 87% for CT-MIBI, have been reported.[6–8] However, each imaging test has its own inherent strengths and weaknesses, which are influenced by characteristics of both the patient and the PT(s). In a cohort of 161 PHP patients, we have previously identified PT size and patient preoperative ionized calcium level as being the best predictors of sestamibi scan accuracy.[9] Concurrently applying multiple imaging tests may also improve the accuracy in localizing a PT preoperatively.[10–13] Regardless, in individuals with a PHP diagnosis, preoperative PT nonlocalization should not preclude neck exploration.

Dual-energy CT (DE-CT) was 1st conceived in 1976 as consecutive single-slice acquisitions with different kVp, but this method suffered from breathing and partial volume artifacts that limited its clinical application.[14–16] Technological developments have helped to eliminate these early limitations. Different vendors have approached this differently, namely, either with 2 separate X-ray sources offset at 90° (Siemens, Berlin, Germany), or via novel detector elements that allow detection of rapidly alternating voltage potentials (General Electric, Gemstone Spectral Imaging, NY). DE-CT has the ability to differentiate materials of different effective atomic numbers based on attenuation measurements acquired with different energy spectra. Patients imaged with DE-CT receive a similar or lower dose of radiation as a single-energy CT examination, of the neck, approximately 3 to 5 mSv.[14–16] The clinical application of DE-CT to the brain, chest and abdomen, and in the cardiovascular and musculoskeletal systems, has been well described.[16] However, the application of DE-CT has received little study for preoperative parathyroid localization in individuals diagnosed with PHP.[17,18] In the present study, we have evaluated the clinicopathological and imaging characteristics of a group of PHP patients treated at a single center to determine the clinical utility of DE-CT in the preoperative localization of PT(s) to facilitate a focused PTx. The objective of this study was to investigate the diagnostic accuracy of contrast enhanced neck CT, using dual energy, for the preoperative localization of PT(s) to facilitate successful PTx.

Methods

Participants

A retrospective chart review was carried of all patients undergoing treatment of PHP between May 2014 and June 2015 at a single Canadian tertiary care Endocrine Surgical center, St. Paul's Hospital (Vancouver, BC). Inclusion in the study population required the patient to have a PHP diagnosis, undergone preoperative localization with all 3 imaging modalities (CT-MIBI, US, and DE-CT) at our center, and to have undergone a neck exploration for PTx. A "successful" PTx was characterized by postoperative pathological confirmation of PT removal and normalization of postoperative serum calcium and PTH levels. Individuals who had undergone prior central neck surgery or a prior PTx, with either persistent or recurrent PHP, were excluded from the study population. Individuals with either known hereditary or lithium-related PHP were also excluded from the study population. All PTx were focused procedures carried out through a small central neck incision and performed as a same day discharge operation by 1 of 2 subspecialty-trained high-volume surgeons (each carrying out >100 parathyroid and/or thyroid operations annually). In total, 24 patients met the inclusion criteria and made up the study population.

Imaging protocol

The DE-CT (Fig. 1) was carried out with a 64-slice dual-energy scanner (GE Discovery HD750; GE Healthcare, Milwaukee, WI). The scan range covered from the external auditory meatus to the inferior aortic arch. A contrast CT (injection of 100 mL of Omnipaque at 3 mL per second, a set delay time of 45 seconds) was acquired on a single breath hold, performed immediately after a noncontrast scan. Data were acquired at .625 mm, and reconstructed at 2.5-mm slice thickness in axial, coronal, and sagittal planes. Dual energy was used for both the noncontrast and IV contrast examinations. Rapid kVp switching (80/140kVp) was performed to allow for creation of monochromatic energy level images. Images sent to the picture archiving and communication system were virtual monochromatic data sets at—50, 70, and 90 KeV for both noncontrast and IV contrast acquisitions. In addition, virtual noncontrast images were also created from the DE data sets on a dedicated postprocessing workstation (GE Advantage 4.6; GE Healthcare) and sent to picture archiving and communication system. All DE-CT images were interpreted by 3 board-certified radiologists with a special interest in parathyroid imaging, and coread with a medical imaging fellow with a special interest in parathyroid imaging. A PT was defined by the presence of an avidly contrast enhancing lesion (attenuation greater than skeletal muscle after contrast), that had attenuation subjectively less than the thyroid on the precontrast images present in an expected anatomical site, or an ectopic location.