In: Thyroidectomy
Editor: Kimberly Rodolfo
ISBN: 978-1-63321-440-8


*Chapter 5*

# Thyroidectomy: Indications, Technique and Perioperative Care

***Dilip Dan[1], Kavita Deonarine[2], Christian Beharry[2], Shamir Cawich[1] and Vijay Naraynsingh[1]***

[1]Department of Clinical Surgical Sciences, Faculty of Medical Sciences, University of the West Indies St. Augustine Campus, St. Augustine, Trinidad and Tobago, West Indies

[2]Residents Faculty of Medical Sciences, University of the West Indies St. Augustine Campus, St. Augustine, Trinidad and Tobago, West Indies

## Abstract

The first thyroidectomy was performed in Baghdad circa 500 BC, but it was not until Emile Theodor Kocher refined his operative technique in the nineteenth century that it became accepted as a mainstream operative procedure. Due to the intricate relationship of numerous important functional structures in the neck, thyroidectomy was still fraught with life altering, and sometimes life threatening, complications. Despite this, surgical intervention for thyroid disease remains as one of the pillars of treatment with 80,000 thyroidectomies being performed in the United States annually [1].

We reviewed the surgical anatomy of the thyroid gland along with its relations to the parathyroid glands, recurrent and external laryngeal

nerves in a prior chapter in this book. Anatomic variations were discussed as well as tips and tricks to identify these important structures at the time of surgery.

The indications for thyroidectomy together with the necessary pre-operative assessment including history, examination, thyroid function tests, ultrasound and fine needle aspiration cytology will be reviewed. The role of Computerised Tomography scan, radionucleotide scanning and Magnetic Resonance Imaging will be mentioned.

Traditional thyroid surgery involved the use of cold steel. In this era, bleeding was a major concern as the vessels are numerous and thin walled and they may retract to make control difficult. With the introduction of monopolar and bipolar diathermy operative time has decreased. Operative time and blood loss are even shorter now with the use of ultrasonic dissectors [2]. Other tools including nerve stimulators will be discussed and the data analysed.

Recent advances in surgical equipment has fostered an evolution of the traditional thyroidectomy technique using sub-platysmal flaps. Considering that cosmesis remains one of the main indications for this operation, we have witnessed the introduction of video assisted thyroidectomy and robotic thyroidectomy. These minimally invasive techniques are explored, including their cost-benefit ratios and learning curves.

We also discuss modifications of the traditional open technique including the retrograde sub-capsular approach that facilitates preservation of the external branch of the superior laryngeal nerve when removing large bulky glands. We also strive to discuss means to prevent complications, treat them and look at the long term outcomes.

## A Brief History of Surgery of the Thyroid Gland

The history of thyroid surgery dates back thousands of years. A rudimentary understanding of the thyroid gland as an endocrine organ existed with goiters being recognized by the Chinese in 2700 B.C. and the Indian Ayurvedic system as ‘Gala Ganda’ in 1400 BC [3].

Details of the thyroid gland first appeared in the drawings of Da Vinci in 1511 with detailed anatomy being described by Andreas Vesalius (1514–1564). Eustachius (1520–1547) described the isthmus and the term thyroid was coined by Thomas Warton. James Berry described the ligamentum thyroideum in the 1800’s [4].

The genesis of thyroid surgery has deep historical roots with the first thyroidectomy being performed in Baghdad around 500 BC followed by work in the first and second century by Celsus and Galen [2]. Research continued in Europe with Lorenz Heister describing colloid substance in 1754 and acknowledging that goiters can become malignant. Further interest in thyroid function continued with Kocher performing 2000 thyroid excisions by 1912, the first being in 1876 [5].

Despite continuing research and development of new techniques thyroid surgery even in the hands of experienced surgeons was a life threatening procedure in the 1800's. Kocher saw a decrease in his operative mortality from 40% in 1877 to 14 % in 1884 to 2.4 % in 1889 and 0.18 % in 1898 [6, 7]. He attributed this in part to antiseptic techniques introduced by Lister in 1867 and anaesthesia [5].

The introduction of anaesthesia in the mid 1800's allowed the first successful thyroidectomy to be performed in St. Petersburg by Nikolai Pirigoff. Haemostatic forceps was another remarkable tool introduced at the same time by Spencer Wells and Jules Pear in 1874 [8].

Thyroid surgery evolved from the use of hot setons to destroy thyroid nodules to ligation of arterial poles and finally to excision of the thyroid gland totally or in part.

