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Minimal-access/minimally invasive parathyroidectomy for primary hyperparathyroidism

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When minimally invasive parathyroidectomy (MIP) was last reviewed in *Surgical Clinics of North America* only 3 years ago, Howe [1] noted that a striking change had already taken place in the management of primary hyperparathyroidism. The traditional paradigm of bilateral neck exploration (BNE) and four-gland evaluation was being replaced with one of unilateral exploration and limited evaluation, based upon preoperative localization studies. In that review, a cogent case was made that unilateral exploration was safe if preoperative imaging studies showed a single intense focus of uptake on sestamibi scan. The review then focused on the variety of techniques being investigated at that time to achieve a safe and effective minimal-access unilateral exploration. Those techniques included radio-guided parathyroidectomy, endoscopic parathyroidectomy, video-assisted parathyroidectomy, and mini incision parathyroidectomy under local anesthesia in an outpatient setting. In the conclusion to the review, Howe [1] made three pertinent comments: (1) that although measurement of intraoperative parathyroid hormone (IOPTH) was a valuable method for confirming that surgery is curative, he himself had not used it; (2) that the gamma probe had not been useful in his experience; and (3) that in most cases, with accurate sestamibi localization, an adenoma can be easily dissected and removed through a small incision, leaving the neck tissues undisturbed.

Over the last 3 years there has been an extensive body of literature assessing the various techniques available for MIP; however, those earlier observations have turned out to be remarkably perceptive. In a recent

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international survey of members of the International Association of Endocrine Surgeons (IAES) [2], a consensus on techniques seems to have evolved, with 92% of surgeons who undertook MIP using the focused, mini-incision approach, either through a central or lateral incision. In addition, the gamma probe has been largely abandoned as a useful tool, and IOPTH measurement is regarded as an accurate technique and used by the majority of surgeons, although its cost-effectiveness has been questioned. Some groups do continue to question the role of MIP; Schell and Dudley state that patients with primary hyperparathyroidism (pHPT) are best served by a full BNE performed by an experienced endocrine surgeon [3]. Others passionately support the procedure; Denham and Norman state that BNE for all parathyroid patients is an operation that should be confined to the history books, being only supported by surgeons holding on to old-school techniques [4]. The reality is that both MIP and BNE have important defined roles in the management of pHPT. The goal of this article is to seek to define what minimal-access or minimally invasive parathyroid surgery is, and to review the evidence upon which current practice is based.

Background

Surgery is currently the only available cure for primary hyperparathyroidism [5]. Traditionally the indication for parathyroidectomy in pHPT has been symptomatic hypercalcaemia in the presence of an inappropriately raised parathormone (PTH) level. Parathyroidectomy improves the fatigue as well as the bone, abdominal, urological and the mental symptoms associated with pHPT [6], and is recommended in symptomatic pHPT irrespective of age [7,8]. Although the majority of patients with pHPT are considered asymptomatic, many experience vague symptoms, such as fatigue, that improve following surgery. Surgery in such patients remains controversial, but the data increasingly appear to support parathyroidectomy in all patients with pHPT because it is associated with a quantifiable improvement in health related quality of life [9]. Also, 25-year follow-up of patients with untreated hypercalcaemia demonstrates an excessive number of premature cardiovascular deaths compared with age-matched normocalcaemic controls [5]. Another large cohort study from Denmark with a median follow-up of 6.1 years from diagnosis, although unable to confirm excess cardiovascular disease, does indicate a lower incidence of peptic ulcers and fractures in patients with pHPT treated surgically [10].

In recent years, improved preoperative parathyroid localization has allowed alternative approaches to the conventional bilateral neck exploration, using smaller skin incisions—"minimal-access" or "minimally invasive" parathyroidectomy. The terminology can be less than clear, because just how minimal the access should be to qualify as a minimal-access procedure has previously lacked definition, and many of the original names and acronyms

adopted during developmental stages of the techniques have not been updated; for example: minimally invasive parathyroidectomy (MIP), focused lateral exploration (FLE), unilateral exploration under local anesthetic (UELA), minimally invasive, videoscopically assisted parathyroidectomy (MIVAP), endoscopically assisted, minimally invasive parathyroidectomy (EAMIP), or minimally invasive, radio-guided parathyroidectomy (MIRP). Brunaud et al have recently addressed the issue of the definition of "minimally invasive" and describe it as the ability of the surgeon to perform traditional surgical procedures in novel ways that minimize the trauma of surgical exposure, with the principal advantage of a smaller incision [11].

