Chapter 2
Preoperative Parathyroid Imaging for the Endocrine Surgeon

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Introduction

Over the past decade, minimally invasive directed parathyroidectomy (DP) has become the operation of choice for most patients with sporadic primary hyperparathyroidism (PHPT). Using preoperative imaging as a tool to guide the operation, DP has many advantages over the traditional four-gland exploration. This minimally invasive approach may be performed under local anesthesia, requires less operative time, results in decreased postoperative pain, and offers improved aesthetics [1, 2].
The DP approach has the added advantage of earlier hospital discharge and a decrease in the overall associated costs for the procedure.

Following biochemical confirmation of PHPT, a high-quality preoperative imaging evaluation for localization of one or more abnormal parathyroid glands is essential if a DP approach is considered. Ideally, the patient is referred to the surgeon prior to imaging so that the localization evaluation may be tailored to provide a roadmap that allows efficient and effective surgical intervention. It is important to remember that the diagnosis of PHPT is made by satisfying biochemical parameters, not by findings on a radiographic study. Positive imaging modalities help guide a surgeon where to begin a parathyroid exploration. Rapid intraoperative assay for intact parathyroid hormone (PTH) along with surgical expertise used to suggest when to cease the operation.

**Candidates for DP**

Success of DP is dependent on several key elements: (1) the patient must have biochemically proven primary hyperparathyroidism; (2) the PHPT should not be associated with multigland disease, such as that seen with multiple endocrine neoplasia (MEN or familial PHPT); and (3) there should be a lack of coexisting thyroid disease that would require concomitant surgical management.

**Anatomic Considerations**

The focused approach of DP requires a thorough knowledge of cervical anatomy and embryology. The DP technique is based on previous observations that the recurrent laryngeal nerve (RLN) is seldom anomalous and further that the inferior parathyroid gland is consistently anterior (ventral) to the RLN and the superior parathyroid gland posterior (dorsal) to the RLN [3]. Anatomic sites of the superior parathyroid gland are, in order of frequency, the cricothyroid junction, the dorsum of the upper pole of the thyroid, and the retropharyngeal space. The inferior parathyroid gland most commonly rests at the lower pole of the thyroid or in the cervical thymic tongue or descendent into the anterior mediastinum. Rarely, the inferior parathyroid gland resides in the upper neck (an undescended gland) or in the posterior or middle mediastinum.

Locations of enlarged parathyroid glands adhere to a definite pattern. Because the embryologic origin of the superior gland shares a common primordium in the fourth branchial pouch with the lateral thyroid, nondiseased superior parathyroid glands are invariably found in proximity to the posterior surface of the upper thyroid parenchyma. The relationship of a normal parathyroid gland to the thyroid capsule is critical to the potential position of a diseased gland. When located within the thyroid capsule, the diseased parathyroid gland remains in place and expands locally
within the confines of the surgical capsule of the thyroid. When located outside of the capsule, enlarged parathyroid glands tend to displace into a dependent area (both posteriorly and caudally), especially in the tracheoesophageal groove, and their migration is met with little resistance.

The inferior parathyroid gland shares an embryologic origin with the thymus and both arise from the third branchial complex. An enlarged inferior parathyroid gland is located in the lateral-posterior aspect of the lower thyroid pole or descends with the thymus into the anterior mediastinum.

A common misconception is that a parathyroid gland located high in the neck is always a superior gland and that one low in the neck is an inferior gland. In fact, a superior enlarged parathyroid gland may descend caudally in the tracheoesophageal groove and be located near the lower pole of the thyroid or in the posterior mediastinum. In this situation, the gland frequently is suspended by a long, vascular pedicle from the inferior or superior thyroid artery rendering it to a posterior position in the neck near the esophagus or cervical spine.

