Minimally Invasive Video Assisted Thyroidectomy (MIVAT) Technique

Essay

Submitted for fulfillment for master degree in general surgery

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بسم الله الرحمن الرحيم

قالوا سبحانك لا علم لنا إلا ما علمتنا إفك أنف العلم الحكيم

صدق الله العظيم

سورة النجاة

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<td>CCA</td>
<td>Common carotid artery</td>
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<td>CND</td>
<td>Central node dissection</td>
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<td>Co2</td>
<td>Carbon dioxide</td>
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<td>CT</td>
<td>Computerized tomography</td>
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<td>ET</td>
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<td>FNA</td>
<td>Fine needle aspiration</td>
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<td>GTET</td>
<td>Gasless transaxillary endoscopic thyroidectomy</td>
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<td>HS</td>
<td>Harmonic scalpel</td>
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<td>HT</td>
<td>Hemithyroidectomy</td>
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<td>PCT</td>
<td>Papillary carcinoma of the thyroid</td>
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<td>PTH</td>
<td>Parathyroid hormone</td>
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<td>PTU</td>
<td>Propylthiouracil</td>
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<td>MITS</td>
<td>Minimally invasive thyroid surgery</td>
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<td>MIVAT</td>
<td>Minimally invasive video assisted thyroidectomy</td>
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<td>MRI</td>
<td>Magnetic resonance imaging</td>
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<tr>
<td>ml.</td>
<td>Milliliter</td>
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<td>ng.</td>
<td>Nano gram</td>
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<td>Natural orifice surgery</td>
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INTRODUCTION

The thyroid is a highly vascular, brownish-red gland located anteriorly in the lower neck, extending from the level of the fifth cervical vertebra down to the first thoracic. The gland varies from an H to a U shape and is formed by 2 elongated lateral lobes with superior and inferior poles connected by a median isthmus, with an average height of 12-15 mm, overlying the second to fourth tracheal rings. Occasionally, the isthmus is absent, and the gland exists as 2 distinct lobes. (Cummings, et al. 1998).

Thyroid surgery has evolved considerably from the times of Billroth and Kocher due to better understanding of the surgical principles, better equipment and advanced surgical techniques. Kocher, in 1909, pioneered what is today known as the conventional thyroidectomy. It has remained the standard approach to the thyroid gland and is still the most widely used technique world-wide. A recent advance is minimally invasive thyroid surgery. Though the concept of minimal access surgery is not new and it has been practiced in many other surgical specialties for over two decades now. (Mouret, et al. 1996).
Thyroidectomy is the removal of all or part of the thyroid gland. Thyroidectomy is used to treat thyroid disorders, such as cancer, noncancerous enlargement of the thyroid (goiter) and overactive thyroid (hyperthyroidism). How much of the thyroid gland is removed during thyroidectomy depends on the reason for surgery. If only a portion is removed (partial thyroidectomy), the thyroid gland may be able to function normally after surgery. If the entire thyroid gland is removed (total thyroidectomy), daily treatment with thyroid hormone is essential to replace the thyroid's natural function. (Brunicardi, et al. 2010).

Minimally invasive video-assisted thyroidectomy (MIVAT) was first introduced and popularised by Miccoli et al. in Italy in the late 1990s. It has been extensively used in other parts of the world and appears to be an excellent minimally invasive approach to the thyroid. A small incision (1.5 cm) is made in the cervical skin crease and the operation is completed using a video-endoscope, except for the final delivery of the gland, which is removed through the original neck incision. (Shimizu, et al. 2002). The lateral neck (Inabnet, et al. 2001), axillary (Ikeda, et al. 2002), anterior chest (Takami, et al. 2002) and breast (Ohgami, et al. 2000) approaches have all been described. All these approaches have in common the use of a 50° endoscope. They differ only by the site of placement of the access
cannulas. This technique avoids a visible neck scar, provides excellent cosmetic results and allows early return to work. (Miccoli, et al. 2004).

Single-incision laparoscopic surgery has been successfully applied to abdominal general and bariatric procedures with advantages of less morbidity over conventional laparoendoscopic surgery. Minimally invasive and laparoendoscopic procedures have also recently been expanded for thyroid surgery. Trans-areola single-incision endoscopic thyroidectomy (TASIET) is feasible with excellent cosmesis and advantages of minimally access surgery. Ongoing studies with TASIET are in progress to define the optimal indications and patient selection criteria for this new thyroidectomy technique. (Youben, et al. 2011).

Robotic surgical systems are among the most innovative surgical developments and have radically promoted the use of minimally invasive techniques. Robotic technologies using different approaches have also been applied to thyroid surgery. Recently, a novel robotic surgical method was described for thyroid surgery based on a gasless, transaxillary approach (TAA). Robotic thyroidectomy using a gasless TAA is a feasible, safe, and promising surgical alternative for selected patients with low-risk thyroid cancer. (Kang, et al. 2011).
MIVAT is most commonly used for thyroid nodules within specific size limits and for low-stage papillary carcinoma of the thyroid (PCT). (Lombardi, et al. 2005). The following are the most widely accepted criteria: a thyroid nodule size less than or equal to 30 mm in diameter, stage T1 or small T2 PCT, total thyroid volume less than 30 mL, and absence of previous history of thyroiditis or neck radiation. Recent studies have demonstrated that MIVAT can be safely used with patients who have histories of prior thyroiditis, prior MIVAT, and a thyroid volume up to 50 mL. (Lombardi, et al. 2006) and (Ruggieri, et al. 2007).

As MIVAT continues to evolve, the only absolute contraindications to this procedure are thyroid malignancy beyond low-stage papillary carcinoma and preoperative evidence of lymph node metastasis. Nodule diameter above 35 mm and thyroid volume over 30 mL are relative contraindications because some groups have demonstrated questions about safety with larger lesions. (Ruggieri, et al. 2007). Prior conventional thyroidectomy is considered a contraindication by most authors. Some groups consider patients candidates for completion MIVAT if a prior lobectomy was performed via a MIVAT approach. (Lombardi, et al. 2006). A
history of prior thyroiditis is considered a relative contraindication because some groups have demonstrated that MIVAT can be safely performed in this population. (Ruggieri, et al. 2007).

The targets of minimally invasive video assisted thyroidectomy (MIVAT) could be summarized by: achievement of the same results as those obtained with traditional surgery, less trauma, better post-operative course, early discharge from hospital and improved cosmetic results. MIVAT can be described as either endoscopic "pure" approach (completely closed approach with or without CO2 insufflation), or "open approach" with central neck mini-incision or "open video-assisted approach". Traditionally, open thyroidectomy requires a 6 to 8 cm, or bigger, transverse wound on the lower neck. The minimally invasive approach wound is much shorter (1.5 cm for small nodules, up to 2-3 cm for the largest ones, in respect of the exclusion criteria) upon the suprasternal notch. Patients also experience much less pain after MIVAT surgery than after conventional thyroidectomy. This is due to less dissection and destruction of tissues. Pathologies treated are mainly nodular goiter; the only kind of thyroid cancer which may be approached with endoscopic surgery is a small differentiated carcinoma without lymph node involvement. The patients were considered eligible for MIVAT on the
basis of some criteria, such as gland volume and the kind of disease. (Ruggieri, et al. 2005).

The main disadvantages of MIVAT procedures are the longer duration of surgery, steep learning curve and increased cost of surgery due to equipment usage. The reported rate of important complications (like recurrent laryngeal nerve palsy and hypoparathyroidism) are similar to those seen in after conventional thyroid surgery. Reported rates of recurrent nerve palsy and hypoparathyroidism of 1.3% and 0.3%, respectively, in their report of MIVAT. (Miccoli, et al. 2004).
AIM OF THE WORK

The aim of this work is to verify the suitability of minimally invasive video assisted thyroidectomy (MIVAT) technique and the applicability in clinical practice.
Anatomy

The thyroid gland has been described throughout history but was first so named by the Romans for being a "shield-shaped" gland. Not only were thyroid masses mentioned in the literature throughout the 12th and 13th century, but in 1170 Robert Frugardi described the extirpation of a goiter.

The thyroid gland is composed of two lobes connected by an isthmus that lies on the trachea approximately at the level of the second tracheal ring. The gland is enveloped by the deep cervical fascia and is attached firmly to the trachea by the ligament of Berry. Each lobe resides in a bed between the trachea and larynx medially and the carotid sheath and sternocleidomastoid muscles laterally. The strap muscles are anterior to the thyroid lobes, and the parathyroid glands and recurrent laryngeal nerves are associated with the posterior surface of each lobe. (Cummings, et al. 1998).

A pyramidal lobe is often present. This structure is a long, narrow projection of thyroid tissue extending upward from the isthmus and lying on the surface of the thyroid cartilage. It represents a vestige of the embryonic thyroglossal duct, and it often becomes palpable in cases of thyroiditis or Graves’ disease. The normal thyroid varies in size in different parts of the world, depending on the iodine
content in the diet. In the United States it weighs about 15 g. (Williams, et al. 1995).

Figure 1. The normal anatomy of the neck in the region of the thyroid gland.
Figure 2. Anatomy of the thyroid and parathyroid glands. A, Anterior view. B, Lateral view with the thyroid retracted anteriorly and medially to show the surgical landmarks (the head of the patient is to the left).

**VASCULAR SUPPLY**

The thyroid has an abundant blood supply. The arterial supply to each thyroid lobe is twofold. The superior thyroid artery arises from the external carotid artery on each side and descends several centimeters in the neck to reach the upper pole of each thyroid lobe, where it branches. The inferior thyroid artery, each of which arises from the thyrocervical trunk of the subclavian artery, crosses beneath the carotid sheath and enters the lower or midpart of each thyroid lobe. The thyroidea
ima is sometimes present; it arises from the arch of the aorta and enters the thyroid in the midline. A venous plexus forms under the thyroid capsule. Each lobe is drained by the superior thyroid vein at the upper pole, which flows into the internal jugular vein; and by the middle thyroid vein at the middle part of the lobe, which enters either the internal jugular or the innominate vein. Arising from each lower pole is the inferior thyroid vein, which drains directly into the innominate vein. (Cummings, et al. 1998).

NERVES

The thyroid gland’s relationship to the recurrent laryngeal nerve and to the external branch of the superior laryngeal nerve is of major surgical significance because damage to these nerves leads to disability in phonation or to difficulty breathing. Both nerves are branches of the vagus nerve. (Kaplan, et al. 1990)

Recurrent Laryngeal Nerve

The right recurrent laryngeal nerve arises from the vagus nerve, loops posteriorly around the subclavian artery, and ascends behind the right lobe of the thyroid. It enters the larynx behind the cricothyroid muscle and the inferior cornu of the thyroid cartilage and innervates all the intrinsic laryngeal muscles except the cricothyroid. The left recurrent laryngeal nerve comes from the left vagus nerve, loops posteriorly around the arch of the aorta, and ascends in the
tracheoesophageal groove posterior to the left lobe of the thyroid, where it enters the larynx and innervates the musculature in a similar fashion as the right nerve. Several factors make the recurrent laryngeal nerve vulnerable to injury, especially in the hands of inexperienced surgeons (Thompson, et al. 1990):

Figure 3. Anatomy of the recurrent laryngeal nerves.