Damage to the recurrent laryngeal nerve has always been avoided; Billroth, Kocher, and other investigators avoided the nerve and proposed that the inferior thyroid artery should be isolated and ligated laterally to avoid nerve injury. Kocher also left behind the posterior portion of the internal thyroid capsule to avoid the nerve injury. Nerve injuries however were largely unnoticed until the invention of laryngoscopy by Spanish singer Manuel Garcia in 1851 due to his extreme enthusiasm to see inside his throat while singing. Billroth, Kocher, and Joll tried to avoid the nerve at surgery and Frank Lahey, in 1938, advocated that exposure of the nerve routinely resulted in an injury rate of only 0.3% [8].

The importance of superior laryngeal nerve function was realized after the injury to the nerve during the surgery on the famous singer Amelita Galli-Curci. Arnold Kegel and G. Raphael Dunleavy performed this surgery[3].

Thyroid surgery today uses multiple techniques and technology developed over the span of 200 years so that thyroidectomy can even be considered as an outpatient procedure in selected cases [9].

## The Anatomy of the Thyroid Gland

This subject has been extensively discussed in our chapter on thyroid anatomy earlier in this book. We looked at the relevant surgical relations and the landmarks used to identify and preserve the recurrent laryngeal nerve (RLN) and external branch of the superior laryngeal nerves (EBSLN) and the parathyroid glands. Beautiful anatomical illustrations were provided which will assist in understanding the principles involved in safe thyroid surgery.

## Diagnostic Investigations and Preoperative Preparation

Prior to thyroid surgery the lesion must be accurately diagnosed and malignant disease accurately staged in order to plan the operation and improve outcomes. The distinction between benign and malignant disease governs the type of procedure done and the following investigation may help with this:

*Thyroid Ultrasound:* A high frequency (7.5-15mHz) probe is used. The sensitivity of ultrasound in identifying asymptomatic nodules is 67% compared to physical examination (5-8%) [10]. Features suggestive of malignancy include marked hypo echogenicity, loss of the associated halo, mixed cystic and solid components, increased vascularity, irregular margins, micro calcifications, length >width and associated cervical lymphadenopathy. The presence of the "halo" sign (a thin hypoechoic rim surrounding a nodule) is very suggestive of benign pathology [11, 12]. Ultrasound is also useful for guided FNAC of the thyroid mass or lymph nodes.

*Fine Needle Aspiration for Cytology (FNAC):* FNAC differentiates between benign and malignant disease, helps select patients for surgery and governs type of operation done. It can be done under ultrasound guidance for non-palpable nodules, cystic nodules and posterior nodules [13]. Also FNA of suspicious lymph nodes can determine if lymph node dissection should be performed intra operatively [13, 14].

Papillary, medullary, anaplastic carcinoma as well as lymphoma can be reliably diagnosed by FNAC. Follicular or Hurthle cell neoplasms cannot be deemed malignant on FNAC and requires histologic proof of capsular invasion. Papillary cystic nodules that repeatedly yield non-diagnostic aspirates should be considered for surgery as well as solid solitary lesions of indeterminate FNAC. Generally lesions less than 1cm are not investigated with FNAC unless there is a strong suspicion of cancer based on the history, physical findings or ultrasound.

*Molecular Diagnostic Testing* can be done on indeterminate FNA specimens to identify true carcinomas. These include BRAF, RAS, RET/PTC, Pax8-PPAR gamma, or galectin-3 [13].

*Thyroid Scintigraphy (Radio Isotopes or Technetium-99):* Although not always necessary this test can be used determine the functional status of a nodule. Non-functioning (cold) and indeterminate nodules should be assessed by FNA. Autonomous (hot/hyper functioning nodules) do not routinely need FNA. The cold nodule is malignant in 15-20% of cases and hot nodules can have malignancy in up to 9% of cases [15]. Technetium can be used to determine function due to its short half-life and it is not organified by the thyroid gland. Radioactive iodine $I^{123}$ and $I^{131}$ are both used for scanning and are organified by the thyroid gland. Both have a longer half life than technetium. $I^{123}$ is used due to its shorter half-life and lower radiation dose. $I^{131}$ can be used to perform the same function but in higher does and is used to ablate residual thyroid tissue left after surgical intervention or for distant metastases.

*Computed Tomography (CT) or Magnetic resonance imaging (MRI)* can be used to preoperatively stage malignant disease (detect involved lymph nodes, muscle invasion and distant metastases). There should be a 2 month delay between CT with iodine and future radioiodine therapy as contrast may block iodine uptake by thyroid gland and limit the effectiveness of radioiodine therapy[11]. If retrosternal extension is suspected clinically, a CT scan with contrast must be done preoperatively. Imaging is also important to assess vascular invasion by tumours, relationship to the great vessels and the location of the lesion in the mediastinum.