**Parathyroid Nomenclature**

**Parathyroid Classification System**

As a means of improving communication between the various radiologic teams and the surgical team, a system of classification was created based on the most frequently encountered positions of enlarged parathyroid glands (Fig. 2.1) [3]. In this classification scheme, a type A gland is a “normal” superior gland in proximity to the posterior surface of the thyroid parenchyma. It may be compressed within the capsule of the thyroid. A type B gland is a superior parathyroid gland that has fallen posteriorly into the tracheoesophageal groove. There is minimal or no contact between the gland and the posterior surface of the thyroid tissue. On anterior views, the type B parathyroid gland is in the plane of the superior pole of the thyroid. An undescended gland high in the neck near the carotid bifurcation or mandible may also be classified as a type B gland. Because these glands are cephalad to the superior pole of the thyroid, they are referred to as B+ glands. A type C gland is a superior gland that has fallen posteriorly into the tracheoesophageal groove and lies at the level of or below the inferior pole of the thyroid. This places the type C gland posterior to the RLN. The type D gland (“difficult” or “dangerous”) lies in the mid region of the posterior surface of the thyroid parenchyma, near the junction of the RLN and the inferior thyroid artery. The type D gland may be either a superior or inferior gland, depending on its exact relationship to the nerve. Whether this gland is an upper or lower parathyroid gland generally cannot be determined on imaging. These glands are in direct proximity to the nerve, as a result the dissection may be dangerous. The type E gland is an inferior gland in close proximity to the inferior pole of the thyroid parenchyma anterior to the trachea. Because these glands are relatively anterior in the neck and anterior and medial to the RLN, they are often
Fig. 2.1 (a) Anterior view displaying nomenclature of possible locations of parathyroid adenomas. 
A: Superior gland, in proximity of posterior surface of thyroid parenchyma, may be intracapsular/compressed. 
B: Superior gland, fallen posteriorly into tracheoesophageal groove, no contact with posterior surface of thyroid tissue in the cranio-caudal confines of thyroid lobe. 
C: Superior gland, fallen posteriorly into tracheoesophageal groove, no contact with posterior surface of thyroid tissue and is caudal/inferior to cranio-caudal confines of thyroid lobe. 
D: Superior or inferior gland, in mid region of posterior surface of thyroid parenchyma near junction of RLN and inferior thyroidal artery. 
E: Inferior gland, in region inferior to thyroid parenchyma, anterior to trachea. 
F: Inferior gland, descended into thyrothymic ligament or superior thymus and may appear in mediastinum. 
G: Intrathyroidal parathyroid. (b) Lateral view

“easiest” to remove. The type F gland is an inferior gland that has descended into the thyrothymic ligament or superior thymus. It may appear to be “ectopic” or within the mediastinum. An anterior-posterior view shows the type F gland to be anterior to and near the trachea. Finally, the type G gland is a rare intrathyroidal parathyroid gland.

Once familiar with the nomenclature, radiologists can more easily and concisely communicate with parathyroid surgeons the precise location of diseased glands.
The nomenclature allows a universal language among the multidisciplinary team, including radiologists, surgeons, anesthesiologists, endocrinologists, and pathologists. At our institution, we use the alphabet reference in approximately 90% of our preoperative imaging reports and operative records.

**Preoperative Planning**

Preoperative differentiation of an adenoma as superior or inferior allows the surgeon to plan the incision site and minimize both dissection and operative time. Superior glands are excised with a lateral approach, whereas inferior glands are often more easily excised with an anterior approach (Fig. 2.2). The surgical approach for a suspected superior parathyroid gland is a 2-cm incision made at the lateral extent of the marked 5-cm standard Kocher incision. The anterior border of the sternocleidomastoid muscle is identified and retracted laterally. The sternothyroid and sternothyroid muscles (the strap muscles) are separated longitudinally and retracted medially. The thyroid gland is retracted medially and the thyroid bed is inspected with fine dissection. Once identified, the enlarged parathyroid gland is removed after securing its vascular pedicle with small hemoclips. The surgical approach for a suspected inferior gland is a 2-cm incision made toward the ipsilateral side from the midline (Fig. 2.2). The strap muscles are identified, separated

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**Fig. 2.2** Illustration of medial and lateral incisions for directed parathyroidectomy
longitudinally, and retracted laterally. The inferior pole of the thyroid is retracted medially. Gentle and meticulous dissection of the dorsal side of the gland and the superior thyrothymic ligament is performed in search of the adenoma. Because of the differences in these two approaches, it is of utmost importance that the surgeon and the radiologists have excellent communication and that the surgeon reviews all images prior to surgical intervention.