The term "minimally invasive surgery" was initially applied to coelioscopic procedures such as laparoscopic cholecystectomy and hernia repair, thoracoscopic sympathectomy, and arthroscopy, but has since been abandoned, because doing the same operation through a smaller incision is not necessarily less invasive. The term "minimally invasive parathyroidectomy" does not fully convey the nature of the techniques, and, as previously debated in the wider field of minimal-access surgery, carries connotations of increased safety that are not necessarily supported by the existing data [12]. If one accepts that any parathyroidectomy that involves a conventional Kocher-type cervicotomy is a *conventional access procedure*, then it follows that the term "minimal-access parathyroidectomy" is the umbrella term that should apply to all procedures that aim to achieve parathyroid excision with less access. The issue is further complicated by surgeons performing an entirely conventional operation through a reduced ("minimal") incision [13] and those that perform a unilateral exploration through a standard neck incision. The point at which the procedure becomes a minimal-access operation presumably is best defined by the length of the incision; however, current techniques for open conventional parathyroidectomy have evolved to use shorter incisions—4.1 cm for bilateral and 3.2 cm for unilateral explorations [11]—and these rather than the traditional Kocher incision of 8 cm to 10 cm should be used for comparison. The suggestion has therefore been made that the designation MIP be adopted only when the incision is less than 2.5 cm [11]. In view of the effects of the patient's body mass index (BMI) on incision length (at least in thyroid minimal-access procedures), this should perhaps be qualified by either the condition that the patient has a BMI of less than 30, or that 2.5 cm is the maximum mean (rather than absolute) length when performing a minimal-access parathyroidectomy. Hence endoscopic, videoscopically-assisted, and focused lateral approaches are minimal-access procedures, whereas a unilateral exploration through an anterior cervicotomy of greater than 2.5 cm is not. Whatever the terminology adopted, each minimal-access technique has a number of enthusiasts, and may be performed with or without IOPTH measurement.

Whatever technique used, a minimal-access approach to parathyroidectomy has become the procedure of choice in many specialist centers, and has been shown to be associated with an increase in the number of

parathyroidectomies performed [14]. Part of the reason for this increase may well lie in the perception that minimal-access procedures are indeed less invasive, and so physicians are more prepared to refer patients for surgery. In a recent survey of referring endocrinologists, it was found that one of the principle hesitations in referring patients for surgery is that parathyroidectomy is perceived as an unnecessarily extensive and potentially dangerous operation. Indeed, it was stated that 80% of endocrinologists would send more patients if this MIP were readily available [4].

Evolution of technique

Wide exposure and evaluation of all four parathyroids has been accepted surgical practice since Felix Mandl performed the first successful parathyroidectomy in Vienna in 1925 [15]. Indeed, the requirements for a positive outcome following parathyroidectomy have not changed since the 1930s, when Edward Churchill, Chief of Surgery at the Massachusetts General Hospital, stated that "the success of parathyroid surgery must lie in the ability of the surgeon to know a parathyroid gland when he saw it, to know the distribution of the glands, where they hide, and also be delicate enough in technique to be able to use this knowledge" [16]. The view of James Walton, among the most experienced surgeons in the field of this time, that "a wide exposure is essential, for not only is it necessary to explore all the parathyroid glands, but also sometimes to search beyond the trachea and in the mediastinum" may not equally have stood the test of time [17].

Traditionally, parathyroidectomy has been based on a collar incision involving bilateral exploration of the neck, with the aim of identifying all four parathyroids and the removal of abnormal parathyroid tissue. This approach ensured cure rates of up to 97% with minimal morbidity [3,18], although such excellent results may not reflect general surgical practice.

