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REVIEW ARTICLE

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Minimally invasive thyroid and parathyroid surgery: modifications for low-resource environments

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Abstract

Minimally invasive thyroidectomy (MIT) and parathyroidectomy (MIP) are gaining popularity in the current surgical practice. The need for specific equipment and technology is an obstacle in the low-resource environment. This article provides simple and practical guidance for surgeons practicing in low-resource environments to help them attain quality surgical practice, maintain patient safety, preserve available resources, and achieve the best outcomes.

Keywords: Endocrine, Thyroid, Parathyroid, Minimally invasive, Low-resource

Background

Endocrine surgery of the head and neck has almost become a separate subspeciality with the subsequent need for dedicated training and research. This article summarizes the notion of minimally invasive surgery in endocrine surgery to provide guidance and critical analysis to interested surgeons looking forward to pursuing this practice. Limited-resource environment adds to the hurdles a surgeon can face. A summary of how to overcome these obstacles is also addressed in this article.

The concept of minimal invasiveness

The principles of minimally invasive neck surgery were first applied by Gagner in 1996 with the performance of endoscopic parathyroidectomy. Minimally invasive thyroidectomy (MIT) and minimally invasive parathyroidectomy (MIP) are two terms used to describe a broad spectrum of surgical procedures. An endocrine operation should not be presumed as being minimally invasive only because it utilizes a shorter skin incision. For patients having thyroid and parathyroid surgeries, the classic surgical procedures through a cervical incision remain the gold standard. These procedures are typically performed under general anesthesia and usually need no muscle transection other than the platysma. Six to eight cm incisions are typically utilized.

The term minimally invasive surgery implies the ability of the surgeon to perform conventional surgical procedures in innovative ways to minimize the trauma of the surgery. As the standard surgical procedures already have high success rates with acceptable cosmetic result, the potential advantages of the minimally invasive surgical procedures are minimal physical invasiveness with less tissue trauma, better cosmetic outcome, and shortening of the hospital stay. It is misleading to think of MIT and MIP only as procedures of shorter length of incision. Minimizing invasiveness is extended to include all structures involved in the surgical procedure, the type of anesthesia, the postoperative period, and the surgical outcome. Less invasive anesthesia leads to reduced postoperative nausea and vomiting and therefore reduces the likelihood of postoperative hematoma.

New technological advances like laryngeal nerve monitoring (LNM), advanced energy devices (for example, ultrasonic shears), endoscopic visualization, and magnification have paved the way for MIT. The absence of subplatysmal flap elevation reduces operative time and

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the risk of seroma formation. Patients having parathyroid disease are usually good candidates for minimally invasive surgery as they have small and benign disease. Improvement in preoperative localization techniques and the advent of rapid intraoperative parathyroid hormone (ioPTH) monitoring have helped to limit the extent of surgical dissection during a parathyroidectomy, reducing the need for the classical four-gland exploration. MIP has shown to be superior to conventional parathyroidectomy in terms of early postoperative hypocalcemia and shorter operative time. Surgical procedures performed through extracervical approaches require more dissection and larger operative field and are generally not considered as minimally invasive procedures [1–3].

Technological adjuncts

Advanced energy devices

The thyroid gland has very rich blood supply. The unique location of the gland, the multiplicity of the blood vessels supplying it, and the high blood volume circulation make bleeding after a thyroidectomy a potentially life-threatening complication. Therefore, hemostasis is essential during the procedure. Because of the vulnerability of the structures adjacent to the thyroid gland (mainly the recurrent laryngeal nerve (RLN) and the parathyroid glands), hemostasis in thyroidectomy can sometimes be challenging. The standard method for controlling bleeding during a thyroidectomy has long been through dividing blood vessels between surgical clips, suture and electrocoagulation (bipolar or monopolar). In modern surgical practice, the developments in laparoscopic surgery paved the way for the advent of innovative hemostatic devices including ultrasonic surgical instruments and advanced bipolar. These devices have been developed in a way to allow for dissection, coagulation, and transection of the blood vessels and other tissues promptly and efficiently. The use of hand-activated shears was eventually customized to fit the kind of surgical field in the head and neck especially during thyroid surgery with the acquisition of thin and delicate tips that allow the surgeon to work in a narrow field. The application of ultrasonic technology to thyroid surgery has significantly reduced operative time, blood loss, postoperative pain, and overall cost of treatment [4–7].