1. The presence of a nonrecurrent laryngeal nerve. Nonrecurrent nerves occur more on the right side (0.6%) than on the left (0.04%). They are associated with vascular anomalies such as an aberrant take off of the right subclavian artery from the descending aorta (on the right) or a right-sided aortic arch (on the left). In these abnormal positions, each nerve is at greater risk of being divided. (Henry, et al. 1988).
Figure 4. “Nonrecurrent” right laryngeal nerves coursing (A) near the superior pole vessels or (B) around the inferior thyroid artery.

Because of the abnormal location of “nonrecurrent” nerves, they are much more likely to be damaged during surgery.

2. Proximity of the recurrent nerve to the thyroid gland. The recurrent nerve is not always in the tracheoesophageal groove where it is expected to be. It can often be posterior or anterior to this position or may even be surrounded by thyroid parenchyma. Thus, the nerve is vulnerable to injury if it is not visualized and traced up to the larynx during thyroidectomy.
3. Relationship of the recurrent nerve to the inferior thyroid artery. The nerve often passes anterior, posterior, or through the branches of the inferior thyroid artery. Medial traction of the lobe often lifts the nerve anteriorly, thereby making it more vulnerable. Likewise, ligation of this artery, practiced by many surgeons, may be dangerous if the nerve is not identified first.

4. Deformities from large thyroid nodules. In the presence of large nodules the laryngeal nerves may not be in their “correct” anatomic location but may be found even anterior to the thyroid. Once more, there is no substitute for identification of the nerve in a gentle and careful manner. (Thompson, et al. 1990).
Figure 5. Recurrent laryngeal nerve displacements by cervical and substernal goiters.

Such nerves are at risk during lobectomy unless the surgeon anticipates the unusual locations and is very careful. Rarely, the nerves are so stretched that spontaneous palsy results. After careful dissection and preservation, functional recovery may occur postoperatively.
External Branch of the Superior Laryngeal Nerve

On each side, the external branch of the superior laryngeal nerve innervates the cricothyroid muscle. In most cases, this nerve lies close to the vascular pedicle of the superior poles of the thyroid lobe (Moosman, et al. 1968), which requires that the vessels be ligated with care to avoid injury to it. In 21%, the nerve is intimately associated with the superior thyroid vessels. In some patients the external branch of the superior laryngeal nerve lies on the anterior surface of the thyroid lobe, making the possibility of damage during thyroidectomy even greater (Cernea, et al. 1992). In only 15% of patients is the superior laryngeal nerve sufficiently distant from the superior pole vessels to be protected from manipulation by the surgeon. Unfortunately, many surgeons do not even attempt to identify this nerve before ligation of the upper pole of the thyroid. (Lennquist, et al. 1987) (Friedman, et al. 2002).
Figure 6. Proximity of the external branch of the superior laryngeal nerve to the superior thyroid vessels.

PARATHYROID GLANDS

The parathyroids are small glands that secrete parathyroid hormone, the major hormone that controls serum calcium homeostasis in humans. Usually, four glands are present, two on each side, but three to six glands have been found. Each gland normally weighs 30 to 40 mg, but they may be heavier if more fat is present.
Because of their small size, their delicate blood supply, and their usual anatomic position adjacent to the thyroid gland, these structures are at risk of being accidentally removed, traumatized, or devascularized during thyroidectomy (Kaplan, et al. 1983). The upper parathyroid glands arise embryologically from the fourth pharyngeal pouch. They descend only slightly during embryologic development, and their position in adult life remains quite constant. This gland is usually found adjacent to the posterior surface of the middle part of the thyroid lobe, often just anterior to the recurrent laryngeal nerve as it enters the larynx.

Figure 7. A and B, Shifts in location of the thyroid, parafollicular, and parathyroid tissues. C approximates the adult location. Note that what has been called the
lateral thyroid is now commonly referred to as the ultimobranchial body, which contains both C cells and follicular elements.

Figure 8. Descent of the lower parathyroid. Whereas the upper parathyroid occupies a relatively constant position in relation to the middle or upper third of the lateral thyroid lobe, the lower parathyroid normally migrates in embryonic life and may end up anywhere along the course of the dotted line. When this gland is in the chest, it is nearly always in the anterior mediastinum.

The lower parathyroid glands arise from the third pharyngeal pouch, along with the thymus; hence, they often descend with the thymus. Because they travel so far in embryologic life, they have a wide range of distribution in adults; from just beneath the mandible to the anterior mediastinum (Gilmour, et al. 1937).
Usually, however, these glands are found on the lateral or posterior surface of the lower part of the thyroid gland or within several centimeters of the lower thyroid pole within the thymic tongue. Parathyroid glands can be recognized by their tan appearance; their small vascular pedicle; the fact that they bleed freely when a biopsy is performed, as opposed to fatty tissue; and their darkening color of hematoma formation when they are traumatized. With experience, one becomes much more adept at recognizing these very important structures and in differentiating them from either lymph nodes or fat. Frozen section examination during surgery can be helpful in their identification.

LYMPHATICS

A practical description of the lymphatic drainage of the thyroid gland for the thyroid surgeon has been proposed by Taylor (Taylor, et al. 1975). The results of his studies, which are clinically very relevant to the lymphatic spread of thyroid carcinoma, are summarized in the following:-

Central Compartment of the Neck

1. The most constant site to which dye goes when injected into the thyroid is the trachea, the wall of which contains a rich network of lymphatics. This fact probably accounts for the frequency with which the trachea is involved by thyroid
carcinoma, especially when it is anaplastic. This involvement is sometimes the limiting factor in surgical excision.

2. A chain of lymph nodes lies in the groove between the trachea and the esophagus.

3. Lymph can always be shown to drain toward the mediastinum and to the nodes intimately associated with the thymus.

4. One or more nodes lying above the isthmus, and therefore in front of the larynx, are sometimes involved. These nodes have been called the Delphian nodes (named for the oracle of Delphi) because it has been said that if palpable, they are diagnostic of carcinoma. However, this clinical sign is often misleading.

5. A bilateral central lymph node dissection, called a level 6 dissection, clears out all these lymph nodes from one carotid artery to the other carotid artery and down into the superior mediastinum as far as possible. (Grodski, et al. 2007).
Figure 9. The lymph node regions of the neck are divided into levels I through VII: 
1) level I nodes are the submental and submandibular nodes; 2) level II are the upper jugular nodes; 3) level III are the midjugular nodes; 4) level IV are the lower jugular nodes; 5) level V are the posterior triangle and supraclavicular nodes; 6) level VI or central compartment nodes incorporate the Delphian/prelaryngeal,
pretracheal, and paratracheal lymph nodes; and 7) level VII nodes are those within the superior mediastinum.

Lateral Compartment of the Neck

A constant group of nodes lies along the jugular vein on each side of the neck. The lymph glands found in the supraclavicular fossae may also be involved in more distant spread of malignant disease from the thyroid gland. Finally, it should not be forgotten that the thoracic duct on the left side of the neck, a lymph vessel of considerable size, arches up out of the mediastinum and passes forward and laterally to drain into the left subclavian vein, usually just lateral to its junction with the internal jugular vein. If the thoracic duct is damaged, the wound is likely to fill with lymph; in such cases, the duct should always be sought and tied. A wound that discharges lymph postoperatively should always raise suspicion of damage to the thoracic duct or a major tributary. A lateral lymph node dissection encompasses removal of these lateral lymph nodes. Rarely, the submental nodes are involved by metastatic thyroid cancer as well. The lymph node regions of the neck are divided into levels I-VII: (i) level I nodes are the submental and submandibular nodes; (ii) level II are the upper jugular nodes; (iii) level III are the mid-jugular nodes; (iv) level IV are the lower jugular nodes; (v) level V are the posterior triangle and supraclavicular nodes; (vi) level VI or central compartment nodes incorporate the Delphian/paralaryngeal, pretracheal and paratracheal lymph
nodes; and (vii) level VII nodes are those within the superior mediastinum.

(Grodski, et al.

Figure 10. Lateral neck dissection. Note that during this procedure the vagus nerve, sympathetic ganglia, phrenic nerve, brachial plexus, and spinal accessory nerve are preserved. In a modified neck dissection the sternocleidomastoid muscle is not usually divided, and the jugular vein is not removed unless lymph nodes with tumor are adherent to it.
**History of thyroid surgery**

**Ancient times**

Thyroid surgery has been performed since ancient times. In 1st century AD Celsus, the Roman encyclopedia reported the operation for removal of such a mass was dangerous.

Albucasis the 11th century surgeon of corodoba (Spain) also explained extirpation of the gland. Certainly the surgeons of Salerno in 12th century were transfixing large goiters with Setons, thread passed through the mass to produce suppuration as well as treating their patients; with seaweeds either dried or burned.

These methods were published by Roger Frugardi in 1170. Technical improvements did not occur until the middle of the 19th century. In the interim period, appalling results led in 1646 to the imprisonment of a surgeon for his work and to a total ban on thyroid surgery by the French academy of medicine in 1850.

**Dawn of new age**

The first documented partial thyroidectomy was carried out by Pierre Joseph Desault in 1791. He removed a 4 cm mass from thyroid through a vertical incision, tying of superior /inferior thyroid arteries and then dissecting the gland from trachea. Caleb hillier Parry of Bath who identified exophthalmic goitre in 1786
before graves description in 1835. Parry's account was published posthumously in 1825.

Even in the 19th century, thyroid surgery was considered barbaric, described by Samuel Gross as "horrid butchery," and banned by the French medical society due to its high mortality. As technology improved and with the advent of aseptic technique, mortalities associated with these surgeries decreased. (Giddings, et al. 1998).

During the 1850s, operations on the thyroid gland were undertaken via longitudinal, oblique, or vertical neck incisions. Jules Boeckel of Strasbourg introduced the collar incision to thyroid surgery in 1880, and this approach was popularized by Theodore Kocher. Theodor Kocher, whose own reported mortality rate for thyroidectomy dropped to 1%, was awarded the Nobel Prize in 1909 for his advancement of thyroid surgery in the late 19th century. (Pinchot, et al. 2008).

The surgical technique of thyroidectomy, as well as adjunct technology, continued to advance. Most recently, various new instruments (ie, harmonic technology) and approaches including video-assisted thyroidectomy and robot-assisted thyroidectomy have emerged. (Jancewicz, et al. 2002).
Indications

Various indications for thyroidectomy exist. One of the major indications is a diagnosis of thyroid cancer, usually biopsy-proven by fine-needle aspiration of a nodule. Thyroid nodule histology can have significant ramifications to chose operative management. In patients with biopsy-proven papillary thyroid cancer, or medullary thyroid cancer, a total thyroidectomy is indicated. Patients with a fine-needle aspiration showing either Hürthle cells or follicular neoplasm require at least a thyroid lobectomy of the side ipsilateral to the nodule and possibly a total thyroidectomy if the permanent operative specimen shows signs of malignancy. In addition to these malignancies, anaplastic thyroid cancer can occasionally be an indication for thyroidectomy, if no significant extension and infiltration into the surrounding structures is found. (Lai, et al. 2010).