The initial move away from a bilateral approach to parathyroidectomy in the mid 1980s was based on the principle that it would be enough to remove the single abnormal gland and visualize a normal second ipsilateral gland, to avoid the need for a contralateral exploration [19] while reducing the theoretically higher incidence of complications associated with bilateral exploration [20]. The choice of which side to operate on was initially arbitrary, but was later aided by techniques such as palpation, esophagography, venography, and angiography. The reservations expressed at that time regarding a unilateral approach centered on the unreliability of the preoperative imaging, the possible contralateral double adenomas, or asymmetrical hyperplasia. Consequently, the unilateral approach failed to gain universal support.

The development of improved preoperative imaging and localization significantly aided the development of a unilateral approach. Better still, if a parathyroid could be reliably localized, it might be possible to remove it

with even less trauma of access, say through a 2 cm incision, which in turn might be sufficient to enable a clinically demonstrable advantage of a minimal-access procedure. This assumption is the basis upon which minimal-access parathyroid surgery has spread, aided by new surgical devices and intraoperative confirmation of parathyroid excision.

Localization of parathyroid disease

The excellent results achieved by a bilateral neck exploration bear out the often-quoted truism that the most important preoperative localization procedure required in parathyroid surgery is the localization of an able parathyroid surgeon [3,21]. Indeed, in the past, preoperative localization of the parathyroid was used only in cases of re-exploration following an unsuccessful parathyroidectomy. Of the methods previously used to localize parathyroid glands, thallium-technetium subtraction scintigraphy was very much dependent on the size of the adenoma [22]. Ultrasound localizes up to 80% of parathyroid adenomas, is cheap and noninvasive, but is operator-dependent, and not particularly good at localizing ectopic glands [23]. CT and T2-weighted MRI can also be adopted with some success, particularly in ectopic glands. The breakthrough in preoperative imaging came with the discovery that an agent used for cardiac imaging—Tc99m sestamibi—is avidly taken up by parathyroid tissue, especially adenomas, in virtue of their high mitochondrial content [24,25]. Tc99m sestamibi scanning, using either single photon-emission computed tomography (SPECT) or oblique pinhole images [26], is able to localize over 90% of adenomas, including ectopic glands [27], but is less accurate in multiple gland disease [28]. False positive results may occur due to multigland disease, thyroid nodules, sarcoidosis, thyroid carcinoma, and lymphomas, but Tc 99m sestamibi remains the preoperative localization investigation of choice in parathyroid disease [29]. Interestingly, although sestamibi does not improve surgical outcome, a negative sestamibi scan is a predictor of those patients that are less likely to be cured [21]. When both ultrasound scan (USS) and Technetium Tc 99m sestamibi scanning are concordant, localization of a parathyroid adenoma is accurate in over 95% of cases [30], and may allow the marking of the position of the parathyroid on the overlying skin for orientation [31]. Combined preoperative localization is the optimum method for routine parathyroid adenoma localization, and offers the option of a focused surgical approach to the diseased gland [29]; however, the use of such strict criteria will achieve concordance in 64% of all patients with pHPT at best [28]. Therefore, at present no single method of parathyroid localization compares with the unguided neck exploration by an experienced surgeon, but when a single adenoma is present and localized, equivalent results may be achieved. Whether routine preoperative localization can be justified on economic grounds in virtue of its permitting a minimal-access approach is

questionable [32], but meta-analysis suggests that cost effectiveness begins when more than 51% of patients are suitable for a unilateral approach [33].

Types of minimal-access surgical techniques

Given that when Tc99M sestamibi is used in combination with ultrasonography, it provides over 95% likelihood of a localization of a single adenoma [31], its use has allowed a minimal-access approach to parathyroidectomy to develop. A number of different surgical techniques have subsequently evolved.