## Specific Work up for Medullary Carcinoma

Carcinoembryonic antigen (CEA) and Calcitonin should be measured preoperatively to use as a baseline for comparison after surgery [11, 16].

A patient with medullary thyroid carcinoma should be investigated for Multiple Endocrine Neoplasia Type 2 (MEN2) syndrome. Serum calcium should be done to screen for hyperparathyroidism. The diagnosis of pheochromocytoma can be established by measuring plasma metanephrine levels or through measuring metanephrine in the supine position or catecholamine levels in a 24-hour urine collection [17]. If pheochromocytoma is found it should be removed prior to thyroidectomy [18]. All patients with Medullary thyroid cancer should be offered germ line RET analysis even those who appear to have sporadic mutations [16]. If the patient is positive for the RET proto-oncogene then family members should be screened.

## Work up Specific to the Operation

Thyroid surgery may result in numerous intraoperative and postoperative complications. However if a patient is optimized thoroughly prior to surgery some of these complications can be avoided.

| | | |
|---|---|---|
| Blood Tests | Complete Blood count<br>Group & Cross Match<br>Renal function<br>Liver function<br>Thyroid Function Tests (Serum TSH, Serum free T4, Total T3)<br>Serum Calcium | Should have optimal haemoglobin since intra-operative blood loss may be significant.<br>Patient should be euthyroid at surgery to minimize risk of thyroid storm (see below)<br>Screen for hyperparathyroidism |
| Evaluate cardiac risk | Functional status<br>Pulse: rhythm and rate<br>Blood pressure.<br>ECG<br>Echocardiogram | Thyroid hormone is positively inotropic, increases stroke volume, cardiac output and left ventricular ejection fraction predisposing to high output cardiac failure, arrhythmias, tachycardia, systolic hypertension and angina |
| Pulmonary and airway assessment | Chest X Ray<br><br>Respiratory Flow loops studies | Tracheal deviation, mediastinal extension and pulmonary metastases.<br>Extra thoracic compression of the trachea by a goiter results in flattening of intra thoracic and extra thoracic loops |
| Pre operative laryngoscopy | To evaluate vocal cords and document adequate function | Important for baseline documentation [19]. |

### Pharmacological Therapy

Hyperthyroidism should be controlled before surgery to minimize adverse cardiovascular outcomes and prevent precipitation of thyroid storm.

The use of the following drugs can render the patient euthyroid prior to surgery:

- Beta blockers (e.g. Atenolol) for control of adrenergic symptoms [20, 21].
- Thionamides: Carbimazole (active metabolite is methimazole) is usually started in patients with biochemical evidence of hyperthyroidism. Propylthiouracil should never be used first line, because of the risk of severe liver injury, except in the following circumstances: the first trimester of pregnancy, for people with minor reactions to carbimazole who refuse treatment with radioactive iodine or surgery and in the treatment of thyroid storm (since it inhibits T4 conversion to the more potent T3) [21].
- Iodine decreases the synthesis of thyroid hormone and decreases the release of thyroid hormone from the gland. In thyrotoxic patients Saturated Solution of potassium Iodine (SSKI) or Lugol's Iodine can be used as an adjunct to antithyroid drugs 10-14 days before surgery to reduce vascularity of the gland and reduce intraoperative blood loss. Thyroid hormone production must first be blocked with thionamides before starting iodine to prevent an iodine-induced thyrotoxicosis. Iodine should not be used in conditions with autonomous thyroid synthesis (e.g. toxic adenoma and toxic multinodular goiter) as they may lead to thyrotoxicosis by the Jod-Basedow phenomenon [20].

## General Measures

### Prophylaxis of Post Operative Nausea and Vomiting

There is a relatively high incidence of postoperative nausea and vomiting (PONV) with thyroidectomies. Serotonin antagonists, corticosteroids and dopamine antagonists can be used independently or in combination to decrease PONV [22, 23].

### Deep Venous Thromboembolism Prophylaxis

Given the high risk of bleeding with thyroidectomies and low risk of deep vein thrombosis (DVT), if no risk factors for DVT are present no routine pharmacological prophylaxis is indicated. Ambulation should be encouraged before surgery and mechanical methods (graduated compression stockings and pneumatic calf compression devices) can be employed [14].

### Nursing Post-Operatively

Patients should be nursed in close proximity of the staff in event of major post op bleeding which will cause acute respiratory compromise. Also they should be nursed in a 30-45 degree head elevation. A thyroid tray and crash cart should be close to bedside in the event the incision needs to be opened urgently for bleeding.