Beyond malignancies, thyroidectomy is also a viable option for patients with symptomatic thyroid masses or goiters. Patients who have compressive symptoms including dysphagia, dyspnea, shortness of breath, and/or hoarseness due to a large goiter should undergo a thyroidectomy. Usually dysphagia to solids is the earliest presenting symptom. Aesthetic concerns due to a goiter may be an indication for thyroidectomy. Another indication includes patients with medically refractory Graves disease or hyperthyroidism. (Myers, et al. 2008).
Contraindications

Uncontrolled severe hyperthyroidism (ie, Graves disease) is a relative contraindication to surgery due to concerns for intraoperative or postoperative thyroid storm. Although thyroidectomy can be performed during pregnancy for malignancy, many authors cite postponing surgery until after delivery if possible, secondary to risks to the fetus from the anesthesia. Indications for surgery during pregnancy include aggressive cancers or airway compromise. If elective thyroid surgery is undertaken during pregnancy, it should be performed during the second trimester if possible. (Owen, et al. 2010) (Kuy, et al. 2009).

Preparation

Preoperative workup

For thyroid nodules, the patient should have a thyroid ultrasound, and a fine-needle aspiration should be performed for large or suspicious nodules. Those with lesions suspicious for papillary or medullary thyroid cancer should also have an ultrasound performed of the lateral neck compartments to be evaluated for metastatic disease. CT imaging of the neck is helpful, especially in patients with significant goiters, to rule out substernal extension. Contrast-enhanced scans can limit the ability to

Additionally, all patients undergoing thyroidectomy should have their vocal cord function evaluated and documented prior to surgery.

Equipment

A basic head and neck set, to include the following, is necessary:

- No.3 knife handle.
- No.15 blade.
- Adson tissue forceps with and without teeth.
- DeBakey forceps.
- Halsted mosquito forceps.
- Reinhoff swan neck clamp (or Burlisher clamp).
- Allis tissue forceps.
- Richardson retractor.
- Peanut/Kittner sponges.
- Double-pronged skin hooks.
- Mahorner retractor (alternatively, other self-retaining retractors may be used).
- Bovie electrocautery, Harmonic scalpel, and/or Shaw scalpel.
- Bipolar electrocautery forceps.
- Nerve monitoring Leads and surface electrode primed endotracheal tube.
- Nerve Stimulator.

Anesthesia

Thyroidectomy under regional or local anesthetic may be performed safely if necessary; most cases, however, are performed under general anesthesia with endotracheal intubation.

Positioning

The patient should be placed in a supine position with the apex of the patient’s head at the top of the operating bed. A shoulder roll or gel pad should be placed at the level of the acromion process of the scapula to help extend the neck. Care should be taken to avoid hyperextension of the neck, and the head should be supported to provide maximal exposure of the surgical field without hyperextension. The patient’s arms should be gently tucked by either side. After intubation, the bed can either be rotated 180° from the anesthesiologists or sufficiently moved away from their machines to provide a maximal work area.

Marking

According to the surgeon’s preference, the following key anatomic locations should be found by superficial palpation and marked with a marking pen:
Thyroid notch

Cricoid cartilage

Superior edge of clavicles

Sternal notch

Traditionally, a collar incision is used. The incision should be created in a curvilinear fashion within a skin crease approximately 2 cm or 2 finger-breadths above the superior edge of the clavicle and sternal notch. Although smaller incisions lengths have been described, in the authors' experience, an incision length of between 6 cm and 8 cm is used to allow for adequate exposure without causing stretch injury to the surrounding skin. (Pinchot, et al. 2008).

Intraoperative nerve monitoring

Some controversy still remains with regard to the use of intraoperative recurrent laryngeal nerve monitoring. Although strong anatomic knowledge is a prerequisite to any surgery, the use of intraoperative nerve monitoring allows for an intraoperative assessment of nerve function prior to removing the gland, immediately after removing the gland, and just prior to closure of the surgical site. The use of recurrent laryngeal nerve monitoring has been described since the 1970s and has evolved from intramuscular electrodes to the currently used
endotracheal tubes, which have integrated surface electrodes that contact the vocal cords. (Eisele, et al. 1996).

Opponents to nerve monitoring cite the increased cost and set up in the operating room, as well as the risk of false positives and negatives. They also note that nerve monitoring does not reduce the rate of RLN palsy. (Cavicchi, et al. 2009).

However, studies show that while intraoperative nerve monitoring may not have a significant difference in reducing nerve injury, the presence of monitoring can be used to predict how well the nerve functions postoperatively.

Technique

A variety of techniques were described to perform the dissection, including sharp dissection with vessel suture ligation, electric cautery, as well as the use of electric and ultrasonic scalpels. Many trials have evaluated the use of the electric and ultrasonic scalpel use in performing thyroidectomies and found an associated lower operative time with similar postoperative complication rates and cost. (Kowalski, et al. 2012).

Incision and exposure of the thyroid gland

The initial incision is made over the marked line as described in the preparation section. A no.15 blade is used to incise through the epidermis and dermis. Using a Shaw scalpel or monopolar cautery, dissection is carried through the subcutaneous
fat to the platysma. Once the level of the platysma has been identified along the length of the incision, the platysma is incised. Using the double-pronged skin hooks and the Shaw scalpel or monopolar cautery, subplatysmal flaps are elevated superiorly and inferiorly. After elevating the subplatysmal flaps, the Mahorner or alternative self retaining retractor may be inserted. Care should be taken to not lacerate or damage the skin edges with the retractor.

The strap muscles (sternohyoid and sternothyroid) should then be identified. In the midline between the strap muscles, the cervical linea alba can be identified. Once identified, bluntly dissect through this fascia. The Harmonic scalpel or monopolar cautery can then be used to dissect through this fascia superiorly and inferiorly along the length of the sternohyoid muscle. In cases of large goiter or neoplasm, the strap muscles may be divided to aid exposure. Division of the strap muscles should be performed high (cephalad), as the innervation of the strap muscles occurs more inferiorly. Just deep to this dissection lies the thyroid gland, and overlying fascia should be easily identified. (Pinchot, et al. 2008).
Releasing the superior pole

Once the thyroid gland is identified, attention should be turned to a single lobe. Using the Richardson retractors and blunt dissection, capsular dissection should be carried to the lateral aspect of the thyroid lobe, where it meets the carotid sheath fascia. Once the lateral border of the dissection has been performed, the carotid artery identified, blunt dissection may be carried out superiorly.
At the superior pole, care should be taken to dissect the overlying strap muscles off of the thyroid gland without injuring the subcapsular vessels. Next, the cricothyroid space should be identified and dissected. By retracting the thyroid inferiorly and medially, and using a small Richardson retractor to retract the strap muscles superiorly and laterally, the surgeon can allow for maximal visualization of the superior pole of the thyroid. After dissecting both laterally and medially (cricothyroid space) to the superior pole, the superior pedicle can be divided using either a Harmonic scalpel, clips, or ties. Care should be taken to avoid injuring the external branch of the superior thyroid nerve. (Bliss, et al. 2000).

Fig. 12. Exposure of the superior pole.
Identifying the parathyroid glands

Once the dissection of the posterior aspect of the thyroid lobe begins, the surgeon and assistants should be vigilant in identifying the parathyroid glands. The superior parathyroid gland can often be found cephalad to the tubercle of Zuckerkandl and can also be found adjacent to the superior pole. The inferior parathyroid gland is usually located in a 1 cm radius around the inferior pole of the thyroid gland and almost always anterior to the plane of the recurrent laryngeal nerve. Of note, 3-7% of patients may have supernumerary glands. (Eisele, et al. 1996).

After identifying the glands, they should be carefully dissected from the thyroid and left in the thyroid bed.

Identifying the recurrent laryngeal nerve

Slight variations in the anatomy and location of the recurrent laryngeal nerves (RLNs) can exist. During surgery, a few anatomic landmarks can assist in identification of the nerves. The Tubercle of Zuckerkandl marks the posterolateral aspect of the thyroid lobe and is most often found lateral to the recurrent laryngeal nerve. The tubercle can be found in 80% of thyroids and when found can lead directly to the recurrent laryngeal nerve, as 93% of the nerves are found medial to this tubercle. (Gauger, et al. 2001).
Fig. 13. The recurrent laryngeal nerve.

Most often, the nerve is found in a groove between the tubercle and the lobe of the thyroid gland. (Yun, et al. 2008).

Berry’s ligament can be used for identification, since the nerves are found in close proximity to the ligament; however, the literature describes various anatomic relationships between the 2 structures.\textsuperscript{[12]} Berlin described the nerve penetrating the ligament in 25% of cases; however, a recent study by Sasou et al described 24 cases showing the nerve travelling posteriorly and dorsally to the ligament. (Sasou, et al. 1998).

The inferior thyroid artery can also be used as a landmark for the RLN, with its close association with the pathway of the nerve. Again variations exist, and the branches of the inferior thyroid artery can be anterior or posterior to the nerve, or the nerve can run in between the branches of the artery.
Once the nerve is identified anatomically, its identity and integrity may be confirmed with nerve stimulation. A threshold value may be obtained to determine the minimum current necessary to stimulate the nerve. The course of the nerve should be bluntly dissected using the Reinhoff or a right angle clamp. A sufficient portion of the nerve should be dissected to ensure its safety during dissection and removal of the thyroid gland. Too extensive of a dissection of the nerve can increase the risk of neurapraxia or injury to the nerve. (Gravante, et al. 2007).

Removing the thyroid gland

After identifying and stimulating the recurrent laryngeal nerve, the thyroid gland can be removed. Berry’s ligament defines the posterolateral attachment of the thyroid gland. Blunt dissection can be used to further expose this fascial attachment. Then a harmonic scalpel can be used to transect the ligament. Often, a minimal amount of thyroid tissue is left adjacent to the entrance of the recurrent laryngeal nerve into the larynx, to reduce the risk of injuring the nerve.

If the patient is undergoing a total thyroidectomy, attention should first be turned to the opposite thyroid lobe and recurrent laryngeal nerve. Once the entire specimen has been dissected and is only attached posteriorly to the pretracheal fascia, it can be removed. The removed specimen should be inspected.
Closure

Obtaining hemostasis in the thyroid bed is imperative. A thin layer of thrombin mesh may be applied to the superior aspect of the bed. The usage of drains is controversial and some authors do not feel that they are routinely necessary. Note that drain usage does not replace meticulous hemostasis nor prevent hematoma accumulation. If a large defect or void exists following thyroidectomy, especially in patients with large goiters, a suction drain may be placed. The neck is then closed in a layered fashion with special attention to a meticulous skin closure.

Other Considerations:

1-Substernal goiter

Some patients that present with compressive symptoms and an enlarged thyroid demonstrate substernal extension of their goiter either on physical examination, ultrasound, or CT imaging. The technique and approach for removing these goiters is very similar to a conventional thyroidectomy. Because the goiters originate in the neck, they rarely have a mediastinal blood supply. Most often, removing substernal goiters does not require a sternotomy; instead, they can be removed by digital dissection along the thyroid capsule. These patients are at an increased risk of recurrent laryngeal nerve injury, with reports as high as 17.5%. Randolph et al found that sternotomy was indicated in patients who had superior vena cava
syndrome, a goiter with mediastinal blood supply, a posterior mediastinal goiter, a larger diameter to the intrathoracic component, recurrent substernal goiters, malignancy extending into the mediastinum, or the presence of significant adhesions to mediastinal vessels or pleura. (Randolph, et al. 2011).