Intraoperative RLN monitoring

Surgery of the thyroid and parathyroid glands has been associated with the risk of injury to the RLNs. Neural injury may be unilateral or bilateral, with profound impact if bilateral neural injury occurs simultaneously. The injury may be temporary or permanent. Half of patients with bilateral vocal fold paralysis will need an acute airway intervention, including a tracheostomy or other procedures. The technology of intraoperative nerve monitoring has been successfully utilized for nerve prognostication in bilateral thyroid surgery by ensuring function of the first nerve before proceeding to the contralateral lobe. This principle is supported by the recommendations of the American Thyroid Association Surgical Affairs Committee Consensus Statement on Outpatient Thyroid Surgery and on Optimal Surgical Management of Goiter while there may be additional value to using laryngeal nerve monitoring, such as predicting the presence of a non-recurrent nerve or distinguishing between anterior and posterior branches, the most compelling argument for its use is the ability to minimize the risk of bilateral nerve dysfunction [8–12].

Endoscopes

The use of endoscopes in neck surgery was initially applied to parathyroid surgery. With advances in technology and with increased efficiency of surgical training and expertise, the approach has gained popularity for resecting thyroid nodules. The benefits which ignited the enthusiasm for expanding the use of endoscopes in thyroid and parathyroid surgery are the rapid, improved pain profile, and the excellent cosmetic outcomes. The main drawback encountered was the prolonged operative time associated with the use of endoscopes. In thyroid surgery, special attention is paid to the cosmetic result owing to the unique patient population which is mainly young and middle-aged women. For endoscopic neck surgery to be feasible, special retractors, multiple wounds, or CO2 insufflation may be needed which represents additional surgical burden [13–15].

Alternatives for low-resource environment

Bipolar electrocautery

Advanced energy devices are expensive disposables which cost in the range of 500 dollars per instrument. Electrocautery instruments including the monopolar and the bipolar devices are reusable and represent a reasonable alternative in low-resource settings. The mechanism of action is fundamentally different from that of the ultrasonic devices. Electrocautery works by oxidation and desiccation of blood and tissues with resultant formation of an eschar that covers and seals the bleeding area [4]. The availability of electrocautery devices at a low cost and the absence of need for specific training in their use make them a reliable and convenient substitute for ultrasonic technology in thyroid and parathyroid surgery. The principal drawback is that electrocautery is unable to replace the use of surgical clips and sutures for large blood vessels, and especially the upper pedicle of the thyroid gland. Bloodless transection of the thyroid is also less possible with electrocautery. The use of electrocautery alone is

especially sufficient in parathyroid surgery, and ultrasonic devices are rarely used. The new generations of the ultrasonic devices with fine tips have allowed for better dissection and hemostasis in narrow and critical areas such as dissection of the ligament of Berry.

The hand-held nerve stimulators

The Handheld Prass (Medtronic, Jacksonville, FL, USA) or Montgomery (Boston Medical Products, Boston, MA, USA) nerve stimulators can be safely used to directly stimulate the RLN at currents of 1 to 2 mA with the surgeon's finger placed behind the larynx to palpate the posterior plate of the thyroid cartilage. Contraction of the posterior cricoarytenoid muscle (laryngeal twitch) can be detected, which confirms neural circuit integrity [16]. These disposable devices are convenient in the context of their low cost, availability, and reliability in accurately reflecting the status of the neural structures in thyroid and less commonly parathyroid surgeries. Their use may be limited to high-risk and challenging cases such as reoperative surgery, the presence of cancer, surgery on the only-functioning nerve, and in bilateral cases. An important concept to be applied in all circumstances is that nerve-monitoring technology should not replace visual identification of the important neural structures except in very challenging situations such as extensive scar tissue or hostile anatomy. The importance of adequate well-structured surgical training to avoid surgical risks, dangers, and pitfalls cannot be overemphasized [17]. The advantage of hand-held nerve stimulators is well-established regarding the cost as—with using them—there is no need for nerve integrity monitoring (NIM) endotracheal disposable tubes.

