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Minimally invasive parathyroidectomy

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Most patients with primary hyperparathyroidism are afflicted with a single parathyroid adenoma. Advances in parathyroid imaging localization and parathyroid hormone testing have allowed for the use of a focused approach in many patients with parathyroid adenomas. In this article, we describe the indications, preoperative considerations, and technique for minimally invasive parathyroidectomy.

Introduction

The mainstay in the treatment of primary hyperparathyroidism has classically been surgical excision of the abnormal gland(s). Traditionally, this involved a surgical exploration of all 4 parathyroid glands, intraoperative identification of the abnormal gland(s), and surgical excision of the abnormal gland. More recently, an increase in effective parathyroid imaging, in conjunction with intraoperative parathyroid hormone (PTH) measurement, has led to the ability to localize abnormal glands preoperatively and allowed for a more focused and minimally invasive parathyroid surgery. Several benefits have been touted in doing a focused parathyroidectomy, including decreased operative times, decreased complications, shorter hospital stay, and an overall decreased morbidity of the procedure.[1,2]

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Indications

The diagnosis of primary hyperparathyroidism is established biochemically in the presence of an elevated serum calcium level with an associated elevation in the parathyroid hormone level.

More than 85% of cases of primary hyperparathyroidism are caused by a single adenoma developing from 1 of the 4 parathyroid glands. Less frequently, it can be caused by double adenomas, multigland hyperplasia, or rarely parathyroid carcinoma.[3] Single adenoma, if preoperatively localized, is amenable to a focused or minimally invasive surgical approach, whereas multigland disease typically requires bilateral surgical exploration.

A few other conditions exist in which minimally invasive surgery should be avoided or is contraindicated. In patients with a history of previous neck surgery or irradiation, the resultant scarring can make minimally invasive parathyroidectomy challenging, if not impossible to perform. Additionally, in cases of a family or suspected patient history of multiple endocrine neoplasia, or concern for parathyroid carcinoma, focused parathyroidectomy is contraindicated. Finally, a concurrent finding of thyroid pathology is also concerning, and minimally invasive surgery should be avoided.[4]

To perform a focused parathyroidectomy, the adenomatous gland must be identified preoperatively with imaging. The imaging results serve as road map for a limited dissection. If the abnormal gland is unable to be localized with preoperative imaging, then a minimally invasive parathyroidectomy is likely not feasible. In these cases, bilateral cervical exploration becomes necessary to evaluate all 4 glands and identify the abnormal one intraoperatively before excision.

Preoperative imaging and localization

Several forms of parathyroid imaging have been used for preoperative imaging. Ultrasound is a simple and inexpensive technique, which can be used as a first-line imaging study. Although ultrasound typically is unable to identify normal parathyroid glands, it has a sensitivity of approximately 76% for localizing enlarged and abnormal glands. Adenomatous glands appear as ovoid structures, which are homogenous and hypoechoic, and Doppler images reveal a peripheral rim of vascularity and increased blood flow when compared with the thyroid.[1]

Sestamibi scintigraphy is a nuclear radiology technique of parathyroid imaging. It uses the Technetium-99m isotope that is taken up by the thyroid and parathyroid glands, but has a differential washout rate. After approximately 1.5-3 hours, the radioisotope is washed out of the thyroid gland, but persists within the parathyroid glands. Planar images are taken at this delayed time-point and abnormal glands are detected as bright with a sensitivity between 54% and 95%.[1,5] Physiologic uptake of the Technetium-99m is also seen in the heart, submandibular glands, and parotid gland.[1]

Single-photon emission computed tomography (SPECT), a variant of sestamibi scintigraphy provides a 3-dimensional set of images. The addition of sagittal and axial images can help to localize posterior or retroesophageal adenomas, which could not be differentiated on traditional scintigraphy.[1] Sestamibi-SPECT has a sensitivity of approximately 79% and is frequently used as a first-line imaging.[6,7] SPECT can be combined with conventional computed tomography (CT) to increase the anatomical detail. SPECT-CT has the potential to help differentiate parathyroid adenomas from thyroid nodules and cervical lymph nodes, in addition to localizing more ectopic adenomas than SPECT alone. The addition of the CT component increases the sensitivity of the imaging (~86%), but also increases the radiation exposure and cost.[1]

For those difficult to localize glands that are not found on ultrasound or SPECT-CT, the multiphase 4-dimensional CT scan has emerged as a highly sensitive (~93%) method of localization. The 4-D CT uses multiple CT passes during the presence and washout of contrast to identify the abnormal glands. Typically, the 4-D scan images are taken before contrast, during the arterial phase, and during washout at 25 seconds and 85 seconds postcontrast administration.[7,8] Characteristically, parathyroid adenomas exhibit rapid uptake and washout of contrast differentiating them from similar structures, such as lymph nodes.[9] The use of 4-D imaging has been shown to increase the rate of minimally invasive parathyroidectomies and be associated with shorter hospital stays.[10]

One or multiple parathyroid imaging techniques may be used for preoperative localization of parathyroid adenomas to guide minimally invasive parathyroidectomy. Despite the advancements in parathyroid imaging, it remains the case that not all parathyroid adenomas are identifiable radiologically, and in these cases a minimally invasive approach to adenoma removal may not be possible.[11]

Intraoperative rapid PTH

The development of rapid parathyroid hormone assays has been a critical factor in allowing surgeons to perform focused parathyroidectomy. PTH is an 84 amino acid peptide with a biologically active N-terminal. The intact PTH assay detects 2 sites on the peptide and is both a highly sensitive and specific laboratory test to detect PTH levels. Previously, this test took several hours to perform. Several recent modifications in the test have allowed for the creation of a rapid intact PTH assay that takes less than 15 minutes to complete.[12]

PTH has an in vivo half-life of approximately 3 minutes, and serum levels fall rapidly following excision of a parathyroid adenoma. Therefore, blood samples can be drawn before and after excision of the adenoma and compared to assess surgical success. Several criteria have been developed to interpret the drop in parathyroid hormone level, including the most common—Miami criteria—deeming that a 50% drop in parathyroid hormone level 10 minutes after excision from preoperative or preexcision levels predicts surgical cure and normocalcemia.[13]

If the postexcision parathyroid hormone level does not drop adequately to meet criteria, this suggests that the focused surgery has not been successful and prompts the surgeon to consider converting the procedure to a bilateral neck exploration in search of a second abnormal gland or even 4-gland hyperplasia. In this way, performing intraoperative PTH testing during minimally invasive surgery obviates the need for a revision surgery in many cases.

Technique

The patient is brought to the operating room and placed supine on the operating room table. General anesthesia is induced by the Anesthesiologist. The use of long-acting nondepolarizing paralytic agents is specifically avoided. If intraoperative neural monitoring is to be used, an endotracheal tube with surface electrodes is placed, and continuous neuromonitoring may be performed throughout the procedure.[14] Appropriate neck extension is achieved with the use of a shoulder roll, and important midline cervical landmarks should be palpated and marked before the onset of the procedure—including midline mandible, thyroid notch, cricoid cartilage, and sternal notch. Eye pads are placed to protect that patient′s eyes.