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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.

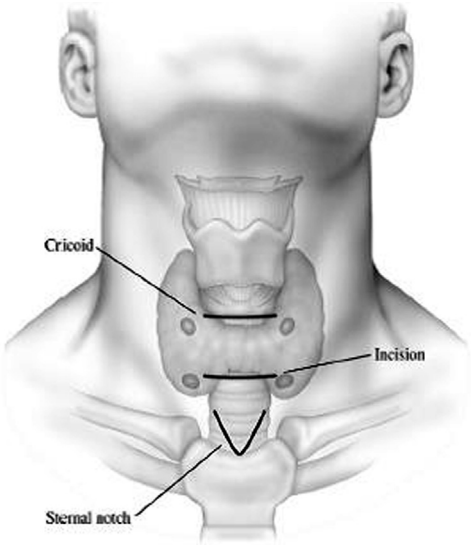

Figure 1 The incision is designed 2 fingerbreadths above the sternal notch on the side of the preidentified abnormal gland. (Reprinted with permission from Elsevier.[19])

An incision is designed 2 fingerbreadths above the clavicle and sternal notch, on the side of the suspected adenoma, approximately 2-3 cm in length (Figure 1). The incision is designed in a way that the extension of the incision, if necessary, is similar to a standard Kocher incision. If possible, the incision may be aligned within a pre-existing skin crease for improved cosmesis. The planned incision line is injected with 1% lidocaine with 1:100,000 epinephrine for hemostasis. A venous blood sample for a rapid PTH level is drawn by the anesthesiologist before the start of the procedure.

A 15 blade is used to sharply make the incision through skin. Following this, a Bovie electrocautery is used to divide the subcutaneous tissue and platysma. Using skin hooks for retraction, superior and inferior subplatysmal flaps are raised. Self-retaining retractors are then placed in the wound bed for good exposure. The midline is identified and the strap muscles are divided 1 layer at a time using Bovie electrocautery or the Harmonic scalpel. Once the final layer of strap muscles is divided, the thyroid capsule is exposed. Bluntly, the strap muscles are dissected off the thyroid lobe on the preoperatively identified side of the abnormal parathyroid gland, and the retractors are placed beneath the strap muscles.

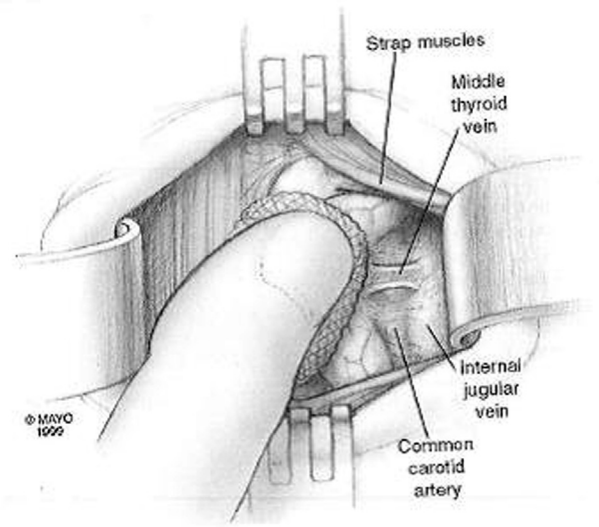

Figure 2 Once the strap muscles are dissected off the thyroid lobe, the thyroid is rotated and retracted medially. The middle thyroid vein would be encountered and may need to be divided to adequately rotate the thyroid. (Reprinted with permission from Elsevier.[20])

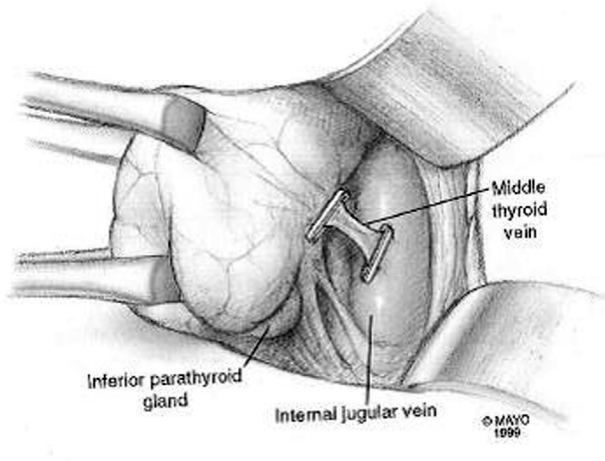

Figure 3 The middle thyroid vein is ligated. The inferior parathyroid gland is visible in its relationship to the recurrent laryngeal nerve. (Reprinted with permission from Elsevier.[20])