2-Reoperative/revision thyroid surgery

In patients who initially had a hemithyroidectomy for a follicular adenoma seen on fine-needle aspiration, a chance exists that the surgical specimen pathology will yield a follicular adenocarcinoma. Additionally, with the prevalence of subtotal thyroidectomy until the 1970s, a population of patients may need reoperative thyroidectomy for recurrent benign or malignant conditions. Additionally, patients may need revision thyroid surgery if they present with paratracheal, central compartment, or lateral neck nodes. One of the significant challenges presented by a reoperative or revision surgery is the scarring present from the prior violation of the neck. (Shaha, et al. 2008).

For patients needing completion thyroidectomy, some surgeons advocate for early intervention within 5-7 days after the first operation, before significant inflammation and scarring occur in the surgical bed. Others argue that the surgery should occur 2-3 months later when induration in the area is reduced.
A preoperative evaluation including imaging and reviewing previous operative reports can help with surgical planning. Ultrasound can help localize recurrent disease or suspicious masses, while a CT scan or MRI can give better delineation of surgical planes. The use of CT scanning with contrast should be discussed with the multidisciplinary team if radioactive iodine may be used postoperatively. If significant scarring exists, one can consider using a trap door technique, in which dissection is carried from the lateral border of the thyroid medially to the central compartment.

The parathyroid glands as well as the recurrent laryngeal nerves are especially at risk during revision thyroid surgery. Care should be taken to not avulse the vasculature of the parathyroids, and the inferior thyroid artery branches should be ligated one by one and not together to avoid injuring the branches supplying the parathyroids. Additionally, the surgeon should be prepared to autoimplant parathyroid tissue should an avulsion occur. (Shaha, et al. 2008) (Pai, et al. 2010).

Terris et al describes a population of 321 patients undergoing reoperative surgery under experienced hands for benign thyroid disease. In this population, no patient suffered transient or permanent RLN injury from the reoperative surgery and one patient had temporary hypoparathyroidism. (Terris, et al. 2010).
In a review by Ruggiero and Fedok, the complication rates for reoperation for both well-differentiated thyroid cancer as well as medullary thyroid cancer were described and found to be higher. Although generally regarded as safe, and with the suggestion that intraoperative nerve monitoring may provide benefit, (Johnson, et al. 2008) the overall complication rates were directly correlated to the degree of aggressiveness with the second operation. (Ruggiero, et al. 2008).

3-Parathyroid autoimplantation

In the event of accidental avulsion of a parathyroid gland or compromising its blood supply, the effected parathyroid gland should be removed and placed within a specimen cup on ice. A portion of the removed tissue should be sent for frozen section to confirm it to be in fact parathyroid tissue. The surgeon should then consider auto-implantation of the gland.

The parathyroid gland specimen should be minced into small 1-2 mm pieces and placed in a muscular pocket. Auto-implantation is described in the forearm or the sternocleidomastoid muscle. When implanting into the sternocleidomastoid muscle, a small pocket should be made within the muscle fibers. A nonabsorbable radio-opaque marker, such as a surgical clip, can be used to identify this location in the event of future surgical intervention.
Post-Procedure

Immediate postoperative course

In the authors’ practice, patients who have undergone thyroidectomy remain overnight for a 23-hour stay. Some surgeons perform thyroid surgery on an outpatient basis. (Terris, et al. 2007).

Patients who undergo a total thyroidectomy have their calcium levels monitored for iatrogenic hypoparathyroidism. Recent studies have compared the use of postoperative parathyroid hormone as an adjunct or replacement to measuring serum calcium levels in predicting hypoparathyroidism. Al-Dhahri et al describes the use of postoperative PTH 6 hours after surgery with a cutoff of 1.7 pmol/L as being more accurate at predicting which patients are at risk for hypocalcemia. (Fahad, et al. 2010).

Graff et al, on the other hand, note that a PTH value less than 14 pg/mL was 100% sensitive and 83% specific, while combining this value with a postoperative serum calcium raised specificity to 88%. (Graff, et al. 2010).

Long-term monitoring
Patients undergoing a total thyroidectomy are iatrogenically hypothyroid following the operation. Medical management of hypothyroidism and continued monitoring are imperative. Those patients with thyroid cancer should also be monitored for disease recurrence.

Patient education

Before discharge, patients should be instructed on proper incision care as well as given information on signs of hypocalcemia (ie, numbness or tingling of the digits or perioral area). Additionally, they should be made aware of neck hematoma as a possible complication and the signs to observe. For incision care, hydrogen peroxide and petroleum jelly can be applied to the incisions twice a day. Should patients develop neck swelling or difficulty breathing, they should go immediately to the nearest emergency room.

Postoperative complications

Hypocalcemia secondary to hypoparathyroidism

Reported rates of transient hypocalcemia vary in the literature from between 5-50%, but the rate of permanent hypocalcemia secondary to hypoparathyroidism (ie, lasting more than 6 months) is between 0.5-2%. The pathophysiology behind transient hypoparathyroidism and hypocalcemia is not well understood but is
thought to be related to a transient ischemia to the parathyroid glands or perhaps an
increased release of the acute phase reactant endothelin 1. (Nomura, et al. 1994).

Patients who are at increased risk for this complication are those with Graves
disease or malignancy or those undergoing total thyroidectomy, or total
thyroidectomy with central compartment neck dissection.

Patients may initially be asymptomatic while hypocalcemic. Classic presenting
symptoms include numbness and tingling of the digits or perioral area, carpopedal
spasm, or the presence of a Chvostek sign or a Trousseau sign. In severe cases,
patients may also experience tetany, ECG changes (QT prolongation), seizures,
mental status changes, or cardiac arrest secondary to hypocalcemia. The Chvostek
sign can be reproduced by tapping on the face just anterior to the ear, causing
contraction of the ipsilateral facial muscles. A patient with a positive Trousseau
sign will have spasm of the wrist, fingers, or thumb with inflation of a
sphygmomanometer above the systolic blood pressure. Either sign is indicative of
neuromuscular excitability associated with hypocalcemia.

Patients who are noted to have postoperative hypocalcemia should be managed
with calcium supplementation. By following the trend of serum calcium levels,
oral calcium supplementation can be titrated accordingly. If patients are receiving
2 grams of elemental calcium and continue to have decreasing or low serum
calcium, calcitriol supplementation between 0.25-1 mcg per day can be considered. Additionally, intravenous calcium replacement may be necessary for patients refractory to oral management or those with severe symptomatic hypocalcemia. Endocrinology consultation should be considered in these patients. Serum calcium levels should be corrected for concurrent hypoalbuminemia and any hypomagnesemia should be medically corrected.

Patients who develop hypocalcemia should be discharged with calcium and vitamin D supplementation and if necessary calcitriol supplementation. After a few months, weaning from the calcium supplementation can be considered.

Injury to the recurrent laryngeal nerve

Injury to the recurrent laryngeal nerve (RLN) can yield vocal fold paresis or paralysis. The implementation of nerve monitoring has not been proven to lower this risk, but may provide prognostic value. (Donnellan, et al. 2009).

Studies show that identifying the RLN is associated with lower rates of injury.

Permanent RLN paralysis occurs in 1-2% of thyroidectomies in experienced hands. These cases may be underestimated, as not all patient undergo postoperative laryngeal evaluation. Should an injury occur, the patient usually presents with postoperative persistent hoarseness. Patients may also describe dysphagia or aspiration with thin liquids. Patients who undergo total thyroidectomy are at risk
for bilateral vocal fold paralysis, a devastating complication. This usually manifests in the immediate postoperative period with airway obstruction, biphasic stridor, or respiratory distress. (Gourin, et al. 2010).

Patients with suspected recurrent laryngeal nerve injury should be evaluated with flexible laryngoscopy or videostroboscopy to confirm the position and movement of the vocal folds. Should they have aspiration or dysphagia symptoms, they should be evaluated by a speech language pathologist. Patients with suspected bilateral vocal fold paralysis may require urgent and definitive airway management with a tracheotomy. Permanent corrective procedures for vocal fold paralysis are not entertained until 9-12 months have passed. At this point, any persistent injury may be considered permanent. (Stavrakis, et al. 2007).

Injury to the superior laryngeal nerve

The superior laryngeal nerve has both an internal and external branch. The internal branch provides sensory innervation to the larynx, while the external branch innervates the cricothyroid muscle. This posterior laryngeal muscle assists with lengthening of the vocal fold. Estimates of this complication vary, and are likely underestimated.

Often this injury is relatively asymptomatic. Patients may occasionally experience hoarseness or vocal fatigue. Voice professionals, however, can be significantly
affected by this injury, as it affects the ability to produce higher-pitched sounds and thus may affect a singer’s upper register.

This injury too may be evaluated videostroboscopy, as well as laryngeal EMG. Some slight bowing of the affected vocal cord may be present, and the affected vocal cord may be lower than the normal cord. Additionally, EMG shows a deficit in the cricothyroid muscle.

Neck hematoma

A rare but dangerous complication of thyroidectomy, neck hematomas can form secondary to inadequate hemostasis or a coagulopathy. Incidence of this complication is approximately 1%, but its occurrence can lead to asphyxiation and airway compromise. (Watkinson, et al. 2010).

When identified on physical examination, the patient must be taken back to the operating room for exploration and achieving hemostasis. If the patient is in respiratory distress, the surgical wound should be opened and the hematoma evacuated immediately (even at the bedside) and then the patient should be taken to the operating room.

Infection
The rates of infection after thyroidectomy have significantly decreased with improvements in technology and aseptic technique and are currently estimated between 1-2%. (Watkinson, et al. 2010). The usual presentation is a superficial cellulitis with warmth, erythema, and tenderness surrounding the surgical incision. If fluctuance is present, a superficial abscess may also be present. Other signs of infection, such as fever and leukocytosis, without an overlying cellulitis, may point to a deep space neck infection or abscess.

CT imaging can be helpful in evaluating the deep spaces of the neck. Abscess needs to be drained, and the aspirate should be sent for cultures. Patients with a superficial cellulitis need to be on antibiotics that cover gram-positive organisms, while those with abscesses should be placed on broad spectrum antibiotics until cultures yield specific bacteria.

Thyrotoxic storm

One of the contraindications for thyroidectomy is a patient with untreated or uncontrolled Graves disease or hyperthyroidism. One of the rarer complications from thyroid surgery is precipitation of a thyroid storm, which can occur intraoperatively or postoperatively. It is thought to occur secondary to thyroid gland manipulation in the operating room in patients with hyperthyroidism.
Manifestations include tachycardia, hyperthermia, cardiac arrhythmias, and increased sympathetic output. Awake patients also present with nausea and altered mental status. If untreated, it may precipitate coma and death.

Intraoperatively, if signs of a thyrotoxic storm develop, the case needs to be halted and the patient needs to be medically managed to reduce sympathetic output. Cooling blankets, beta blockers, PTU, and iodine should be administered.

Postoperatively, the patient may still have signs of thyrotoxicosis and should be continued on preventative medication. Medications can be weaned as thyroid hormone levels decrease.

Larger cysts if preoperatively aspirated may be removed by cervical access. Generally benign nodules <3 cm do not require surgery, so only small nodules presenting with follicular cytology or small toxic adenomas are eligible.