Endoscopic parathyroidectomy

A coelioscopic-thoracoscopic approach to parathyroid disease was first described in Lille [34]. A full endoscopic exploration of the neck was later attempted by Gagner [35], but the length of the operation and surgical emphysema that followed suggested that this was unlikely to be a popular approach to a full neck exploration. A revised endoscopic approach has, however, been successfully applied to preoperatively localized disease with favorable results [36]. The procedure is performed under a general anesthetic, and, as in other coelioscopic surgical approaches in developmental stages, a consensus on port placement has not been established. Approaches have varied from a three-port lateral approach along the anterior border of the sternomastoid muscle [37] to a midline suprasternal port and two lateral ports on the same or opposite sides of the neck, in front or behind the sternomastoid muscle [36]. Whatever the port placement preferred, the technique is essentially an endoscopic lateral approach. Variations on that theme include endoscopic parathyroidectomy via an axillary approach [38]. This completely avoids any scars in the neck or anterior chest by inserting three trocars via the axilla. Most would now accept that the technical challenges of such alternative approaches mitigate against their efficacy in other than the hands of the enthusiast.

Although undoubtedly feasible, the prolonged learning curve, the limited operative space and the loss of tactile effect during surgery [39] have made these approaches less popular than other minimal-access approaches. In some ways, the endoscopic approach has been a useful developmental step in the evolution toward the focused lateral approach; indeed, frequently the abnormal parathyroid could be clearly seen, but endoscopic removal was found to be easier [14].

Videoscopically assisted parathyroidectomy

Minimally invasive videoscopically assisted parathyroidectomy (MIVAP) was developed in Pisa [40]. It is performed principally under a general anesthetic. The localized adenoma is approached via a 15 mm suprasternal incision, a 30°, 5 mm endoscope is inserted, and retractors are used to

maintain good visualization of the operative field. This is dissected with 2 mm spatulas and forceps. The rest of the operation follows the standard principles of open parathyroid surgery, with recurrent laryngeal nerve (RLN) identification and ligation of the parathyroid vascular pedicle.

MIVAP offers advantages over the endoscopic approach, with the preservation of tactile contact with the surgical field, and a considerably smaller incision and thus excellent cosmesis. Also, with experience the exclusion criteria appear to be shrinking, as the absence of preoperative localization, the presence of tumors larger than 3 cm, and previous neck surgery no longer preclude a videoscopically assisted approach, which can be achieved with a mean operating time of 24 minutes [41]. The conversion rate using this technique ranges between 8.1% and 14% [42], with results and complications that are comparable to the results achieved using an open exploration. The greatest advantage of MIVAP appears to be the possibility of a four-gland exploration in those cases where the gland cannot be localized [41].

One possible disadvantage of the videoscopic approach is that, although the technique has been performed under local anesthetic, most series have been performed with a general anesthetic and an overnight stay—unlike the focused lateral approach where local anesthetic with sedation and same-day discharge are commonly practiced [43].

Radioguided parathyroidectomy

Minimally invasive radio-guided parathyroidectomy (MIRP) uses a gamma probe to determine the position of the incision and guide the dissection [44]. Two to 4 hours before surgical exploration, 20 mCi of Technetium 99m-sestamibi are injected intravenously, and a handheld gamma counter similar to that used in sentinel lymph-node detection is used at the time of surgery [45]. Gamma counts in the four quadrants of the neck and in ectopic positions are compared and used to guide the operator to the diseased gland. Once removed, the gland should continue to provide a signal significantly higher than the postexcision neck, which itself should no longer have a gradient between its quadrants [46]. This technique should shorten the time to localization of the diseased gland and may be useful, particularly in reoperative surgery.

Radio-guided parathyroidectomy has its enthusiasts, but does not appear to have been adopted very widely, presumably because it adds little to the intraoperative adjuncts already available, in particular IOPTH. It is also unlikely to add anything to the excellent results currently achieved with a bilateral neck exploration and no IOPTH [3,21].