The thyroid lobe is then carefully grasped with an Allis clamp and rotated and retracted medially. The middle thyroid vein may prevent adequate rotation of the thyroid and can be divided if necessary (Figure 2). Dissection should be carried out gently with a peanut and a hemostat spreading in the direction of the recurrent laryngeal nerve (RLN). An inferior parathyroid gland adenoma may be located especially close to the course of the RLN (Figure 3). Superior gland adenomas are frequently within 1 cm of the intersection of the inferior thyroid artery and the RLN (Figure 4). With the assistance of the preoperative imaging,

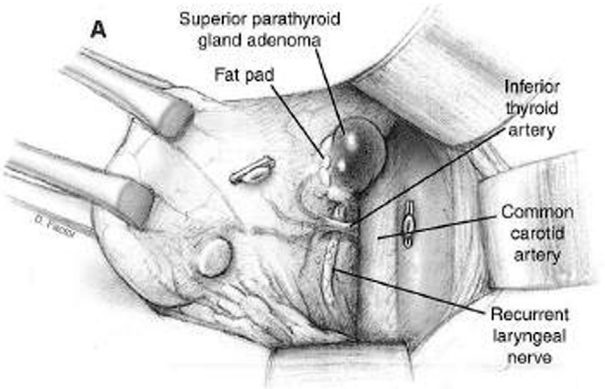

Figure 4 A superior parathyroid gland adenoma is identified near the intersection of the inferior thyroid artery and recurrent laryngeal nerve. (Reprinted with permission from Elsevier.[20])

the adenoma is relatively easy to identify. The adenoma is bluntly dissected out from the surrounding fat and thyroid capsule. The vascular pedicle can be suture ligated or divided using the harmonic scalpel.

A small piece of the excised parathyroid gland is then sent to pathology for frozen section to confirm the presence of hypercellular parathyroid tissue. If deemed appropriate, the ipsilateral parathyroid gland may be identified during a focused exploration, but is not necessary in every case. Between 10 and 15 minutes after excision, a second blood sample is drawn and a rapid postexcision PTH level is obtained. If the PTH level confirms biochemical cure, the surgery is deemed to be successfully complete.

Before closure, the wound bed is carefully examined to ensure adequate hemostasis. Absorbable hemostatic agents may be placed if necessary. The straps are then loosely sewn back together in the midline using an interrupted technique. The platysma and deep dermis are closed in layers using absorbable sutures with minimal tension. The skin is then reapproximated at the incision site, using any one of a variety of techniques based on surgeon's preference.

Patients can often be discharged home the same day following surgery and usually without any need for supplemental or replacement calcium.

Outcomes

In general, focused parathyroidectomy is a well-tolerated procedure with a low risk of complications and benefits beyond the cosmesis of a small incision. Compared to bilateral neck exploration, which has a reported success rate of 95%-97%, minimally invasive procedures have been found to have equal to slightly higher success rates of surgery, up to 99%.[15,16] Overall complications rates have been found to be lower in minimally invasive procedures, 1.5% vs 3% in bilateral exploration.[15]

Specifically, the rate of recurrent laryngeal nerve injury is less than 1% in both bilateral cervical exploration and minimally invasive approaches without a significant difference, but does trend toward a lower rate in minimally invasive parathyroidectomy. Hypocalcemia, the next most prevalent complication, is less than 0.5% for both procedures, although some studies report a slightly lower rate following minimally invasive surgery. Rates of postoperative hematoma are also similar between the 2 approaches.[15,17]

Performing a focused parathyroidectomy is reported to have shorter operative times than traditional bilateral surgery, averaging approximately 15-25 minutes less per procedure.[18] As mentioned previously, minimally invasive parathyroidectomy is also typically an outpatient procedure resulting in significantly shorter hospital stays. The shorter length of stay in the hospital reduces hospital charges. Approximately, $1,500 in hospital charges are saved per case when minimally invasive surgery is performed.[15] These cost savings should be weighed against the costs of the different types of preoperative imaging to establish the true cost-effectiveness of a minimally invasive parathyroidectomy.

Overall, focused parathyroidectomy has good outcomes which are comparable to, or slightly more favorable than traditional exploration, and benefits in terms of complications rates, operative times, and cost.

Conclusion

In the right subset of patients with single-gland primary hyperparathyroidism, minimally invasive parathyroidectomy can be performed in the presence of localizing preoperative imaging. It has a number of advantages over bilateral cervical exploration, including lower complication rates, shorter operative times, and decreased costs. The use of the intraoperative rapid PTH assay has helped make the focused procedure as successful as bilateral exploration with regards to cure. Over time, minimally invasive parathyroidectomy has become the procedure of choice in select patients with primary hyperparathyroidism.

Disclosure

The authors reported no proprietary or commercial interest in any product mentioned or concept discussed in this article.

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