Small goiters and limited Graves’ disease also may be a potential indication for ET, although they generally do not require surgery. Some contraindications are common to all these techniques: large goiters, invasive malignant tumors, previous cervical operations, and history of neck irradiation. Extracervical access permits larger lesions up to 60 mm in size and enlarged glands (up to 60 ml volume) to be extracted endoscopically and also low-risk carcinomas (to 10– 20 mm in size; younger than aged 50 years, node-negative, intrathyroidal) have been assessed by the extracervical approach. (Inabnet, et al. 2003) (Choe, et al. 2007) (Ikeda, et al.)

### Table 1. Indications and Contraindications of MIVAT

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<tr>
<th>Indications</th>
<th>Contraindications</th>
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<tr>
<td>- Nodule &lt;3cm of diameter.</td>
<td>Absolute:</td>
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<tr>
<td>- Thyroid volume &lt;25ml.</td>
<td>- Previous neck surgery.</td>
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<td>- Benign or low grade follicular lesions.</td>
<td>- Large goiter.</td>
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<td>- Papillary carcinoma.</td>
<td>- Locally metastases.</td>
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<td></td>
<td>Relative:</td>
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<td></td>
<td>- Previous neck irradiation.</td>
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<td>- Hyperthyroidism.</td>
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Neck surgery is one of the newest fields of application of minimally invasive surgery. The technique of minimally invasive video-assisted thyroidectomy (MIVAT), developed by Miccoli, is the method that has so far become most widespread. Limiting factors of this method include the bothersome 20-mm cervical incision and consequently the specimen size to remove. Several papers describing an access outside the front neck region have been published. Such approaches are via the chest, axilla, a combined axillary bilateral breast, or a bilateral axillary breast approach. The development of cervical scarless thyroid surgery is a great step toward better cosmetic outcomes. However, these techniques just moved the scars from the front neck region to the axilla or the chest where they are still visible. And the mentioned minimally invasive accesses as well as the conventional approaches to the thyroid gland do not respect the anatomically given surgical planes. This may result in complaints by the patients, e.g., scar development and swallowing disorders. Furthermore, the extra cervical approaches do not comply with the use of the term "minimally invasive," because they are associated with an extensive dissection of the chest and neck regions, thus being rather maximally invasive for the patients. The main goal nowadays is the introduction of a technique of thyroid resection that fulfills the following criteria: (i. Respecting surgical planes and minimizing surgical trauma in thyroidectomy, ii. The access itself should be close to the thyroid gland to achieve a minimally
invasive procedure, iii. Achieving an optimal cosmetic result may only be obtained by performing a scarless operation, iv. The minimally invasive character of this approach and the optimal cosmetic result may not be reached at the expense of patient's safety.) (Benhidjeb, et al 2009).

Endoscopic thyroidectomy (ET) is a demanding surgical technique in which dissection of the gland is entirely performed with an endoscope, in a closed area maintained by insufflation or mechanical retraction. ET by direct cervical approach (anterior or lateral) is minimally invasive, but ET using an extracervical access (chest wall, breast, or axillary) is not. Since its introduction in 1996, endoscopic thyroidectomy (ET) has yet to become a standard procedure. From the start, technical issues slowed down widespread application, and ET is still technically challenging procedure. During the last 10 years, the use of an endoscope has been reported in several techniques of thyroidectomy. In some of these techniques, the endoscope is used during just one step of the procedure. Other steps are performed as in open techniques, by direct vision, through a minicervical incision. Video-assisted thyroidectomy may be a more appropriate name for these semi-open techniques. ET is defined as a surgical technique in which dissection of the gland is entirely performed with the help of an endoscope, in a closed area maintained by insufflations or mechanical retraction (Henry, et al. 2006). ET techniques can be subdivided into cervical or direct approaches and
extra cervical or indirect approaches. Generally endoscopic techniques are introduced because of their minimal invasiveness, expected to result in quicker convalescence and better cosmesis compared with traditional Kocher cervicotomy.

**The anterior cervical approach** (Gagner, et al. 2003) This approach uses a midline access and permits bilateral dissection of the thyroid. A 5-mm optical trocar is inserted just above the suprasternal notch. Carbon dioxide is insufflated with a pressure of 10 mmHg. Three additional trocars are used: two 2-mm trocars and one 5-mm at the superio-medial border of the sternocleidomastoid muscle (Fig. 14). Using ultra vision, all vital structures are identified and dissected as in a conventional procedure. The piece is extracted in a plastic bag through the superio-lateral trocar.

Fig. 14 Anterior direct approach.
An alternative way to perform ET by anterior approach has been proposed. (Fig. 15).

Fig. 15 Other anterior direct approach

Starting with a 15-mm median incision above the suprasternal notch, a 5-mm optical trocar is inserted, with 8 mmHg CO2 insufflation. Along the line of a virtual cervicotomy, two other trocars are introduced: 3-mm trocar on the side of the operator/lesion, and 5-mm trocar at the other end. A Veress needle is added in the upper midline to improve working space only if necessary. The gland is extracted through the 15-mm median incision, leaving a central neck scar along the line of virtual cervicotomy (Cougard, et al. 2005).
Fig. 16. Instruments for Laparoscopic thyroidectomy and their introduction.

Fig. 17. Minimally invasive video-assisted thyroidectomy. Upper pedicle sectioned by Harmonic Scalpel Scissor. (anterior neck approach).
The lateral cervical approach (Palazzo, et al. 2006) It uses the plane between the carotid sheath laterally and the strap muscles medially. This “back door” route can only be used for unilateral lesions. The procedure is performed via a 10-mm optic port and two 3-mm operating ports, placed on the medial border of the sternocleidomastoid muscle on the side of the lesion. This approach allows direct access to the posterior aspect of the thyroid lobe, without the need for the dissection of the strap muscles (Sebag, et al. 2006). The initial skin incision for the 10-mm port is placed such that in the event of conversion it can be extended.
medially to result in a symmetric collar incision (Fig. 19). Low-pressure (8 mmHg) insufflation with CO2 maintains the space. Once the lobe is entirely freed, the specimen is extracted. Use of a balloon dilator for creating the working space instead of blunt dissection has been described (Granada, et al. 2007).

![Image](image.png)

Fig. 19 Lateral direct approach.

Another lateral approach has been described. The surgery begins with a 10–15-mm incision at the superior lateral area of the neck. Once sufficient working space is created, three additional trocars (two 3 mm and one 5 mm) are inserted under direct vision (Fig. 20). The specimen is extracted in a retrieval bag through the 1-cm superior lateral incision (Inabnet, et al. 2003).
**The chest wall approach** is an extra cervical approach favored for bilateral thyroid dissection. A 30-mm skin incision is made below the inferior border of the clavicle on the side of the lesion, retracting the upper border of the pectoralis major muscle manually. A 12-mm trocar is introduced for a flexible laparoscope. CO2 is insufflated to a pressure of 4 mmHg (Kitano, et al. 2002). Alternatively, cutaneous lifting devices are available. One 5-mm trocar is inserted inferior to the sternal notch, and one 5-mm trocar below the ipsilateral clavicle (Fig. 21). Dissection of the gland is performed with ultra-vision (Shimizu, et al. 2003). The specimen is retrieved in a bag through the 3-cm subclavicular incision, leaving no scar in the neck (Usui, et al. 2001).
The breast approach allows bilateral dissection on both upper circumareolar areas. A trocar is inserted (two 10-mm ports, or one 12-mm and one 15-mm port) after blunt dissection with the use of a Rochester clamp and vascular tunneler or Dingmann dissector (Ohgami, et al. 2000). The working space is established with CO2 insufflation at a pressure of 4–6 mmHg. The third port (5 mm) can be inserted 3cm below the clavicle on the side of the thyroid mass or parasternal at the level of the nipple or in the axilla as shown in Fig. 22 (Park, et al. 2003). Ipsilateral strap muscles are split longitudinally to elevate the thyroid and achieve good exposure of the gland.
Axillary approach can be used for a large thyroid lesion but doesn’t extend contra laterally (Yoon, et al. 2006). The patient is in supine position, and the ipsilateral arm on the side of the lesion placed at a 90angle to the axis of the body (Ikeda, et al. 2000). Three 5-mm incisions are placed below the anterior axillary line equidistant apart or one 30-mm incision is made for a 12-mm and 5-mm trocar apart from the third trocar (5 mm) (Fig. 23). A 5-mm optical scope or flexible laparoscope with CO2 insufflation at 4–9 mmHg pressure is introduced before
starting sharp scissor dissection to dissect an a vascular plane between platysma
and pectoralis major muscle (Ikeda, et al. 2002). A gasless axillary approach is
feasible if an external lifting device is applied (Ikeda, et al. 2002). Next, the plane
between SCM and sternohyoid muscle is developed to elevate the sternothyroid
muscle and allow retraction anteriorly, exposing the ipsilateral thyroid gland
(Ikeda, et al. 2003). Harmonic scalpel and clips are used for division. A retrieval
bag is used for extraction of the gland through the axilla. All incisions are hidden
in the axillary fossa (Duncan, et al. 2007).

Fig. 23 Indirect axillary approach.
Bilateral axillo-breast approach has been developed to obtain optimal visualization of both lobes especially for total thyroidectomy in which the third and fourth port are inserted in left and right axilla (Shimazu, et al. 2003). The specimen is retrieved through the 12-mm breast ports. Depending on port placement, there are scars parasternal, perimammillary, and/or axillary (Choe, et al. 2007). The patient is placed in the supine position under general anesthesia. The neck is extended slightly and the lesion-side arm is raised to fully expose the axilla. The surgical team consisted of the surgeon and one assistant, who were required to hold a 30° rigid endoscope and a suction-irrigator. A 4.5-5.5 cm skin incision is made parallel to the skin crease in the axillary fossa (Koh, et al. 2010), through which a rigid endoscope and the endoscopic instruments are inserted (Fig. 24).

Fig. 24. ABBA (Axillo-Bilateral-Breast Approach).
A working space is created by inserting an external retractor (Sejong Medical Corporation) through the axillary skin incision. The periareolar skin incision is used for the placement of a 12-mm trocar. The skin is elevated above the pectoralis major muscle exclusively under direct vision, using monopolar cauterization through the axillary skin incision, until the anterior border of the sternocleidomastoid muscle was exposed (Huscher, et al. 1997). To create a working space, an external retractor (Sejong Medical Corporation, Gyoha, Korea) is inserted through the skin incision in the axilla, which is raised using a lifting device (Yamashita, et al. 2002). A second 1.0 cm skin incision is made along the upper margin of the mammary areola on the tumor side for inserting a 12 mm trocar, which is directed to the midline of the sternal notch. Using only a harmonic scalpel (HS; Harmonic Ace 36P®; Johnson & Johnson Medical, Cincinnati, OH,
USA), the anterior border of the sternocleidomastoid muscle is dissected from the sternohyoid muscle and, in some cases; the omohyoid muscle is divided (Shimizu, et al. 1999).