**Description of Imaging Modalities**

**Ultrasound**

The goal of ultrasound (US) evaluation of the soft tissues of the neck in patients with PHPT is to identify potential parathyroid adenomas, alert the surgeon to the presence of reactive or malignant lymph nodes or nodules that could be misinterpreted as parathyroid adenomata, and identify concomitant thyroid disease. Because of the limited dissection associated with DP, the thyroid parenchyma is unable to be adequately palpated and inspected. Therefore, preoperative ultrasonographic (US) evaluation of the thyroid and regional lymph nodes for coexisting concomitant pathology is important when planning this procedure [4].

The effectiveness of ultrasound and US-guided fine-needle aspiration biopsy (FNAB) of the soft tissues of the neck is highly dependent on the expertise of the operator [5]. The successful usage of US is directly related to the skill level and experience of the ultrasound technologist and the radiologist, endocrinologist or surgeon performing the examination [6, 7]. A systematic US examination of the soft tissues of the neck includes a focused evaluation of the thyroid and nodal basins, including the jugular territories, paratracheal, submandibular, supraclavicular, and suprasternal regions. In patients with PHPT, US imaging is also focused in the traditional locations of the parathyroid glands. These include the regions superior and inferior to the thyroid gland in the anterior and posterior locations.

US of the soft tissues of the neck is performed with the patient in the supine position with the neck hyperextended. The US examination is performed using a high-resolution scanner (such as the Proforma 5500, Aloka Tokyo, Japan), with color and power Doppler capability, equipped with commercially available high-frequency broadband (7–13 MHz) linear-array transducers. Color and power Doppler examination is an integral part of a US examination of the soft tissues of the neck [4, 8].

Sonography has proven to be highly sensitive in detecting minute (a few mm in size) nonpalpable masses in the thyroid and soft tissues of the neck [9]. Although the detection rate of focal abnormalities with sonography is high, specificity of sonographic images is often insufficient to provide a clinically useful characterization of a solid thyroid nodule, an intrathyroidal parathyroid, or to differentiate an abnormal parathyroid gland from a prominent central neck lymph node.
FNAB under US guidance preoperatively provides a reliable tissue diagnosis and can diagnose malignancy in small thyroid nodules and lymph nodes not detected by other methods. US-guided FNAB may be useful for differentiation of an intrathyroidal parathyroid gland from a thyroid nodule—particularly in the reoperative setting. However, it is important that the cytologist is alerted to the concern because parathyroid gland cannot be differentiated from thyroid tissue without specific staining. Specimen assessment for PTH is most useful and very accurate. Additionally, comparison with alternate imaging modalities, such as nuclear scan and 4D-CT, may allow differentiation of thyroid tissue from parathyroid gland.

**Nuclear Medicine**

Technetium-99 sestamibi (Tc-99m MIBI) imaging is a modality that has been widely adopted for preoperative parathyroid localization. This imaging modality is available at most institutions and is complementary to the US evaluation of the soft tissues of the neck [10, 11].

The Tc-99m MIBI imaging technique detects increased radiotracer uptake in the neck associated with a functionally active parathyroid gland or glands. Tc-99m MIBI is distributed in proportion to blood flow and is sequestrated intracellularly within the mitochondria. The large number of mitochondria present in the cells of most parathyroid adenomas, especially oxyphilic cells, may be responsible for the avid uptake and slow release of Tc-99m MIBI seen in many but certainly not all parathyroid adenomas compared to normal parathyroid glands and surrounding thyroid tissue. Physiological thyroid uptake of Tc-99m MIBI gradually washes out with a half-life of 60 min, whereas activity in parathyroid tumors is generally stable over 2 h, thus explaining the better visualization of parathyroid adenomas at 1.5–3 h postinjection.

Typically, Tc-99m MIBI parathyroid scintigraphy is performed as a double-phase study. Following intravenous injection of 740–925 MBq (20–25 mCi) Tc-99m MIBI, two sets of planar images of the neck and upper chest are obtained using a low-energy high-resolution collimator. Views should extend from the mandible to a level below the aortic arch. The initial set of images acquired at 30 min postinjection corresponds to the thyroid phase, and a second set of images obtained at 1.5–3 h postinjection corresponds to the parathyroid phase. A focal activity in the neck or mediastinum that either progressively increases over the duration of the study or persists on delayed imaging in contrast to the decreased thyroid activity is interpreted as differential washout consistent with parathyroid adenoma. This double-phase technique has been reported to be successful in 84% of patients with adenomas and 63% with hyperplasia [5].