Calcium and/or PTH monitoring should be done for patients with symptoms of hypocalcemia or routinely if the dissection of parathyroids was difficult or parathyroids not clearly visualized.

## Indications for Thyroid Surgery

Thyroid surgery encompasses a variety of procedures listed below:

- *Hemi-thyroidectomy*: complete removal of one lobe and isthmus
- *Sub-Total-Lobectomy:* Total lobectomy but leaving behind a small amount of thyroid tissue in an effort to protect the recurrent laryngeal nerves
- *Sub-total Thyroidectomy*: Both lobes are removed except for a small amount of thyroid tissue (on one or both sides) in the vicinity of the recurrent laryngeal nerve
- *Total Thyroidectomy*: the removal of both lobes, isthmus and pyramidal lobe
- *Isthmusectomy:* removal of the isthmus
- *Central Lymph Node Dissection*: the removal of the central compartment nodes in event that one is operating for papillary or medullary carcinoma

**Table 1. Demonstrating the surgical procedure for various thyroid diseases [11, 13, 18, 20, 21, 24-27]**

| Disease | Recommended Procedure | Notes |
|---|---|---|
| Graves Disease | Total thyroidectomy or sub-total thyroidectomy is equally effective as anti-thyroid medications and radioactive iodine therapy in treating Graves Disease | Consider surgery in patients with<br>1) Symptoms refractory to thyroid medications and radio-iodine therapy or severe reactions to medical therapy<br>2) Co-existing pathology (parathyroid disease, thyroid nodule or severe ophthalmopathy)<br>3) Large goitres with compressive symptoms e.g. dysphagia, dyspnea, hoarseness of voice, inspiratory stridor, pain<br>4) Symptomatic pregnant patients who are allergic to or experience serious side effects (e.g. agranulocytosis) on thionamides. Surgery in the second trimester may reduce fetal and maternal risks. |
| Reidel's Thyroiditis | Isthmusectomy | To prevent tracheal compression |
| Multinodular Non Toxic Goitre | Total or near-total thyroidectomy | Multinodular Non Toxic Goitre |
| Toxic adenoma | Ipsilateral lobectomy or Isthmusectomy (if adenoma is located in the isthmus) | Consider surgery over radioiodine therapy in<br>1) Patients with large obstructive goitres<br>2) Patients who need rapid correction of hyperthyroidism<br>3) Coexisting malignancy or parathyroid disease<br>4) Women planning a pregnancy<br>5) Children |
| Toxic adenoma and non functioning nodule in other lobe | Total thyroidectomy | |
| Multinodular Toxic Goitre | Total or sub-total thyroidectomy | |
| Thyroid Nodules:<br>1) If repeat FNA shows atypical features or mixed macro- and microfollicular cells<br>2) follicular neoplasm is suspected or Hurtle cells on FNAC<br>3) suspicion of malignancy but no definitive diagnosis can be given | Diagnostic Hemi-thyroidectomy with completion thyroidectomy if surgical histology shows follicular thyroid cancer | If scintigraphy or molecular testing is available, may do these before deciding on surgical option. |

**Table 1. (Continued)**

| Disease | Recommended Procedure | Notes |
|---|---|---|
| Papillary or follicular cancer | Unilateral lobectomy and isthmusectomy (optional but Total Thyroidectomy standard) | Low risk patients, single nodule, <4cm, with no evidence of extra thyroid extension, confined to one lobe or gland, no lymph nodes involved<br>High risk patients, >4cm<br>Presence of multiple tumour nodules, extra thyroid extension or metastases<br>Previously exposed to radioiodine of head and neck<br>If there is no lymph node involvement consider prophylactic central dissection in large tumours (>4cm)<br>If there is confirmed lymph node involvement therapeutic lymph node dissection is indicated |
| Medullary carcinoma | Total thyroidectomy with central neck node dissection | Consider prophylactic lateral neck dissection if extensive lymph node metastases in central neck or if pre op imaging shows lymph node involvement in the lateral compartment |
| Multiple Endocrine Neoplasia Type 2 (MEN 2) | Prophylactic thyroidectomy | Timing of surgery is based upon the specific DNA mutation in RET proto-oncogene. Patient stratified into risk group based on codons affected.<br>Highest risk: operate in 1st year of life<br>High risk: 2-4 years<br>Intermediate: before 6 years<br>Low risk: by 10 years or if there is an abnormal calcitonin stimulation test (after provocation with calcium or pentagastrin) |
| Anaplastic tumours | Total thyroidectomy with post op external beam radiation if no infiltration and extension into surrounding tissue but rarely present at a stage amenable to surgery | In the majority of cases the surgeon’s role is primarily to biopsy to diagnose or to secure an airway. |
| Thyroid Lymphoma | Thyroidectomy of little or no value | Only role of surgeon is diagnostic biopsy |

One may embark on thyroid surgery for various benign and malignant conditions which will be discussed below (Table 1). Particularly for benign disease other therapeutic options (radioactive iodine therapy or anti thyroid medications) are available and the treatment should be based on patient factors after review with an endocrinologist and discussion with the patient.