The thyroid gland is exposed by dissecting the sternothyroid muscle with the HS and by lateral traction of the sternocleidomastoid muscle. In all cases, only the HS is used for vascular control of the thyroid gland and strap muscles (Park, et al. 2003). The superior, middle, and inferior thyroidal arteries and veins are controlled using a low-power level (70 µm vibration) to improve hemostasis. The other small vessels and surrounding connective tissue are controlled using a higher power level (100 µm vibration) for easy cutting (Ohgami, et al. 2000). After elevating the skin flap with monopolar cauterization, the HS and an endoscopic dissector are used for vessel sealing and tissue dissection throughout the operation (Jung, et al. 2007). The upper pole is fully exposed with careful dissection. The superior thyroid vessels are identified and divided close to the thyroid gland using the HS (Ikeda, et al. 2002), while avoiding injury to the external branch of the superior laryngeal nerve. The superior parathyroid gland is identified during dissection and left intact. The lateral view from the axillary port made it easy to observe the upper pole of the thyroid and to divide the vessels (Kim, et al 2001). The tracheal wall is identified and exposed as a midline landmark and the lower pole is dissected from the adipose tissue and trachea. During this procedure, care is taken to avoid injury
to the tracheal wall with the HS (Shimazu, et al. 2003). The thyroid gland is then retracted medially, and the perithyroidal fascia is divided and dissected using an endoscopic dissector and the HS (Yeh, et al 2000). Careful dissection is performed to identify the inferior thyroid artery and recurrent laryngeal nerve in the tracheoesophageal groove. Until now, there is no experience with a neuron-monitoring system during thyroid surgery. During the endoscopic thyroidectomy procedure, the recurrent laryngeal nerve (RLN) can be easily identified and preserved under magnified surgical view (Yoon, et al. 2006).

Fig. 26. The superior thyroid artery (left) is easily identified and sealed off using the harmonic scalpel.
Fig. 27. The left superior parathyroid gland was identified and preserved between the recurrent laryngeal nerve and common carotid artery (CCA).

Fig. 28. The left endoscopic hemithyroidectomy was completed.
The inferior thyroid artery is divided close to the thyroid gland to avoid injury to the recurrent laryngeal nerve. During this procedure, the lateral view of the thyroid gland from the axillary port helps to ensure complete preservation and exposure of the nerve (Chung, et al. 2007). Proper application of an endoscopic cottonoid and a dissector to Berry’s ligament realized the complete dissection of the thyroid gland from the trachea (Choe, et al. 2007). To prevent thermal injury, especially near Berry’s ligament, a great care is necessary to maintain a distance of at least 5 mm from the major neurovascular structures and the trachea. The thyroid gland is then dissected from the trachea, and the isthmus is resected using the HS (Bellantone, et al. 2002).

Fig. 29. A surgical procedure for the unilateral axillo-breast approach. The inferior thyroid artery was identified close to the recurrent laryngeal nerve.
During ipsilateral CND (Central Node Dissection), dissection is close to the recurrent laryngeal nerve using an endoscopic dissector to avoid damage by collateral energy from the HS. The CND is performed en bloc with a thyroidectomy or separately after hemithyroidectomy (HT) (Henry, et al. 2001).

The resected specimen is extracted through the axillary skin incision. In cases of total thyroidectomy (TT), a contralateral endoscopic lobectomy is performed via a contralateral axillo-breast approach (Sakuraba, et al. 2007).

Fig. 30. Hemithyroidectomy with paratracheal lymph node dissection is performed with careful dissection of the recurrent laryngeal nerve.
Fig. 31. The left hemithyroidectomy-specimen-en bloc with ipsilateral CND is shown.

Fig. 32. A specimen of large goiter resected via hemithyroidectomy (HT). The surgical specimens showed that thyroidectomy was accomplished without violation of the thyroid capsule.
A Jackson-Pratt closed suction drain is placed (200 mL, 3.2 mm diameter; BarovacSewoon Medical, Seoul, Korea) in the wound and close it with 4-0 Vicryl (subcutaneous) and 5-0 nylon (skin) sutures (Tschernko, et al. 1996).

**Trans oral approach** (Concept of natural orifice trans-luminal endoscopic surgery (NOTES) in thyroid gland surgery). *The role of this approach is to reduce the access trauma and establish a non-traumatic approach according to surgical planes for endoscopic minimally invasive thyroidectomy (Wilhelm, et al. 2010).* This approach is still under trial on human cadavers. Safety and reproducibility to reach and resect the thyroid gland was assessed according to a defined road map. At the end of the procedure, the cadavers were dissected to evaluate all defined anatomical key structures regarding possible injuries and also allow an evaluation of the surgery performed. The TOVAT (Trans oral video assisted thyroidectomy) was performed with the help of one 5-mm and two 3-mm trocars that were introduced through the mouth floor and the vestibule of the mouth subplatysmal. A working space was created by insufflating CO2 at a pressure of 4-6 mmHg ("air dissection"). Surgical dissection of the further working space was realized with 3-mm bipolar scissors. The procedure consists of the following steps: (i. Patient in supine position and nasotracheal intubation, ii. 5-mm small incision between the carunculae sublinguales, iii. Penetration through the mouth floor along the superficial fascia colli with a blunt instrument, iv. Insertion of a 5-mm trocar, v.
Blunt dissection subplatysmal by CO2 insufflation ("air dissection"), vi. CO2 insufflation (4-6 mmHg) and creation of a working space, vii. Insertion of two 3-mm trocars in the vestibulumoris on the right and left side, viii. Separation of the platysma from the strap muscles approximately at level of the larynx, extending up to the suprasternal notch. Laterally, this dissection can be continued up to the medial border of the sternocleidomastoid muscles, ix. Division of the linea alba coli and exposure of the strap muscles, x. Separation of the strap muscles from the thyroid gland, xi. Isthmus transection and blunt dissection of the thyroid gland from the trachea, xii. Dissection and division of the upper pole arteries and medial thyroid vein closely to the gland, xiii. Division of branches of the inferior thyroid artery closely to the gland, xiv. If necessary, preparation of the retro-thyroidal area, including visualization of the recurrent laryngeal nerve, xv. Thyroid resection from cranial to caudal and transoral removal of the specimen through the 5-mm midline incision. If the gland is too large, the midline incision can be extended longitudinally, xvi. All three incisions are closed with absorbable sutures (Benhidjeb, et al. 2009).

Minimum impact and a gentle dissection according to anatomical planes are the rational for the transoral route to the thyroid gland. Thus based on anatomical dissections the foundations of a novel procedure in the context of natural orifice surgery (NOS) could be established (Wilhelm, et al. 2010).
Robotic surgery concept:

Robotic surgery is a new and exciting emerging technology that is taking the surgical profession by storm. Up to this point, however, the race to acquire and incorporate this emerging technology has primarily been driven by the market. In addition, surgical robots have become the entry for centers wanting to be known for excellence in minimally invasive surgery despite the current lack of practical applications. Therefore, robotic devices seem to have more of a marketing role.
than a practical role. Whether or not robotic devices will grow into a more practical role remains to be seen.

**Current robotic surgical systems:**

Many robots and robot enhancements are being researched and developed. Schurr et al at Eberhard Karls University’s section for minimally invasive surgery have developed a master-slave manipulator system that they call ARTEMIS ([Schurr, et al. 2000](#)). This system consists of 2 robotic arms that are controlled by a surgeon at a control console. Dario et al at the Mi Tech laboratory of Scuola Superiore Sant’Anna in Italy have developed a prototype miniature robotic system for computer-enhanced colonoscopy ([Dario, et al. 1999](#)). FDA approach robotic systems were commercially developed for general surgical use. These include the AESOP system (ComputerMotion Inc., Santa Barbara, CA), a voice-activated robotic endoscope, and the comprehensive master-slave surgical robotic systems, Da Vinci (Intuitive Surgical Inc., Mountain View, CA) and Zeus Computer Motion Inc., SantaBarbara, CA) ([Hu, et al. 2002](#)). The da Vinci and Zeus systems are similar in their capabilities but different in their approaches to robotic surgery. Both systems are comprehensive master-slave surgical robots with multiple arms operated remotely from a console with video assisted visualization and computer enhancement ([Kennedy, et al. 2002](#)). In the da Vinci system, which evolved from the telepresence machines developed for NASA and the USA army, there are
essentially 3 components: a vision cart that holds a dual light source and dual 3-chip cameras, a master console where the operating surgeon sits, and a moveable cart, where 2 instrument arms and the camera arm are mounted. The camera arm contains dual cameras and the image generated is 3-dimensional. The master console consists of an image processing computer that generates a true 3-dimensional image with depth of field; the view port where the surgeon views the image; foot pedals to control electrocautery camera focus, instrument/camera arm clutches, and master control grips that drive the servant robotic arms at the patient’s side. The instruments are cable driven and provide 7 degrees of freedom. This system displays its 3-dimensional image above the hands of the surgeon so that it gives the surgeon the illusion that the tips of the instruments are an extension of the control grips, thus giving the impression of being at the surgical site (Kennedy, et al. 2002).
The Zeus system is composed of a surgeon control console and 3 table-mounted robotic arms. The right and left robotic arms replicate the arms of the surgeon, and the third arm is an AESOP voice-controlled robotic endoscope for visualization. In the Zeus system, the surgeon is seated comfortably upright with the video monitor and instrument handles positioned ergonomically to maximize dexterity and allow complete visualization of the OR environment. The system uses both straight shafted endoscopic instruments similar to conventional endoscopic instruments and...
jointed instruments with articulating end-effectors and 7 degrees of freedom (Kim, et al. 2002).

Fig. 35. Zeus system set up.

In 2007, a Korean group aiming to improve the ergonomics of GTET pioneered the gasless, transaxillary robotically assisted thyroidectomy (RAT), which uses the same approach as GTET but with the assistance of a robot. Their initial experience was subsequently reported in 2009, and their techniques were reproduced at two centers in the United States (Chantawibul, et al. 2003). The RAT technique is
performed using the da Vinci Surgical robotic system. Patients are positioned supine with one arm extended over the shoulder to shorten the distance between the incision and the neck. A small pillow is placed behind the neck area for some neck extension. After prepping and draping, a 4- to 5-cm skin incision is made in the axilla, and a subcutaneous flap is raised over the anterior surface of the pectoralis major muscle and the clavicle under direct vision (Kang, et al. 2009). For bilateral resection, the side with the dominant nodule or a suspicious fine-needle aspiration (FNA) is generally the side of the axillary incision. After exposure of the sternocleidomastoid muscle, the two arms of this muscle (i.e., the sternal and clavicular parts) are separated. The strap muscles are lifted from the thyroid capsule. An external retractor then is inserted through the axillary wound and lifted upward to maintain a working space over the thyroid gland. For GTET, an additional 5-mm skin incision is made on the medial side of the chest about 2 cm below the lower horizontal line of the lower end of the axillary skin incision (Kang, et al. 2009). A 30 degree 10-mm video camera and one working instrument are inserted through the axillary wound, and one additional instrument is inserted through the 5-mm chest port. During thyroid dissection, the upper pole is retracted downward. Branches of the superior thyroid vessels are identified and individually divided using the Sonosurg (Olympus, Japan). Dissection of the upper pole is kept close to the capsule to avoid inadvertent injury to the external branch of the
superior laryngeal nerve. The lower pole is dissected from the adipose tissue, and the inferiorthyroid vein is divided close the thyroid gland. The ipsilateral lobe then is retracted medially, and the perithyroidal tissue is carefully dissected. With careful dissection, the recurrent laryngeal nerve (RLN) is encountered and identified. For the contralateral side, the RLN is identified by anterolateral retraction of the lobe away from the trachea. A nerve stimulator (Neurosight 100 machine; Magstim Clarify Company, Whitland, UK) is used to confirm the RLN function. For RAT, instead of the 5-mm chest part, an 8-mm skin incision is made on the medial side of the anterior chest wall for insertion of the fourth robotic arm (Lewis, et al. 2010). The other three arms (for 1 camera and 2 working arms) are inserted through the axillary wound. The actual steps of thyroid dissection are similar to those for GTET. As with GTET, the ipsilateral RLN is encountered and identified from the lateral side and the contralateral RLN from the medial side. The resected specimen is retrieved through the axillary wound (Berber, et al. 2010). After hemostasis, a 3-mm closed suction drain is inserted through the main axillary wound. The skin is closed subcuticularly.
Fig. 36. Operative photo during endoscopic thyroidectomy showing the right lobe retracted upward and the ipsilateral (right) recurrent laryngeal nerve (RLN) running under it. A nerve stimulator probe was used to confirm the function of the RLN.