A meta-analysis of 52 studies published in 2004 reported sensitivities of Tc-99m MIBI ranging from 40 to over 90% [12]. Possible effects explaining this wide variation include the biochemistry of the disease; higher preoperative calcium levels
have been observed more often in patients with positive scans [13]. A significant correlation was seen between the uptake ratio and preoperative PTH levels and higher PTH levels were more likely to be observed in patients with positive scans [14–16]. Vitamin D deficiency may also be associated with scan positivity [17]. A limitation in Tc-99m MIBI scanning is the decreased ability to identify patients with multiglandular disease [18]. Patients with single adenomas have been found to have more true-positive scans than those with multiglandular disease [19]. Additionally, the accuracy in this technique to detect double adenomas was only 30% in a cohort of 287 PHPT patients [20].

Tc-99m MIBI does not provide detailed anatomic information about the diseased parathyroid glands and their relationship to other structures in the neck. In addition, parathyroid adenomas within the thyroid and thyroid adenomas both demonstrate focal increased activity on MIBI, and thus cannot be differentiated by this modality. The sensitivity of Tc-99m MIBI has been found to be lower in the presence of thyroid nodules [21–23]. Oblique and lateral views are critically necessary to define the anterior-posterior location of parathyroid glands. Planar views do not provide the detailed information to inform the surgeon of the depth of the adenoma. For such details, the use of SPECT/CT is helpful [24, 25]. SPECT/CT is obtained by using an integrated imaging system with 6–16 slices of CT and software to make iterative reconstruction of 3D images with 1–4-mm-thin slices. SPECT/CT is excellent because it provides a combination of anatomic and functional information. Parathyroid adenomas overlying thyroid tissue and thyroid adenoma can be separated by use of SPECT/CT. It can also help determine whether the parathyroid tumor is in the anterior, posterior, or middle mediastinum. Thyroid pathology and/or coexisting lymphadenopathy may contribute to false-positive findings without SPECT/CT fusion images.

Four-Dimensional Computed Tomography

Four-dimensional computed tomography (4D-CT) is a multiphase multidetector computed tomography (CT). Multidetector CT provides rapid volumetric acquisition and in-plane spatial resolution of 1 mm or better, allowing improved visualization of parathyroid glands. The multiphase technique allows visualization of the temporal changes of the parathyroid adenoma (i.e., early enhancement and early washout) compared to other structures in the neck. The images generated provide detailed anatomic information which serves as a roadmap for the operating surgeon.

Our examinations are performed using a 16 or 64 row multidetector CT scanner (General Electric, 16 Lightspeed or 64 Lightspeed Volume CT, Fairfield Connecticut). The scanning protocol consists of four identical helical scan phases obtained in an automated, predetermined, timed sequence from the carina to the mandibular teeth. The first phase is without contrast. Twenty-five seconds before the beginning of the second phase, injection of 120 mL of iodinated contrast is
commenced at 4 mL/s This timing was chosen such that imaging through the neck occurs during maximum opacification of vascular and tumoral structures. Thirty seconds after the end of the second phase, the third phase commenced and 45 s after the end of the third phase, the fourth and final phase commences. The four phases are identified as pre-contrast, immediate, early-delayed, and late-delayed. The pre-contrast phase allows distinction between the iodine-rich thyroid and surrounding tissue. The three vascular phases distinguish the uptake and washout characteristics of contrast in highly vascular tissue such as a parathyroid adenoma from those seen in thyroid tissue and lymph nodes.

We previously reported the use of 4D-CT in the preoperative localization of parathyroid adenomas [26]. In an evaluation of 75 patients with PHPT, 4D-CT demonstrated improved sensitivity (88%) over Tc-99m MIBI imaging (65%) and ultrasonography (57%), when the imaging studies were used to lateralize hyperfunctioning parathyroid glands to one side of the neck. Moreover, when used to localize parathyroid tumors to the correct quadrant of the neck (i.e., right inferior, right superior, left inferior, or left superior), the sensitivity of 4D-CT (70%) was superior. These results require the presence of an experienced radiologist for optimal results. Therefore, the combination of providing improved sensitivity with detailed anatomy renders CT a robust modality compared to Tc-99m MIBI or ultrasonography in planning minimally invasive parathyroid operations. Furthermore, compared to nuclear imaging and ultrasonography, CT is quicker, does not require nuclear isotope preparation or handling, and is not user-dependent. Disadvantages include radiation dose, cost, and the injection of iodinated contrast which is a contraindication in patients with poor renal function. In addition, the contrast material, as with any medication, can rarely cause severe allergic reactions.