# Thyroidectomy Surgical Techniques

## Basics

The patient should be supine on the operating table with a sandbag placed at the back between the shoulder blades so the shoulders would droop laterally; a head ring is put behind the extended neck to stabilise the head. The chin should be straight and the shoulders symmetrical. The head of the bed is then elevated 15-20° to decrease venous pressure in the neck. It is preferable for the surgeon to operate with loupe magnification (2.5 – 3.5x) and coaxial head lighting.

## Collar Incision

This was first described by the renowned Nobel Prize winning thyroid surgeon, Theodore Kocher. It is a curved, transverse neck incision, 2.0 – 3.0 cm above the sternal notch. Ideally, it should be marked preoperatively, before the neck is extended on the operating table. When the neck is extended, the skin is drawn cranially and a low neck incision could actually be on or below the sternal notch.

These latter incisions often heal with an unsightly scar; it is better to err on the side of placing the incision more cephalad rather than caudad. Another advantage of marking the skin pre-op is that skin creases are less evident when the neck is extended at surgery. Skin marking pre-op also ensures symmetry since in asymmetrical thyroid enlargement it is possible to inadvertently carry the incision further to one side than the other.

Having marked the skin, it should be properly stretched to ensure that the incision is vertical to the skin with no skewing of the knife. The cut should be carried down to the deep cervical fascia ensuring that the platysma is incised throughout the length of the incision and that the anterior jugular veins are preserved.

While meticulous haemostasis is essential, the authors prefer diathermy coagulation over the use of infiltration of an adrenaline solution as the latter produces more bulky and turgid flaps than the softer, pliable flaps.

## Raising Flaps

The flaps must be raised deep to platysma. If this is done superficial to platysma, flap ischaemia and necrosis may occur. Even if healing is achieved, fibrosis between the skin and platysma produces unsightly tethering each time the platysma contracts. It must be noted that the platysma is often deficient in the midline and less evident in the obese patient with the short thick neck.

In these cases, one must ensure that the incision goes right down to the deep cervical fascia before lifting the flap. It is easier to find the correct plane laterally than in the midline.

A tissue forceps is placed on each side of the midline of the upper flap, engaging the platysma and subcutaneous fat. Upward traction on these by the assistant, combined with downward pressure by the surgeon's non-cutting hand help to define a relatively avascular plane between the deep fascia and subcutaneous fat. This plane must be developed cephalad up to the thyroid prominence. By a similar technique the inferior flap is raised down to the sternal notch. Care must be taken to avoid injury to the anterior jugular veins and their branches as they lie adherent to the deep cervical fascia (Figure 2). If injured, haemostasis should be secured by suturing rather than diathermy. The flaps are then held apart by a thyroid retractor (e.g., Joll's).

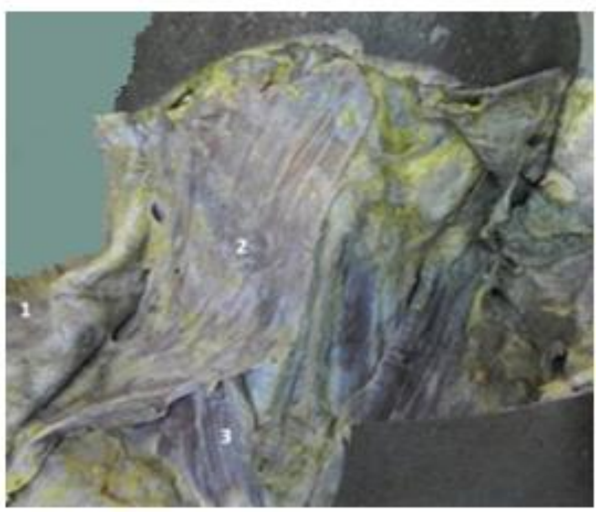


Figure 1. Photograph of the neck of a human cadaver. The skin and subcutaneous tissues (1) have been reflected to reveal the large flat sheet of the platysma muscle (2). Beneath the platysma, the origin of the sternomastoid (3) can be seen on the right.