Fig. 37. Operative photo during robotically assisted thyroidectomy showing the course of the ipsilateral (left) recurrent laryngeal nerve.
Fig. 38. Operative photo during robotically assisted thyroidectomy showing the course of the contralateral (right) recurrent laryngeal nerve with the lobe being retracted anterolaterally away from the trachea.

Transoral robotic-assisted thyroidectomy (TRAT) provides an attractive approach to the central compartment for thyroidectomy in a field of "minimally invasive" and "scarless" techniques. A total thyroidectomy was performed in 2 cadavers using the da Vinci robot transoral technique and the recurrent laryngeal nerve was preserved. (Richmon, et al. 2011)
Fig. 39. Room set-up in robotic assisted surgery in Da Vinci system.

Fig. 40. Application of Da Vinci robotic system in head and neck surgeries.
Advantages of minimally invasive thyroid surgery

Minimally invasive thyroid techniques were primarily introduced to improve the cosmetic result of thyroid surgery. Nevertheless, it has been demonstrated that they have some advantages over conventional thyroidectomy in terms of not only cosmetic results but also postoperative pain and shorter hospital stay.

Miccoli et al., who have the largest series on MIVAT, have reported encouraging data on reduced postoperative pain, better cosmetic results and shorter hospital stay. (Miccoli, et al. 2001).

The Italian group has also directly compared MIVAT with conventional thyroidectomy in a prospective randomized trial and reported similar findings. Similar results have been reported using these minimally invasive procedures in other parts of the world. (Terris, et al. 2006).
The major advantages of MIVAT include:

- Minimal tissue trauma.
- Shorter hospital stay.
- Better cosmesis.
- Minimal postoperative pain.
- Reduced cost of health care.

Video-assisted endoscopic techniques, in addition, offer a magnified, illuminated view of the operative field, which helps to identify important structures such as the parathyroids and the laryngeal nerves. Advantages and disadvantages of various minimally invasive techniques are summarized in the following table:
<table>
<thead>
<tr>
<th>Surgical technique</th>
<th>Advantages</th>
<th>Drawbacks</th>
</tr>
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| Pure endoscopic approach            | - Excellent cosmetic result  
- Illuminated and magnified view.  
- Quick return to work.  
- No drains required.             | - Costly equipment.  
- Steep learning curve.  
- Longer duration of Surgery.  
- Extensive tissue dissection needed. |
| Minimally invasive video assisted throidectomy | - Small incision.  
- Reduced pain.  
- Short postoperative stay.  
- No drains required.  
- Less tissue trauma. | Only for small thyroid lesions <30mm.  
Long duration of surgery.  
Steep learning curve. |
| Minimally invasive throidectomy     | - Small incision.  
- Better cosmetic scar.           | - Long duration of surgery.                                               |

Table 2 Advantages and Disadvantages of different new thyroidectomy techniques

**Complications and controversies**

These minimally invasive techniques have been hailed as the latest in thyroid surgery but they have their own share of complications and controversies. The main disadvantages with these procedures are:

- Longer duration of surgery.
- Steep learning curve.
- Requirement of an additional assistant.
- Increased cost of surgery due to equipment usage.
More importantly, surgeons using minimally invasive procedures must be well versed with the conventional open technique as the outcome of the surgery is also known to be influenced by the experience of the operating surgeon. (Sosa, et al 1998).

The reported rates of complications of minimally invasive techniques and conventional surgery are nearly the same. (Miccoli, et al. 2001)

Miccoli and colleagues have reported a rate of recurrent nerve palsy and hypoparathyroidism of 1.3 and 0.3, respectively, in their large series involving 579 patients treated with MIVAT. Several other studies also endorse comparable rates of complications for MIVAT and conventional thyroid surgery. (Ruggieri, et al. 2007) (Ikeda. et al. 2000) (Miccoli, et al. 2002) (Lombardi, et al. 2005).

The controversies surrounding these minimally invasive techniques are:

- Size of the nodule
  Most authors believe that these techniques are useful if the nodule size is <35mm for benign and <20mm for malignant lesions, but evidence is now accumulating that nodules up to 40mm can be operated safely with MIVAT. (Ruggieri, et al. 2007).

- Cost - effectiveness
Surgery done on an outpatient basis and extended recovery room observation is a feasible and cost-effective approach. A cost-benefit analysis of MIVAT compared with conventional thyroidectomy is needed to further explore the issue.

- Oncological safety

The role of MIVAT in thyroid cancers

The first question that arises whenever MIVAT is being discussed for malignant tumors is:

Is it really feasible to radically cure a thyroid malignancy using this technique?

Till ten years ago, malignancies of the thyroid were not considered as indication for endoscopic approach. The role of MIVAT in patients with thyroid cancer has been viewed with caution and concerns have been expressed about the feasibility of radical excision of the disease with these techniques. Miccoli et al, reported the use of endoscopic surgery in 2002 for the first time for papillary carcinoma of the thyroid. Since then, there have been many studies regarding the probable use of MIVAT in treating malignant thyroid disease (Miccoli, et al. 2002). Jeong et al, compared the outcomes of MIVAT with conventional thyroid surgery for papillary thyroid microcarcinoma, were 13% of the patients were treated by total thyroidectomy using endoscopic procedures and were followed by radio-iodine
scan and serum thyroglobulin (Tg) levels. The authors observed serum (Tg) levels of <1ng/ml. in all patients who were operated by MIVAT. The result reported by Miccoli et al, also showed no statistical difference between MIVAT and conventional thyroidectomy, both in terms of I 131 uptake and circulating (Tg) levels. The average 24-hours radio-iodine uptake observed in patients who underwent MIVAT was similar to that obtained in patients treated with conventional thyroidectomy (5.1% and 4.6% respectively). (Jeong, et al. 2009).

In therefore appears that MIVAT is as effective as conventional thyroid surgery for selected, well-differentiated thyroid cancers, especially papillary thyroid cancers.

MIVAT is a useful addition to conventional thyroid surgeries, what we need to define are the optimal candidates for such minimally invasive procedures and clarity on inclusion and exclusion criteria. More prospective studies with long-term follow-up are required to validate this effectively.

There is a definite need to look into expanding indications as well as completeness of MIVAT for thyroid cancers. (Lai, et al. 2008).
Summary

Thyroid surgery has evolved considerably from the times of Billroth and Kocher due to better understanding of the surgical principles, better equipment and advanced surgical techniques. Kocher, in 1909, pioneered what is today known as the conventional thyroidectomy. It has remained the standard approach to the thyroid gland and is still the most widely used technique world-wide. A recent advance is minimal access thyroid surgery (MITS). Though the concept of minimal access surgery is not new and it has been practiced in many other surgical specialties for over two decades now, its acceptance in head and neck surgery remained rather slow. Since Gagner et al. reported an endoscopic approach to the parathyroid glands, various techniques have been described and popularised for thyroid surgery as well. Shifting focus of thyroid surgery towards less invasive techniques for better aesthetic outcomes has resulted in the emergence of minimally invasive approaches for the thyroid gland/compartment. The concept of MITS is attractive because patients are concerned not only about the results of treating their thyroid disease, but also outcomes such as better cosmesis, reduced hospital stay and decreased pain.

MITS has expanded in the last decade and is being considered as an alternative to conventional thyroidectomy simply because it reduces tissue trauma and
postoperative pain, and provides excellent cosmetic results. Many different techniques have been developed for MITS over a short period; these can be broadly classified into pure endoscopic techniques, video-assisted techniques and minimally invasive open surgery. In pure endoscopic techniques, the thyroid compartment is approached using different routes with the help of endoscopes with or without carbon dioxide gas insufflation. The lateral neck, axillary, anterior chest and breast approaches have all been described. All these approaches have in common the use of a 50° endoscope. They differ only by the site of placement of the access cannulas. This technique avoids a visible neck scar, provides excellent cosmetic results and allows early return to work.

Minimally invasive video-assisted thyroidectomy (MIVAT) is the most widely used MITS technique. MIVAT was first introduced and popularised by Miccoli et al. in Italy in the late 1990s. It has been extensively used in other parts of the world and appears to be an excellent minimally invasive approach to the thyroid. A small incision (1.5 cm) is made in the cervical skin crease and the operation is completed using a video-endoscope, except for the final delivery of the gland, which is removed through the original neck incision. Another less commonly used modification of MIVAT technique is the video-assisted neck surgery where an anterior neck flap is lifted without using gas insufflation and a tent-like working space is created. Minimally invasive open surgery techniques are also known as
‘small incision thyroidectomy’ and do not require specialised instruments like endoscopes and video assistance. Broadly speaking these techniques are similar to conventional thyroidectomy but differ only in the length of the incision.

Major advantages of MITS techniques include reduced tissue trauma, shorter hospital stay, better cosmetic results, minimal postoperative pain, reduced cost of healthcare and, above all, patient comfort. Video-assisted endoscopic techniques in addition offer a magnified, illuminated view of the operating field. Miccoli et al., who have reported the largest series of MIVAT, noted reduced postoperative pain, better cosmetic results and short hospitalisation stay. In another prospective study, the authors reported significant reduction in postoperative pain and better cosmetic results in the MIVAT group as compared to the conventional surgery group.

The main disadvantages of MITS procedures are the longer duration of surgery, steep learning curve and increased cost of surgery due to equipment usage. The reported rate of important complications (like recurrent laryngeal nerve palsy and hypoparathyroidism) are similar to those seen in after conventional thyroid surgery. Miccoli et al. reported rates of recurrent nerve palsy and hypoparathyroidism of 1.3% and 0.3%, respectively, in their report of MIVAT.

There is an expanding role of MITS techniques for thyroid malignancies especially papillary thyroid carcinoma (PTC). Malignancies of the thyroid were not
considered suitable for an endoscopic approach until 2002, when Miccoli et al. reported a series of endoscopic surgery for PTC. The authors found no significant statistical difference between MIVAT and conventional thyroidectomy in these patients, both in terms of iodine ($^{131}$I) uptake and circulating thyroglobulin (Tg) levels. It appears that MITS can be an effective alternative to conventional thyroidectomy for selected patients with well differentiated thyroid cancers, especially PTC.