Case Presentations

**Primary Hyperparathyroidism Treated with Minimally Invasive Parathyroidectomy, Type E Gland**

A 52-year-old woman with a history of depression and insomnia was found to have hypercalcemia on routine physical examination. As part of an evaluation, review of symptoms was notable for fatigue, constipation, muscle weakness, and difficulty with sleep. Laboratory results included a calcium of 2.65 mmol/L or 10.6 mg/dL (reference range 8.4–10.2 mg/dL), an ionized calcium of 1.34 mmol/L (reference range 1.13–1.32 mmol/L), a phosphorus of 0.97 mmol/L or 3.0 mg/dL (reference range 2.5–4.5 mg/dL), and an intact PTH of 108 pg/mL (reference range 9–80 pg/mL). The patient’s urinary calcium was elevated at 401 mg/24 h (<150). Bone densitometry demonstrated osteoporosis of the lumbar spine with a T-score of −2.52. A diagnosis of primary hyperparathyroidism was made and surgical intervention planned.
Ultrasound images performed in both the longitudinal and transverse plane demonstrated an unremarkable thyroid gland and a left nodule caudal to the inferior margin of the thyroid in the region of concern for a parathyroid adenoma (Fig. 2.3a, b). By US criteria, this nodule was considered nonspecific. Correlation with medical history and alternate imaging modalities suggested that this is an enlarged E type parathyroid adenoma.
Routine serial static images as well as SPECT/CT of the neck and chest following the injection of 25 mCi Tc-99m MIBI demonstrated a focal area of slightly increased activity persistently in the left inferior thyroid bed on planar images (Fig. 2.4a). The SPECT/CT images demonstrated the increased activity corresponding to the small nodular density just behind or just below the inferior pole of the left thyroid lobe (Fig. 2.4b). These findings suggested a type E parathyroid gland.
Postcontrast CT scan revealed an enhancing parathyroid adenoma underlying the posterior surface of the left thyroid lobe (Fig. 2.5a). Sagittal imaging demonstrated that the parathyroid adenoma was located along the inferior aspect of the left thyroid lobe consistent with a type E parathyroid adenoma (Fig. 2.5b).

**Surgical Procedure**

Combining the data from all the studies, this lesion was found to be a type E gland. Both the CT and sestamibi studies helped demonstrate the anterior location of the adenoma. Directed parathyroidectomy was performed as an outpatient procedure under local anesthesia with intravenous sedation. A 2-cm incision was made just to the left of midline, and the left strap muscles were retracted laterally. An enlarged and hypercellular left inferior parathyroid gland was identified in the E position and removed. Five and ten minutes following parathyroidectomy, the intraoperative PTH level fell 80 and 83%, respectfully, and into the normal range. The patient experienced an uneventful recovery. Following parathyroidectomy, the patient’s calcium (2.33 mmol/L or 9.3 mg/dL), phosphorus (1.23 mmol/L or 3.8 mg/dL), and PTH (35 pg/mL) returned to within normal limits. Her constitutional symptoms improved.
Comment

This patient has biochemical evidence of primary hyperparathyroidism. The combination of constitutional symptoms and the presence of osteoporosis are indications for parathyroidectomy. As illustrated here, the majority of patients with primary hyperparathyroidism can undergo a directed, anatomic, unilateral operation with a high degree of success and low morbidity using a combination of preoperative imaging. Rapid intraoperative assay for intact PTH can be used to suggest when to stop the operation. In patients with excellent preoperative localization, parathyroidectomy can usually be successfully completed using local anesthesia with intravenous sedation in the outpatient setting. Advantages of this approach include improved patient comfort and rapid recovery.

Primary Hyperparathyroidism, Type C Gland

A 54-year-old woman with a history of recurrent nephrolithiasis was found to have biochemical evidence for primary hyperparathyroidism, with a calcium of 3.13 mmol/L or 12.5 mg/dL (reference range: 8.4–10.2 mg/dL), an ionized calcium of 1.64 mmol/L (reference range: 1.13–1.32 mmol/L), a phosphorus of 0.52 mmol/L or 1.6 mg/dL (reference range: 2.5–4.5 mg/dL), and an intact PTH of 435 pg/mL (reference range: 9–80 pg/mL). She was hospitalized, given intravenous fluid resuscitation, and referred for surgical consultation.