Loupe magnification/small incisions

Even with the standard Kocher incision for a thyroidectomy or bilateral neck exploration for parathyroid surgery, the cosmetic outcome can be very satisfying to patients and some may opt for surgery with the standard surgical technique through a short incision with more convenience to the surgeon and less operative time than an endoscopic surgery which may be more time consuming. From a cosmetic perspective, the scar is best placed in a low-cervical skin crease that is marked in the holding area while the patient in the seated position looking directly forward imitating the neutral neck position during social events and daily life to obtain the best esthetic outcome. The length of the scar is tailored to the patient and their disease characteristics. Unless otherwise indicated, most thyroid surgeries, parathyroid explorations, and central neck dissections may be easily performed through a 4-cm incision. Surgical loupes with 2.5× magnification—especially if provided with head light—allows surgeons to operate in narrow fields facilitating the procedure and optimizing the outcome. They are easy to obtain even in the low-resource environment and may aid surgeons to better perform the surgical procedures without the need for endoscopes. They are neither disposable nor require sterilization.

The concept of minimally invasive surgery relates to the absence of raising subplatysmal flaps (thus optimizing the postoperative symmetrical appearance of upper and lower skin flaps and reducing the incidence of postoperative complications like seroma and wound infection), avoiding excessive closing sutures or drains, and ambulating management. The authors have a low threshold to resect a sliver of the skin edges if they show evidence of ischemia to reduce the risk of developing a hypertrophic scar. Skin closure with deep dermal tension-free simple interrupted absorbable sutures with surface glue to the skin provides predictable healing results and reduces the need for follow-up visits for suture removal. The authors prefer inverted simple interrupted deep dermal stitches with 4-0 chromic sutures for edge approximation. We abandoned continuous subcuticular closure as it is difficult to obtain precise skin edge alignment when using it. A quarter-inch steri-strip is applied to the glue while it is still wet and facilitated glue removal by the patient after 3 weeks. If stitches are to be used for skin closure, early removal helps to avoid railroad tracking deformity. Data support that patients of every age, gender and race prefer shorter and thinner thyroidectomy scars. By applying these concepts to the surgical practice of thyroid and parathyroid surgery, patient satisfaction may be maintained at the highest level even in low-resource environments [18–21].

Although not as powerful as endoscopic magnification (approaching 10×), surgical loupes, especially when coupled with a headlight, provide 2.5× magnification with intense illumination which are excellent adjuncts to achieve safe surgical outcomes.

Drains

The use of drains after uncomplicated thyroid and parathyroid surgery has increasingly been abandoned in high-volume centers. Drain placement has its own consequences such as increased pain, risk of infection, prolonged hospital stay, and cost in an operation that is classified as clean surgery. Multiple reports have shown no evidence of a reduced rate of hematoma or seroma formation with drain placement after thyroid or parathyroid surgery. The physicians and nursing staff should be trained to ensure that the neck is flat after surgery before the patient is discharged. A rare need of a drain arises after subtotal parathyroidectomy in patients with renal hyperparathyroidism who will undergo hemodialysis and

are subjected to heparinization protocols. Similarly, pressure bandages show no benefit in reducing the occurrence of hematoma, and indeed, its use may conceal important blood collection deep to it [11, 22–27].

Outpatient surgery in limited resource practice

The concept of outpatient thyroid surgery has appeal because of cost-effectiveness and convenience to both the surgeon and the patient [24, 28]. However, clinical practice has to be tempered within the context of differences in available resources, culture, beliefs, and ethnicities. Data from the USA support that a complication risk is higher for patients being treated by low-volume surgeons in low-volume hospitals and in certain regions. Also, socioeconomic status and racial differences among patients impact their access to high volume-surgeons and safer institutions [29].

In low-resource practices, patients may have to travel long distances to get access to teaching institutions. High-volume surgeons may not be available in rural settings. These factors represent substantial hurdles for outpatient thyroid surgery in centers with limited resources. In the early postoperative period after thyroid and parathyroid operations, patients may need assistance and supervision especially for airway obstruction, bleeding, and manifestations of hypocalcemia. This guidance may not be available under lower socioeconomic, cultural, and educational conditions. Even though hospital admissions have consequences in terms of cost and the potential for iatrogenic complications, it may be preferable in low-resource settings without supervision, guidance, and prompt medical care.