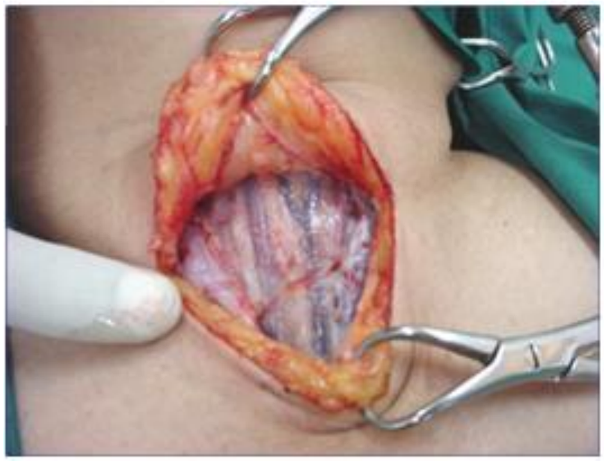

Figure 2. Flaps raised with preservation of the anterior jugular veins.

## Exposing the Thyroid

The deep cervical fascia should be incised along the midline. It could be difficult to identify the midline especially in asymmetrical enlargement. It is easier to find the midline by incising the deep fascia near the sternal notch or the thyroid prominence. At both these points the sternothyroid muscle is fixed while the sternohyoid is attached at the lower end.

Figure 3. Incision of deep cervical fascia in midline.

Figure 4. Incision of pretracheal fascia after separation of strap muscles.

The deep cervical fascia is picked up on each side of the midline and lifted with artery forceps (Figure 3). If diathermy coagulation is used to incise this fascia, the contraction of the underlying sternohyoid may assist in identifying the midline. After the fascial incision is carried from the thyroid prominence to the sternal notch, the strap muscles are separated in the midline. When the thyroid isthmus is approached, the pretracheal fascia should be lifted with artery forceps and incised sharply (Figure 4).

Care should be taken that this layer is opened for the full length of the incision. The surgeon should now stand on the side opposite to the lobe being mobilised. The strap muscles and deep fascia of the side being exposed are grasped by two tissue forceps and lifted. The surgeon depresses the thyroid with one hand while incising the plane between the deep surface of the sternothyroid muscle and the thyroid capsule. This should be done meticulously while coagulating the few small vessels that traverse this plane. When the dissection has extended about 2cm laterally, the tissue forceps are removed and two US Army/Navy retractors used to expose the anterolateral aspect of the thyroid lobe. This dissection should be carried as far cephalad and caudad as possible.

## Mobilization of Lobe

Medial traction on the thyroid lobe and lateral retraction of the strap muscles should reveal the middle thyroid vein when it is present (in 60 – 70%

cases). The vein should be ligated and divided. In many cases, however, when the lobe is quite large, the space between the lobe and the strap muscles may be too narrow to allow easy access to the vein. In such cases, the whole lobe above and below the middle thyroid vein is mobilized with finger dissection. Then the finger is used to tear the vein off the thyroid lobe as it is delivered into the wound; the lateral aspect of the wound is packed with two small gauze swabs while a swab is kept on the thyroid with the hand drawing the lobe medially. (We found it quite unnecessary to divide the strap muscles in 99% of our last 500 cases.) At this stage, it is possible to peel off the areolar tissue posteromedially to reveal the parathyroids, inferior thyroid artery and recurrent laryngeal nerve (Figure 5).

While the retractors hold the two gauze swabs laterally, the inferior thyroid veins are ligated and divided.

The lower pole is lifted and capsular dissection proceeds cephalad using bipolar cautery; dissection should be maintained closely against the thyroid capsule at all times. When the level of the isthmus is reached this is lifted off the trachea by blunt dissection and the isthmus divided using diathermy coagulation. (Figure 6)

At the superior border of the isthmus, there is an arterial arcade extending from the medial border of each superior pole (across the isthmus); this may need suture ligation.