Judicious patient selection is the most important cornerstone for the success of any MITS technique for both benign and malignant thyroid swellings. At present, there are no specific criteria laid down for deciding suitability of a particular candidate for MITS; however, there appears to be a consensus on the size of tumour (< 35 mm for benign and < 20 mm for malignant thyroid nodule/gland). Other commonly agreed indications for MITS are that there should be no previous irradiation or surgery. Low-risk papillary carcinoma without any sub-sternal extension and extrathyroidal spread is the only malignant thyroid disease suitable at the moment.

As technology continues to develop and impact on surgical techniques, it is likely that these minimally invasive approaches will become more widely used and easier to perform. As of now, MITS appears to be a useful addition to conventional thyroid surgery. We need more long-term follow-up and comparative trials to validate these interesting techniques. There is a need to look into the expanding
indications as well as the completeness of MITS procedures, especially in cases with malignant thyroid disease.
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الملخص العربي

ان الغدة الديوية هي غدة صغيرة بالوعية الدموية، بنيوية اللون، وتقع في الجزء الأمامي من الجسر السفلي للرقبة. تمتد الغدة الديوية من الفقرة العنقية الخاسة وحتى الفقرة الصدرية الأولى. يتنوع شكل الغدة مابين شكل حرف (H) باللغة الإنجليزية أو (U) وتتكون من فصين جانبيين كلاهما له قطبين علوي وسفلي متصلين ببروز في الوسط بمسافة ارتفاع يبلغ 12 إلى 15 مم مغطياً حلقات القيمة الهوائية من الثانية وحتى الرابعة منها وفي بعض الأحيان يكون البروز غائب، وبالتالي تتواجد الغدة كفصين متزئين.

وقد تطورت جراحة الغدة الديوية تطوراً كبيراً من أوقات بيلرود وكوخر نظراً للفهم الأفضل لمبادئ العمليات الجراحية، وتتوفر معدات وتقنيات جراحية متقدمة. ابتدع كوخر في عام 1909 وما يعرف اليوم باسم استعمال الغدة الديوية التقليدي وقد بقي هو النهج الاعتيادي للوصول للغدة الديوية. ومئات الأسلاك الأكبر استعمالاً على نطاق واسع في جميع أنحاء العالم. تعتبر جراحة الغدة الديوية بحد ذاتها للتدخل الجراحي تقنية حديثة احترزها البشرية. على الرغم من أن مفاهيم الحد الأدنى للتدخل الجراحي ليس جديداً، وكان يمارس في العديد من التخصصات الجراحية الأخرى لأكثر من عقود.

يعتبر استعمال الغدة الديوية هو أسلوب كل الغدة أو جزء منه واستعمال الغدة الديوية يستخدم لعلاج اضطرابات الغدة مثل السرطان وتضخم الغدة الديوية غير السرطاني وفرط نشاط الغدة. وتستخدم كمية الغدة المزالة أثناء عملية الاستئصال على سبب العملية الجراحية. إذا تم زالة جزء فقط (استعمال الديوية الجزئي)، قد تكون الغدة قادرية على العمل بشكل طبيعي بعد الجراحة. إذا تم زالة الغدة الديوية بأكملها (استعمال الديوية الكلي)، تحتاج إلى جراحة يومية من هرمون الغدة الديوية لتحل محل الوظيفة الطبيعية للغدة الديوية.

كان أول عرض لعملية استعمال الغدة الديوية ذات التدخل الجراحي الاحتى بمساعدة الفيديو وانتشارها بواسطة ميكرولاك وآخرون في إيطاليا في أواخر التسعينات. وقد استخدمت على نطاق واسع في أجزاء أخرى من العالم، بينما أن هذا النهج ممتاز كتدخل جراحي احتى للغدة الديوية. حيث يتم إجراء شق صغير 1.5 سم في تطيات جلد الغدة وتمكين العملية باستخدام منظار الفيديو، باستخدام التسلسل النهائي للغدة، والتي يتم إزالتها من خلال شق الرقبة الأصلي. تم وصف العديد من النماذج لأجراء العملية مثل الجهة الجانبية للرقبة، الابط، الجهة الأمامية للصدر والشذى، ومجموعة صغيرة في استخدام منظار 50 درجة. إلا أنها تختلف فقط في موقع خروج الغدة. هذا الأسلاك يتجنبي ندبيات مرئية بالرقبة، ويوفر نتائج تجميلية ممتازة وتفتيح العودة المبكرة للعمل.
تم تطبيق عمليات المناظير ذات الشق الواحد بنجاح في عمليات البيطن العامة و
المعالجة الناجحة بمساعدة أقل من جراحات المناظير التقليدية. وقد تم إجراء
العمليات ذات المناظير الجراحى الأدنى والمناظير على نطاق واسع لتشمل جراحات
الغدة الدقيقة. استنصال الغدة الدقيقة بالمناظر عن خلال فتحة واحدة في حالة الثدي
يعطي شكلاً جمالياً ممتازاً بالإضافة إلى ميزرة التدخل الجراحى الأدنى. الدراسات
الحديثة في استنصال الغدة الدقيقة بالمناظر من خلال فتحة واحدة في حالة الثدي في
تقدم مستمر لمعرفة دواعي استخدامها والوصفات الواجب توافرها في المريض.

النظام الجراحي الأولي هي مسبب لتطورات الجراحية الأكثر ابتكاراً
وعززت بشكل جذري استخدام التقنيات ذات التدخل الجراحى الأدنى. في الأونة
الأخرى تم استخدام التقنيات الأخرى استخدام مثالية في جراحة الغدة الدقيقة
أيضاً. وقد وصفت طريقة جراحية آبلة لجراحة الغدة الدقيقةالتشاركية بالمناظر عن
طريق من الأبط. أ عليهم استنصال الغدة الدقيقة الأدنى ممكن مع أماناً
وبديلاً جراحيًا واحدًا بالنسبة للمرضى المصابين بسرطان الغدة الدقيقة وقيليل
المخاطر.

استنصال الغدة الدقيقة ذات التدخل الجراحى الأدنى بمساعدة الفيديو هو الأكثر
استخداماً في عمليات الغدة الدقيقة في حدود حجم معين والسريان الحليمي منخفض
المرحلة. وفيما يلي المعايير المقبولة على نطاق واسع لعينات الغدة الدقيقة، حجم
 أقل من أو يساوي 30 مم في القطر، والمرحلة T2 أو T1 الصغرى للحم، وعمر الغدة الدقيقة أقل من 30 سنة، وغياب التاريخ السابق لالتهاب الغدة الدقيقة أو الإشعاع.
كما أثبتت الدراسات الحديثة أنه يمكن استئصال تكنولوجيا استنصال الغدة الدقيقة ذات التدخل الجراحى الأدنى بمساعدة الفيديو
بمساعدة الفيديو بأمان في حالات التاريخ المرضي لالتهاب
الغدة الدقيقة واستئصال الغدة الدقيقة ذات التدخل الجراحى الأدنى بمساعدة الفيديو
السابق، كما أنه من الممكن أن يكون إجمالي حجم الغدة الدقيقة إلى
50 مل.

حيث أن استئصال الغدة الدقيقة ذات التدخل الجراحى الأدنى بمساعدة الفيديو
لا يزال يضخ للعديد من التطورات فان الصمغ المطلق الوحيد لهذه التقنية هو أورام
الغدة الدقيقة الخبيثة التي تعاكس السرطان الحليمي الخبيث منخفض الخطورة أو
تواجد أغلبة في كلاً من سرطان الحليب ومريضة البالج الكبيرة. قطر العقيدات أكثر من
35 مل وحجم الغدة الدقيقة أكثر من 30 مل هي موانع نسبية لأن بعض الدراسات
كشفت عن نسبات عالية من الإصابات. يعتبر استخدام الغدة
الدقيقة التقليدي من قبل معاً لدى معظم المرضى. بعض الدراسات تعتبر
استئصال الغدة الدقيقة تقليدياً لاستئصال الغدة الدقيقة ذات التدخل الجراحى الأدنى
بمساعدة الفيديو إذا تم إجراء استئصال الفص من قبل طريقة تقنية استئصال الغدة
الدقيقة ذات التدخل الجراحى الأدنى بمساعدة الفيديو، كما يعتبر التخدير المرضي
لالتهاب الغدة الدقيقة مناسبًا حيث أن بعض الدراسات أثبتت أنه
يمكن إجراء استئصال الغدة الدقيقة ذات التدخل الجراحى الأدنى بمساعدة الفيديو في
هذه الفئة بأمان.
يُمكن تلخيص أهداف تقنية استئصال الغدة الدرقية ذات التدخل الجراحى الأدنى بمساعدة الفيديو بأنه تحقق نتائج مماثلة لتلك التي يتم الحصول عليها عن طريق الجراحة التقليدية، وأقل معدل صدمات للانسجة، وتحسين الدورة اللاحقة لأجراى العملية، والخروج من المستشفى مبكرًا والحصول على نتائج تجميلية أفضل. يمكن وصف هذه التقنية بأنها إما بالنظر "تقنية" (نهج مغلق تماماً مع أو بدون نفخ غاز ثانياً أكسيد الكربون)، أو "نهاج مفتوح" بجرح صغير بمنتصف الرقبة أو "فتح بمساعدة الفيديو". تتعلق الجراحة التقليدية لاستئصال الغدة الدرقية جرحاً بطول 8 سم أو أكبر، ويكون عرضياً في الجزء الأسفل من الرقبة. أما عن تقنية التدخل الجراحى الأدنى فإنها تتطلب جرحاً صغير (5 سم للعيونات الصغيرة، وقد تصل إلى 6 سم لأكبر منها) باحترام معايير الاستبعاد فهي تشمل عامة الجسم. يشعر المرضى بالألم أقل بكثير من الألم الناتج عن الجراحة التقليدية. هذا يرجع إلى أن هذه التقنية تتسبب في أقل تشريذ وتدبير للأنسجة. وتتطلب هذه التقنية في الأساس التضخم العقدي للغدة الدرقية ونوعاً وحيداً من سرطان الغدة الدرقية وهو ما يكون صغيراً، مما يجعلها غيرxaً لاصابة الغدد الليمفاوية. يتم اختيار المرضى المؤهلين لهذه التقنية على أساس بعض المعايير، مثل حجم الغدة ونوع المرض.

المصادر الرئيسية لتقنية استئصال الغدة الدرقية ذات التدخل الجراحى الأدنى

تستخدم تقنية استئصال الغدة الدرقية ذات التدخل الجراحى الأدنى بمساعدة الفيديو. إنها تستغرق وقتًا أطول، ولكنها صديقة تعليم من تقنية طبية تكفاءة عالية، بسبب استخدام المعدات ويكون أدنى عدد المعادن المتلقاة. مثل الجرس الحجري، وتصور السرطان والأنسجة. نتائج تقنية هذه التي أظهرت في استئصال الغدة الدرقية بالطريقة التقليدية وكمساكن ذلك باستعمال 1.3 % و 0.3 % لتشمل العصب الحجري العائد وتصور السرطان، على عكس تلك التي تستخدم هذه التقنية.
تقنية استئصال الغدة الدرقية بادنى تدخل جراحي
بمساعدة الفيديو

رسالة مقدمة من
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