Focused (mini-incision) parathyroidectomy

This is the current method of choice of the majority of members of the International Association of Endocrine Surgeons that favor a minimal-access approach. It is this procedure that is most commonly referred to as "minimally invasive parathyroidectomy" (MIP), but focused neck

exploration (FNE) seems a more coherent terminology. It can be performed via either a central or lateral neck incision, under a general anesthetic with a cervical block, or more commonly under local anesthetic and sedation. The lateral technique involves a 2 cm transverse incision placed in a skin crease directly over the localized parathyroid gland, along the medial border of the sternomastoid muscle [47] The approach involves the mobilization of the sternomastoid muscle laterally and the strap muscles medially, to reveal the lateral border of the thyroid gland and therefore direct access to the parathyroid bearing areas. An FNE can be performed in as little as 12 minutes [14], and is achieved fully respecting the principles, established with conventional parathyroid surgery, of avoiding a parathyroid capsular breach, and of identification of the recurrent laryngeal nerve. Several large case series using this technique have been published. Most of these have come from specialist centers and have reported results that compare well with those of a bilateral exploration [48,49]. A retrospective cohort study from Yale comparing 255 focused lateral approaches to 401 bilateral neck explorations demonstrated no significant difference in surgical success (99% versus 97%) or complication rates (1.2% versus 3%). A favorable reduction in operating time from 2.4 hours to 1.3 hours for MIP was demonstrated, with the associated cost advantages [43], although this appears to be a prolonged mean operative time for a minimal-access parathyroidectomy.

Whatever the minimal-access parathyroidectomy approach preferred, not all patients are suitable for a minimal-access approach, in particular those with multiple gland disease multiple endocrine neoplasias (MEN) I and IIa, familial HPT, and malignancy. Most other contraindications, such as the presence of concomitant thyroid disease, are no longer absolute, with the possible exception of thyroiditis, which, when present, creates significant fibrosis that can make the operation hazardous and necessitate conversion to an open approach [50].

Intraoperative PTH measurement

When a minimal-access approach to the parathyroid is adopted, the normality of the other glands, and therefore the presence of a double adenoma or multiple gland hyperplasia, cannot be visually confirmed. IOPTH measurements were first introduced in 1990, and represent an alternative to four-gland visualization [51]. Intact PTH has a half-life of several minutes, so the removal of diseased parathyroid tissue is predicted by a fall of PTH by more than 50% of its predissection value, within 10 to 15 minutes of removal of the hyperfunctioning parathyroid. Since its introduction, IOPTH has become widely used, because of the advantages it appears to provide to a minimal-access approach to the parathyroid: reducing operative failure rates, and therefore cure rates; and shortening operating time.

IOPTH reduces the incidence of operative failure rates during a bilateral neck exploration by corroborating that the removed macroscopically

enlarged parathyroid is the one that is hyperfunctioning [52]. The degree to which IOPTH can improve surgical results in a minimal-access approach will of course depend on the surgical approach adopted, and the baseline operative failure rate before the introduction of IOPTH. Clearly, the lower the accuracy of preoperative localization, the greater the value of IOPTH.

There is evidence that IOPTH improves the cure rate from 95% to 98% when a minimal-access approach is used, although this comes at the expense of a 13% additional exploration rate [30]. Others have demonstrated equivalent results without the need for IOPTH [53]. The suggestion that IOPTH shortens operative time [39] when compared with the same operation but without IOPTH seems unlikely when localization has been reliable.

Although some authors feel that IOPTH is an obligatory adjunct in all minimal-access first time approaches to the parathyroid [52], IOPTH may not objectively have lived up to its promise, for several reasons. First, despite the decrease in the unit cost of IOPTH to as little as US $150 per sample [43] (to which the cost of the certified clinical laboratory technician should be added), it does not appear to be cost effective [54]. Second, care must be taken when interpreting IOPTH results in patients on lithium and those anaesthetized or sedated with propofol (which is frequently used in day case surgery), because this interferes with the IOPTH measurements and should be stopped 5 to 10 minutes before blood sampling [48]. Third, IOPTH is associated with a small but not insignificant false-negative rate that may lead to unnecessary neck explorations [30]. The real problem with IOPTH, however, is that it appears to be inaccurate precisely in those patients where it is most required—in multigland disease [55]. False positive results have been experienced in the presence of multigland disease [56,57], failing to avert a re-exploration for persistent disease. In a recent study, IOPTH failed to fall after removal of just one adenoma in 9 of 21 patients, but then fell in 8 of 9 after removal of a second adenoma. In the ninth patient, it took 30 minutes for the IOPTH to fall. In 12 cases (57%), however, IOPTH fell despite the presence of persisting abnormal tissue [58]. In that same group, sestamibi scanning accurately predicted only 6 of 20 (30%) and ultrasound only in 8 of 20 (40%). When all three tests were combined, the accuracy was 80%, but all three tests were accurate in only one patient (5%). In contrast to these results, however, Carneiro and Irvin have reported that only 4% of patients have multiple abnormal parathyroids when IOPTH is used as the sole criterion [59]. The reason for this discrepancy is unclear, but it may be explained by differences in the calcium-sensing receptor density or PTH receptor set-point in different parathyroid adenomas. The real question therefore, is whether a parathyroid "adenoma" is more correctly defined on functional criteria rather than morphological criteria; in other words, some enlarged parathyroid glands may not secrete excess PTH, and thus may not contribute to the presence of hypercalcaemia.