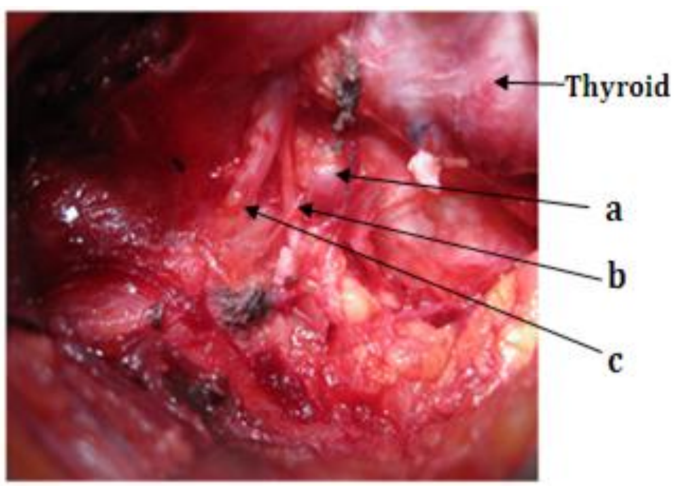


Figure 5. Medical mobilization of the lobe reveals parathyroid (a), RLN (b) and inferior thyroid artery (c).

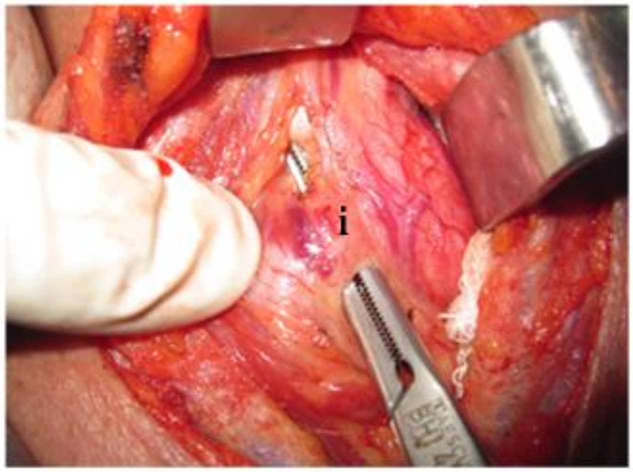


Figure 6. Artery forceps separating isthmus (i) from trachea, facilitating division.

Figure 7. Mobilization of the lobe of the trachea reveals the medial border of the ligament of Berry (arrow).

As the isthmus and lower lobe are lifted off the trachea, the ligament of Berry (LB) is encountered (Figure 7).

This is a firm band of connective tissue that runs from the inner, deep surface of the lateral lobe to the cricoid cartilage. It may also have fibres attaching it to the inferior margin of the thyroid cartilage [28]. This LB must be divided carefully, from medial to lateral, using fine bipolar diathermy forceps.

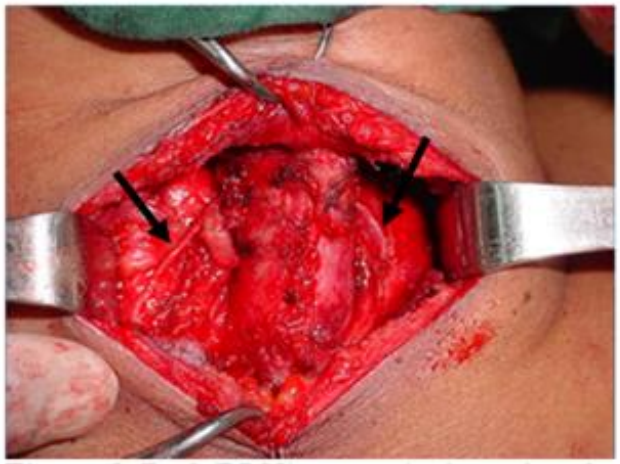

Figure 8. Both RLN’s are quite lateral to the tracheo-oesophageal groove in this patient (arrows).

When the lateral portion of the ligament is reached the gland is lifted and the remaining portion is divided from lateral to medial, the dissection being carried out against the deep surface of the gland itself. This is the point where the recurrent laryngeal nerve (RLN) is most vulnerable as it runs immediately posterolateral to the LB and extends about 2mm cephalad before disappearing beneath the inferior constrictor. Although the RLN usually runs in the tracheo-oesophageal groove, it can be quite lateral (Figure 8).

With this lateral edge of the LB taut, under tension, as the thyroid is lifted, it ‘snaps open’ when divided. If capsular dissection is maintained throughout using bipolar cautery against the gland, it is not necessary to identify the RLN although when the lateral aspect of LB is being divided, the nerve comes into view. In over 50% of cases, a lateral extension of the thyroid lobe, the tubercle of Zuckerkandl may be encountered at this point.

Dissection of this tubercle must be carefully done as the RLN runs immediately deep to it; rarely, the nerve is superficial to it. The thyroid lobe is now fully mobilised by developing the avascular plane of loose areolar tissue between the upper lobe and the cricothyroid muscle. The upper pole is drawn down and the superior pole vessels are peeled free of all areolar tissue with peanut/finger dissection. They are now well visualised and easily ligated and divided (Figure 10).

