Clinical efficacy of 2-phase versus 4-phase computed tomography for localization in primary hyperparathyroidism

Adriana G. Ramirez, MD,[a] Amber L. Shada, MD,[b] Allison N. Martin, MD, MPH,[a] Prashant Raghavan, MD,[c] Christopher R. Durst, MD,[d] Sugoto Mukherjee, MD,[d] John R. Gaughen, MD,[d] David A. Ornan, MD,[d] John B. Hanks, MD,[a] *and* **Philip W. Smith, MD,[a]** *Charlottesville, VA, Madison, WI, and College Park, MD*

Background. *Four-dimensional computed tomography is being used increasingly for localization of abnormal glands in primary hyperparathyroidism. We hypothesized that compared with traditional 4-phase imaging, 2-phase imaging would halve the radiation dose without compromising parathyroid localization and clinical outcomes.*
Methods. *A transition from 4-phase to 2-phase imaging was instituted between 2009 and 2010. A pre-post analysis was performed on patients undergoing operative treatment with a parathyroid protocol computed tomography, and relevant data were correlated with operative findings. Sensitivity, positive predictive value, technical success, and cure rates were calculated. The Fisher exact test or* χ^2 *test assessed the significance of 2-phase and 4-phase imaging and operative findings.*
Results. *Twenty-seven patients had traditional four-dimensional computed tomography and 35 had modified 2-phase computed tomography. Effective radiation doses were 6.8 mSy for 2-phase and 14 mSv for 4-phase. Four-phase computed tomography had a sensitivity and positive predictive value of 93% and 96%, respectively. Two-phase computed tomography had a comparable sensitivity and positive predictive value of 97% and 94%, respectively. Eight patients with discordant imaging had an average parathyroid weight of 240 g compared with 1,300 g for all patients. Technical surgical success (90% for 4-phase computed tomography versus 91% 2-phase computed tomography) and normocalcemia rates at 6 months (88% for both) did not differ between computed tomography protocols. Computed tomography correctly predicted multiglandular disease and localization for reoperations in 88% and 90% of cases, respectively, with no difference by computed tomography protocol.*
Conclusion. *With regard to surgical outcomes and localization, 2-phase parathyroid computed tomography is equivalent to 4-phase for parathyroid localization, including small adenomas, reoperative cases, and multiglandular disease. Two-phase parathyroid computed tomography for operative planning should be considered to avoid unnecessary radiation exposure. (Surgery 2016;160:731-7.)*

From the Departments of Surgery[a] and Radiology and Medical Imaging,[d] University of Virginia, Charlottesville, VA; Department of Surgery,[b] University of Wisconsin, Madison, WI; and Department of Diagnostic Radiology,[c] University of Maryland, College Park, MD

Primary hyperparathyroidism develops secondary to a solitary adenoma in approximately 90% of patients. Historically, parathyroidectomy consisted of bilateral neck exploration with removal of the abnormal gland(s). While this approach remains an acceptable treatment option, many experienced

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Reprint requests: Philip W. Smith, MD, Department of Surgery, University of Virginia, PO Box 800709, Charlottesville, VA, 22903. E-mail: PWS7V@virginia.edu.

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endocrine surgeons prefer a directed operative exploration, or "minimally invasive" parathyroidectomy. The success of this approach is dependent on reliable preoperative imaging, targeted dissection, and availability of intraoperative parathyroid hormone (PTH) monitoring, and minimally invasive parathyroidectomy has been associated with decreased operative risk.[1,2] In particular, outcomes after a successful limited parathyroidectomy are notable for decreased hospital stay, with cure rates and operative times similar to those experienced with traditional bilateral neck exploration.[3]

There are multiple available strategies for preoperative localization which include sonography (US), technetium Tc99m sestamibi +/− single-photon emission computed tomography, 4-dimensional, or 4-phase–contrasted, computed tomography (4DCT), and various combinations of these modalities. The preferred imaging approach remains dependent on patient factors and institutional preference.[4] Decision modeling indicates that the most cost-effective method of preoperative localization is routine US followed by 4DCT as needed, and this is our preferred approach. In contrast, if US sensitivity is low, such as in reoperative cases, evidence recommends the use of routine selective 4DCT as the most cost-effective option.[5,6] Four-dimensional contrasted CT is a multiphase, multidetector imaging modality that uses contrast uptake and washout to identify parathyroid glands and it is particularly effective in identifying adenomas. This imaging modality becomes particularly useful when ultrasound (US) and/or sestamibi scan is negative, as it can identify more than 50% of missed lesions.[7,8] It is also used in reoperative neck surgery cases.

The use of 4DCT has been criticized for its high radiation doses.[9,10] Recent studies have attempted to decrease the number of phases and minimize total radiation exposure with variable recommendations as to single-, dual-, triple-, and traditional 4-phase image acquisition.[5,11-13] To date, there is no consensus among advocates of dual- and triple-phase CT as to which combination of phases yields the most accurate localization of parathyroid lesions.[14,15] The growing body of literature demonstrates similar degrees of localization with modified-phase CT while achieving a marked decrease of total radiation dose compared with 4-phase CT.

Prior to 2010, we used traditional 4DCT for screening patients with a negative or indeterminate US and/or sestamibi scan for parathyroid localization. We determined that we were predominantly relying on the precontrast and early arterial phases for localization only and revised our protocol to eliminate the venous and delayed phases. We set out to examine our single-institution experience with 4DCT, comparing it to our modified 2-phase CT for parathyroid localization. We hypothesized that the use of 2-phase imaging would provide equivalent parathyroid localization compared with traditional 4-phase CT as measured by sensitivity and positive predictive value, and that there would be no difference in operative correlation with imaging findings.

METHODS

Patients with biochemically confirmed, primary hyperparathyroidism who met criteria for operative treatment who underwent operative exploration after preoperative 4-phase or 2-phase CT were identified using the University of Virginia's (UVA's) Clinical Data Repository (CDR) between June 2008 and May 2012. The CDR is a deidentified, Health Insurance Portability and Accountability Act (HIPAA)-compliant, clinical and administrative database maintained by UVA for conducting population-based research. Although patients were identified retrospectively, the CDR database uses prospective collection of data. Research approval for the study was obtained from the UVA Institutional Review Board (HSR-IRB # 18506). Exclusion criteria included patients with secondary and tertiary hyperparathyroidism as well as patients who did not get both a preoperative parathyroid protocol CT of the neck and an operative exploration. Each patient record was reviewed with special attention to type(s) of imaging modalities, radiographic results, operative pathology, and intraoperative findings. Patient age, sex, history of prior neck surgery, and preoperative serum calcium and serum parathyroid hormone (PTH) levels were collected. Intraoperative PTH (IOPTH) levels and 6-month postoperative calcium levels also were recorded.

Helical 0.625-mm, axial images (reconstructed at 1.25 mm) are obtained from the carina to the angle of the mandible prior to intravenous contrast administration using a 32-section multidetector CT scanner. In the 4-phase CT group, 3 sets of postcontrast imaging were performed with an identical acquisition to the noncontrast images at 25, 55, and 85 seconds after administration of 120 mL of iodinated contrast material at 4 mL/s. For the 2-phase CT group, only noncontrasted images and images at 25 seconds following the same 120 mL contrast bolus were acquired. The radiation dose for the unenhanced phase was 26.45 mGy; all other phases were 25.41 mGy. The dose-length product (milligray-centimeter) for the unenhanced phase was 590.49 mGy-cm, and for