What is the current role of minimal-access approaches to parathyroid disease?

To determine whether parathyroidectomy via a minimal-access approach with or without IOPTH is superior to a bilateral neck exploration would require a large, probably multicenter, randomized controlled trial with a long follow-up period. This is unlikely to happen. Several obstacles militate against the use of randomized controlled trials in surgery. These include the intrinsic difficulty in performing large randomized controlled trials (RCTs), threats to personal interest and prestige, problems associated with the surgeon's equipoise, the surgical learning curve, and patient as well as investigator blinding [60]. An additional obstacle can be that the widespread introduction of a new, apparently attractive technique such as minimal-access parathyroidectomy may be partly market-driven [14]. The evidence for many surgical innovations therefore depends on alternative approaches, such as the accumulation of nonrandomized data, often retrospectively after the initial enthusiasm for the innovation has reached a plateau.

In the case of parathyroidectomy, the control group, that is, the existing operation, is an unequivocally excellent operation in the hands of an appropriately trained and skilled surgeon. To demonstrate that a minimal-access parathyroidectomy is better than the control would therefore be even more difficult. A prospective randomized trial has attempted to compare a unilateral with a bilateral neck exploration [61]. This demonstrated that unilaterally explored patients had a lower incidence of postoperative hypocalcaemia and a shorter operating time. No cost advantages were demonstrable. Although this addresses the debate about whether a unilateral approach guided by preoperative imaging is better or worse than a bilateral approach, both groups of patients underwent a 5 cm cervicotomy. Therefore, this is not a comparison of a bilateral exploration with a minimal-access approach, in which the biggest issue is the size of the surgical incision. Thus, to compare a minimal-access technique to a bilateral exploration, one has to use case-controlled series and retrospective data. If there is little to choose between a bilateral exploration and a minimal-access approach as far as outcome is concerned, the same can certainly be said for the various minimal-access techniques when compared with each other. Therefore the minimal-access techniques can be compared as a group with a bilateral exploration.

It has been widely demonstrated that minimal-access parathyroidectomy can be safely performed in a large proportion of patients with single-gland disease, with results comparable to those of a bilateral neck exploration [48,49]. But what does a minimal-access approach to the parathyroid offer above the tried-and-tested, conventional bilateral neck exploration? The quoted advantages include lower costs, shorter hospital stays, quicker recovery time, and the option of surgery under local anesthesia [62]. But to what degree have these advantages been proven? And if true, are they clinically significant?

Clinical outcome/results

The best way of not missing a double adenoma or hyperplasia is not to look for them in the first place. The histological outcome following a minimal-access parathyroidectomy appears to be a self-fulfilling prophesy: a single adenoma every time. This is inevitable, because the other glands are not assessed. Retrospectively comparing the histological findings of a minimal-access technique with a bilateral exploration, we can infer that double adenomas and hyperplasia could be missed during a minimal-access approach, if the preoperative localization was anything but perfect. Indeed, we can see that a single adenoma is found in 92% of MIPs, but in only 81% bilateral explorations [43]. This has been further demonstrated in an eloquent study by Lee and Norton [63], and more recently by Genc et al [55], where it was shown that even when sestamibi localizes a single adenoma (making the patient suitable for a minimal-access approach), 15% of patients in fact have either a double adenoma or hyperplasia. Interestingly, this does not appear to affect the rate of persistent hyperparathyroidism using the currently adopted 6-month criteria. Unfortunately, this suggests that a not insignificant number of patients treated by a minimal-access parathyroidectomy may not be cured [55]. Indeed, there are already reports of patients undergoing removal of a single parathyroid adenoma, with a documented appropriate drop in IOPTH, only to re-present with persistent pHPT that is cured by removal of a second adenoma [64]. Only long-term follow-up will determine the clinical significance of missed multigland disease in the presence of a normal intra- or postoperative PTH and calcium. Unfortunately, the long-term outcome of the introduction of minimal-access parathyroid procedures may well be a re-surgence of recurrent hyperparathyroidism.