Imaging Studies

Ultrasound

Real-time sonographic examination demonstrated a nodule in the left paraesophageal region posterior to the left lobe of the thyroid and extending inferiorly (Fig. 2.6a). Correlation with 4D-CT and nuclear scanned confirmed that this represented a parathyroid adenoma. The sonographic evaluation also demonstrated a multinodular thyroid gland. The dominant nodules in the right and left lobe (Fig. 2.6b) were documented as benign colloid nodules by US-guided FNA.

Nuclear Medicine

There was avid focal tracer accumulation in a 3 × 1-cm soft tissue mass seen in the left paraesophageal region in the tracheoesophageal groove, extending from the lower pole of the left thyroid lobe to below the thyroid gland on both planar images and SPECT/CT (Fig. 2.7a, b). This finding was consistent with a large parathyroid adenoma in the C location.
Axial noncontrast CT showed a soft tissue attenuation parathyroid adenoma (3.4 × 1.4 × 0.9 cm) (arrow) in the paraesophageal region inferior to the left thyroid lobe lateral to the trachea (T) and medial to the carotid (C) that correlates with the position of the parathyroid adenoma documented on 4D-CT. (b) US image in the longitudinal plane demonstrates the parathyroid adenoma (thin arrow) inferior and posterior to the left thyroid (th). Incidental note is made of a multinodular thyroid. The dominant nodules in the right (0.8 cm) and left lobe of the thyroid (1.4 cm) (thick arrows) were documented as colloid nodules on US-guided biopsy prior to the MIP.

**Fig. 2.6** Patient 2 US. (a) US image in the transverse plane demonstrates a parathyroid adenoma (3.2 × 1.3 × 0.9 cm) (arrow) in the paraesophageal region inferior to the left thyroid lobe lateral to the trachea (T) and medial to the carotid (C) that correlates with the position of the parathyroid adenoma documented on 4D-CT. (b) US image in the longitudinal plane demonstrates the parathyroid adenoma (thick arrow) inferior and posterior to the left thyroid (th). Incidental note is made of a multinodular thyroid. The dominant nodules in the right (0.8 cm) and left lobe of the thyroid (1.4 cm) (thick arrows) were documented as colloid nodules on US-guided biopsy prior to the MIP.

**Four-Dimensional Computed Tomography**

Coronal and sagittal reconstructed MIP images nicely demonstrated the parathyroid adenoma relative to the thyroid gland and adjacent structures (Fig. 2.8d, e). With the reconstructed images, the parathyroid adenoma was identified in all three planes.
Combining the data from all the studies, this lesion was thought to be a type C gland and the identified thyroid nodules were known to be benign by FNA. A DP was an appropriate option and the planned approach was a left lateral 2-cm incision with the focal area of interest posterior and inferior in the tracheoesophageal groove. At operation, an enlarged left superior parathyroid gland was identified in

**Surgical Intervention**

Combining the data from all the studies, this lesion was thought to be a type C gland and the identified thyroid nodules were known to be benign by FNA. A DP was an appropriate option and the planned approach was a left lateral 2-cm incision with the focal area of interest posterior and inferior in the tracheoesophageal groove. At operation, an enlarged left superior parathyroid gland was identified in...
the tracheoesophageal groove at the cranial-caudal level of the inferior thyroid pole (Fig. 2.9). A nodular thyroid was encountered without obvious cancer. Following excision of the right superior parathyroid gland, the intraoperative PTH level fell 78 and 85% and into the normal range, 5 and 10 min, respectively.