Thyroid hormone replacement

Total thyroidectomy or near total thyroidectomy (Dunhill operation) has largely replaced subtotal thyroidectomy. In experienced hands, the complication rate with total thyroidectomy is low and similar to subtotal thyroidectomy [30]. In low-income countries, however, the availability and the cost of thyroid hormone replacement may be mitigating factors for the routine practice of total or near total thyroidectomy. In this situation, surgeons may prefer to intentionally leave thyroid tissue on one or both sides to not only decrease the incidence of hypoparathyroidism but also to reduce the need for postoperative levothyroxine replacement. This is particularly preferable in elderly patients who may be less tolerant of complications and less liable to develop recurrence of their goiter as disease recurrence usually requires many years to develop [31, 32]. Some reports indicate that the need for reoperation after subtotal thyroidectomy is as low as 0.8% [33]. The average volume of thyroid tissue that should be preserved as a remnant is a matter of controversy depending on the volume of the ipsilateral thyroid lobe, the patient's body surface area and the underlying pathology [34]. According to one report, the remnant thyroid was classified as small (< 5 gm), intermediate (5–8 gm), and large (>8 gm). The body surface area was also classified into three categories as small (< 1.31 m^2), intermediate (1.31–1.91 m^2), and large (> 1.91 m^2). This classification results in nine possibilities which can be condensed into three main categories for the residual thyroid. These are relatively small remnant, adequate, and relatively large remnant [35].

Thyroid cancer follow-up in low-resource environments

Ultrasonography (US) and serum thyroglobulin (Tg) Differentiated thyroid cancer (DTC) has an excellent prognosis. The 30-year disease-specific survival rates surpass 95%. However, clinically significant recurrence may occur in up to one third of patients and may be delayed up to 20–30 years after the initial treatment. Owing to this need for long follow-up, the need for affordable tools has become necessary. The modern clinical practice shifted from the routine use of whole-body radioactive iodine uptake scan towards the more sensitive neck ultrasonography (US) and serum thyroglobulin (Tg). Both normal neck US and undetectable Tg on suppression in low-risk patients offer a negative predictive value of more than 95%. In that case, the most commonly adopted protocol for follow-up is obtaining a serum Tg on suppression every 6 months and a neck US every 6–12 months. Further follow-up depends on the patient risk for developing a recurrence but usually yearly neck US for the first 3–5 years is suggested [36]. Even this careful and thorough follow-up has been challenged and less intensive surveillance has recently been embraced. Serum Tg is the most sensitive and specific tool in the follow-up of DTC. Undetectable serum Tg values are associated with absence of any grossly visible disease. High values are present in association with disease recurrence [37]. However, these blood tests are expensive. Neck US is significantly more affordable, and it also is excellent for detecting local disease recurrence at either the primary tumor in the thyroid fossa or the regional cervical lymph nodes, especially when performed by an experienced operator. Another advantage is the absence of the need for an iodine-based contrast medium which is usually used in computed tomography (CT) scans [38].

Four-gland exploration for parathyroid surgery Bilateral neck exploration with four-gland identification has been the standard of care for patient undergoing parathyroidectomy for primary hyperparathyroidism (PHPT). In the twenty first century, the advent of the rapid ioPTH monitoring has shifted the surgical practice toward focused

dissection and excision of the abnormal gland(s) only. This has been aided by the evolution of the preoperative localization studies, including the nuclear medicine 99-m technetium scan and high-resolution US [39]. With the cost associated with obtaining the facilities for rapid ioPTH monitoring and the need for special technical expertise to correctly manage the required resources, the practice of four-gland exploration remains to be a reasonable alternative in the environment of limited resources. Apart from the rare events of having parathyroid rests in the thymus, ectopic, or supernumerary parathyroid gland(s), bilateral neck exploration minimizes the risk of missing hyperfunctional parathyroid tissue. In this setting, the level of training and the surgical expertise of the operating surgeon greatly influence the outcomes [40]. Indeed, even with the availability of rapid ioPTH monitoring, the surgeon must exercise judgement about when to deem a patient biochemically cured or in need for further exploration.

Conclusion

Technology has dramatically affected available surgical techniques and outcomes in thyroid and parathyroid surgery. In low-resource environments, these techniques and improved outcomes are still achievable. Modifications may be needed to comply with the available resources, cultures, and expectations. Surgeons should be oriented to the surrounding medical environment and use diligence to achieve the best outcome in the context of the safest practice.

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