Surgical morbidity

Minimal-access parathyroidectomy appears to offer no extra procedure-specific complications in quality or quantity compared with a bilateral exploration. Complications such as recurrent laryngeal nerve palsy and hypoparathyroidism are in any case rare (<1%) in patients that undergo initial parathyroid operations. Conversion to a wider access procedure should not be considered a complication, nor should conversion to a general anesthetic (GA) if the surgery was originally performed under local anesthetic (LA). Using MIVAP, Miccoli and coworkers report a conversion rate of 8.1% [41], and using a focused lateral approach, Udelsman reports a rate of 11% [43]. The commonest reason for conversion to a bilateral neck exploration is the inability to find the diseased parathyroid. This in turn may be a function of the reliability of the preoperative localization—perhaps the adoption of single rather than a double modality preoperative localization—rather than due to the minimal-access method chosen. Nevertheless, a high conversion rate may reflect poor patient selection.

Local anesthesia

One of the advantages of a minimal-access approach is the option of performing the surgery under an LA. Although there are ample series of the focused lateral approach under LA [48,50] and smaller series of a radio-guided approach [44], LA cannot be used in endoscopic parathyroidectomy, and is rarely used in MIVAP. But it is noteworthy that LA is not exclusive to minimal-access techniques; Lo Gerfo describes a large series of bilateral neck exploration under LA [65]. So although both conventional and minimal-access techniques can be performed under LA, with or without light sedation; a smaller approach makes local anesthesia easier to achieve and is more widely practiced.

Cost advantages

Lower overall cost is frequently cited as an advantage of the minimal-access approaches. Most of the financial advantages are related to the reduction in the length of hospital stay [48], and operating theater and recovery room cost reduction [44], with the amount saved varying from institution to institution. A meta-analysis suggested that US $650 can be saved by adopting a minimal-access approach [33]. Schell and Dudley have, however, challenged the cost effectiveness argument, emphasizing that a bilateral exploration requires no costs related to preoperative localization or IOPTH [3]. This is particularly true when one considers that all patients will undergo preoperative localization studies, including those unsuitable for a minimal-access approach, and some surgeons will perform supplementary scans, such as CT and MRI, when sestamibi scans are negative. Can these investigations be justified when an unaided bilateral neck exploration can achieve such excellent results, especially when one considers that the key tools that enable a minimal-access approach may not be living up to their promise [28]?

Favorable cosmesis and patient satisfaction

These are often quoted advantages of the minimal-access techniques. Although both of these are likely to be true—an incision of less than 2.5 cm is probably cosmetically better than a larger one—there is little objective, validated evidence to support these statements. Schell and Dudley have, however, challenged this intuitive view, stating that a larger, centrally placed incision is cosmetically more acceptable than a small lateral incision [3]. On the other hand, there are anecdotal data that unsightly (hyperplastic or keloid) scarring may be more likely in the centrally placed neck wound than in an eccentric incision [66].

Shorter operating time

It stands to reason that the removal of a previously located gland is quicker than exploring four glands before removing one. There are,

however, no randomized trials comparing operating times of a bilateral exploration with a minimal-access approach to prove this. The varying methods of timing (anesthetic time or skin-to-skin time) also make comparison between units performing different operations difficult. The operating time decreases as the familiarity with a new technique increases, as demonstrated by Miccoli's group, which decreased the mean operating time from 40 minutes to 24 minutes over 239 MIVAP procedures [41]. The mean operating time for a focused lateral approach is described as half of that required to perform a bilateral exploration [43]. The problem of comparison of operating times between units is underlined by the mean operating time of 81 minutes for a minimal-access approach published by Udelsman [48]—16 minutes more than the operative time for a bilateral approach in another series [3]. It is one author's experience that the mean operating time for a focused lateral approach skin to skin is less than 25 minutes [67], and this is supported by other series from more than one institution [50].