**Comment**

Patients with advanced hypercalcemia require medical intervention. Medical management for severe hypercalcemic situations (usually defined as serum calcium >14.0 mg/dL) includes vigorous hydration and salt loading. These correct the initial crisis, but parathyroidectomy is the definitive cure. In this case, the ultrasonographic finding of a multinodular thyroid required preoperative FNA to rule out concomitant thyroid cancer. Thyroid nodules are common in patients with hyperparathyroidism, with or without a history of neck irradiation. Preoperative ultrasound is usually superior to physical examination for definitive diagnosis of thyroid nodules. It allows for directed assessment via FNAB of dominant or suspicious nodules in the outpatient setting so that appropriate treatment planning can occur prior to surgical intervention [6, 7].
An 83-year-old woman with hypertension, diabetes mellitus, and mild chronic renal insufficiency (blood urea nitrogen 11.78 mmol/L or 33 mg/dL [normal range 8–20 mg/dL], creatinine 114.39 µmol/L or 1.5 mg/dL [reference range: 0.8–1.5 mg/dL]) presented with biochemical evidence for primary hyperparathyroidism. The patient’s calcium was 3 mmol/L or 12.0 mg/dL (reference range: 8.4–10.2 mg/dL), ionized calcium was 1.34 mmol/L (reference range: 1.13–1.32 mmol/L), phosphorus was 1.07 mmol/L or 3.3 mg/dL (reference range: 2.5–4.5 mg/dL), intact PTH was 133 pg/mL (reference range: 10–65 pg/mL), and urinary calcium was 200 mg/24 h (reference range: <150 mg/24 h). She had undergone prior cervical exploration with an inability to locate an enlarged parathyroid gland. She subsequently underwent a failed reoperative cervical exploration. She presented with biochemically proven persistent disease. Of note, she also had a remote history of thyroid gland ablation with radioiodine for thyrotoxicosis 45 years prior to this presentation. Given her prior cervical procedures, repeat imaging and video stroboscopy to evaluate vocal cord function were performed.
Imaging Studies

Ultrasound

Sonographic examination did not identify a parathyroid adenoma. The thyroid gland was unremarkable.

Nuclear Medicine

On the planar anterior view, there was a focus of persistent Tc-99 m MIBI uptake in the lower thyroid bed region (arrow). On the SPECT/CT images, the parathyroid gland was located immediately posterior to the esophagus, and, therefore, immediately anterior to the vertebral body (of T1 vertebra).

4D-CT

Axial noncontrast CT showed a soft tissue attenuation parathyroid adenoma (0.9×0.5×1.9 cm) in the retroesophageal region (Fig. 2.11a). Of note was evidence of the previous total thyroidectomy. Following contrast administration, the parathyroid adenoma showed early enhancement (Fig. 2.11b) and early washout (Fig. 2.11c).
This parathyroid adenoma was fairly deep in position, located posterior to the left common carotid artery and anterior to the vertebral body. Sagittal reconstructed MIP images demonstrated the parathyroid adenoma anterior to the C5 and C6 vertebral bodies (Fig. 2.11d).
Surgical Intervention

In this case, the parathyroid adenoma was exceedingly posterior. This position was not capable of being visualized by ultrasonography. Both the 4D-CT and SPECT/CT helped localize this gland posterior to the esophagus in a type B position. A large, hypercellular parathyroid adenoma located posterior to the esophagus and immediately anterior to the cervical spine was resected via her previous Kocher col- lar incision. Her localizing studies were consistent with a type B gland (Fig. 2.12). PTH values dropped 77 and 86% and into the normal range, 5 and 10 min, re- spectively, following excision.

Comment

This case is an example of the value of being able to perform complimentary localization studies that are useful for surgical planning. Reoperative cases should have a minimum of two concomitant, concordant studies. The midline, posterior position of this gland was appreciated on both the 4D and SPECT/CT. In this reoperative
setting, the clarity of the preoperative localization allowed for a direct approach with no unnecessary blind dissection amid intense scar tissue. We feel strongly that a thorough knowledge of the coexisting anatomy and precise gland localization is beneficial and cost-effective because it minimizes dissection, operative time, and hospital length of stay. Although difficult to quantify, each minute of dissection in the operating room with a patient under general anesthesia is costly. In addition, if a bilateral exploration is required, the necessary overnight observation as a caution against airway compromise from a postoperative bleed is an additional expense. This compares to accurate imaging and a directed approach which offer same day discharge. Actual billing and charges vary and are not easily trackable. Recent estimated costs of a cervical ultrasonographic examination is $300; Sestamibi scan $2,000, and 4D-CT $1,800. These may indeed be cheaper than the estimated $100 per minute of operating room costs if accurate imaging is not available and a more extensive dissection is necessary. In reoperations, the morbidity and the associated cost of managing aparathyroidism or RLN injury certainly supports concomitant concordant imaging to be cost-effective.

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