Earlier discharge

Many surgeons keep patients in hospital for one night following a bilateral exploration of the neck. In minimal-access parathyroidectomy, discharge usually takes place the same day or even within hours of surgery [43]. Some favor an overnight stay due to the small (0.2%–0.5%) but not negligible risk of postoperative hemorrhage requiring evacuation [30]. Although there are some anecdotes of postoperative hematomas following minimal-access parathyroidectomy, airway compromise is very rare, because the operative space into which bleeding can occur is limited. This may not be true for minimal-access techniques that involve creation of ample surgical space with gas insufflation, such as endoscopic techniques, or a videoscopic procedure where all four glands have been sought.

The distinguishing characteristic of operations in which a minimal-access approach obtained universal approval—cholecystectomy, cardiomyotomy, fundoplication, and adrenalectomy—is that the trauma of access is greater than the trauma of the intrinsic surgical procedure itself. Where this rule has been complied with, evidence of clinical advantages of the technique have rapidly followed, and those minimal-access techniques considered useful have been widely adopted. Conversely, minimal-access procedures wherein the trauma of access has not proved to be so clinically significant—laparoscopic groin hernia repair, laparoscopic colectomy, and endoscopic thyroidectomy—are finding more limited applications or are practiced by fewer surgeons.

Those who promote a policy of surgery for all patients with pHPT, whether symptomatic or not, tend to also be advocates for newer surgical approaches to parathyroid surgery. This should be approached with caution, as a surgical technique can only really alter the indications for surgery if it in some way moderates the risk/benefit ratio of the procedure.

This is currently not entirely true for minimal-access parathyroidectomy, but may be perceived so by referring physicians. Nevertheless, the introduction of minimal-access techniques for parathyroidectomy has coincided with an exponential increase in referrals of patients with pHPT in some centers [14]. One can only speculate as to the degree to which the surgical approach has influenced this change in referral intensity. The option of a parathyroidectomy with a smaller incision under local anesthetic may have made patients previously deemed too unfit for a GA candidates for surgery. The introduction of minimal-access techniques may also be lowering the threshold for surgery, to include asymptomatic disease. Although the threshold for parathyroidectomy is per se lower, due to the evidence that it may be beneficial even in asymptomatic disease, this new evidence may become blurred with the promotion of the minimal-access parathyroid approach. This trend should be viewed with caution, because the documented morbidity of minimal-access parathyroid surgery has not changed from that of a bilateral approach.

It appears that in specialist centers, minimally invasive parathyroidectomy is replacing bilateral neck explorations for most patients with 1°HPT due to a proven single adenoma [39]. This change in practice has occurred without an evidence-based justification. This does not, however, mean that one is not present. Patients and probably referring physicians have embraced these techniques, and only long-term follow-up will determine the role of minimal-access approaches to parathyroid disease. Time will therefore determine the appropriate place for minimal-access parathyroidectomy in the surgical armamentarium for pHPT.

Summary

The terms minimal-access or minimally invasive parathyroidectomy should apply to a parathyroid procedure performed through an incision of less than 2.5 cm. When a parathyroid adenoma has been concordantly localized with USS and sestamibi, excellent results can be achieved using any one of the minimal-access parathyroidectomy techniques, with or without IOPTH. Cure rates are equivalent to those of a bilateral neck exploration, without the need for a general anesthetic, without an overnight stay, and with a smaller scar. Most endocrine surgeons prefer a focused lateral approach, which may reflect the simplicity of the technique and the fact that no supplementary instruments are required.

When a minimal-access technique is used, a number of nonfunctioning second adenomas or hyperplasias will be missed. The significance of these is not known. Therefore, whether the long term results of a minimal-access approach will be as good as the best results obtainable with a bilateral exploration remains to be seen.

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