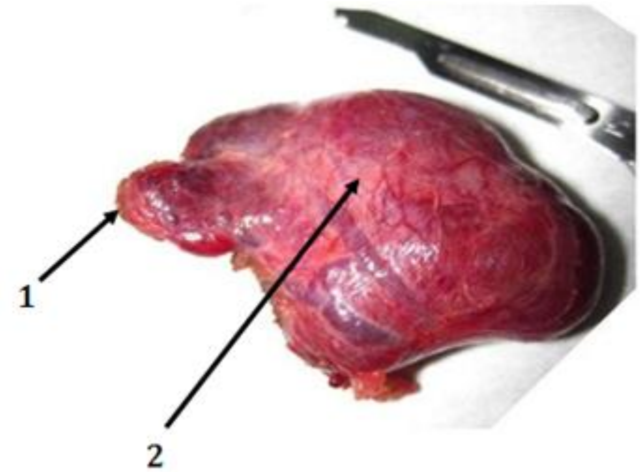


Figure 9. An excised specimen after right hemithyroidectomy. The thyroid gland has been transected at the isthmus. A large Tubercle of Zuckerkandl (1) can be seen at the posterolateral part of the right lateral lobe (2).

Figure 10. Excellent exposure of the superior thyroid pedicle (arrow) by downward traction of the completely mobilized lobe.

Using this technique of 'retrograde thyroidectomy', the entire lobe and superior thyroid vessels are drawn so far inferiorly that the risk of damage to the external branch of the superior laryngeal nerve (EBSLN) is almost eliminated since the nerve is fixed by its entry into the cricothyroid muscle; the EBSLN can be identified in most cases [29].

For a total thyroidectomy, the same procedure is repeated, with the surgeon moving to the opposite side of the table. In these cases, it is easier to do the larger lobe first.

## Subtotal Lobectomy

For subtotal lobectomy, the mobilisation is the same (as above) up to the division of the middle thyroid vein. The lobe is then drawn medially and by blunt (peanut or finger) dissection the lobe is mobilised off the carotid sheath and oesophagus, keeping the plane very close to the thyroid capsule. The inferior thyroid veins are thus divided thus freeing the lower pole.

The upper pole is now mobilised by placing two US Army/Navy retractors laterally and bluntly (using finger/peanut) dissection the lateral and posterior surfaces of the lobe. After thorough lateral and posterior mobilisation, the lower retractor is moved to the midline superiorly so that both sides of the upper pole are exposed. The upper pole is then drawn laterally by the surgeon and the plane between cricothyroid and the upper pole developed by blunt dissection. By this manoeuvre, the upper pole is completely encircled. It must be drawn caudally as far as possible, while gently peeling off all tissue from the superior thyroid pedicle, which is then doubly ligated close to the gland, in continuity, prior to division.

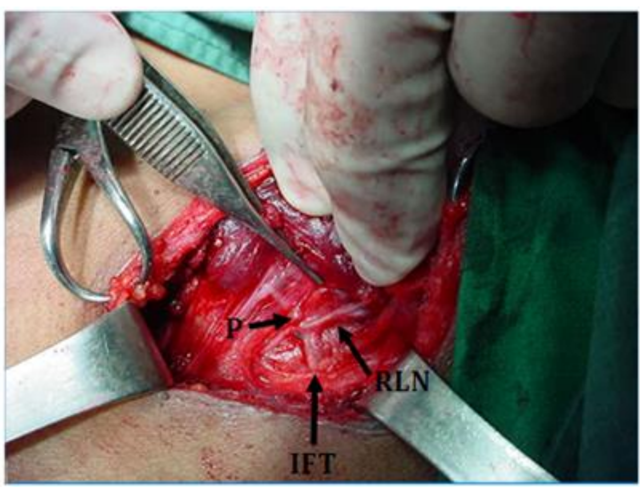


Figure 11. The RLN and parathyroids (P) are preserved if the posteromedial portion of the lobe is not removed. Note: Inferior Thyroid Artery (IFT).

The isthmus is now divided. Thus, the entire lobe apart from its posteromedial attachment is freed. Preservation of this posteromedial portion of the lobe minimises injury to parathyroids and RLN (Figure 11).

Artery forceps are now placed around the lobe at the planned site of resection. These assist with haemostasis but, more importantly, they serve as markers for safe placement of sutures, even if the field is bloody, after transecting the lobe. The thyroid is now resected, constructing a shallow V-wedge if possible. The cut surface is now sutured using a lubricated continuous absorbable suture ensuring adequate bites on both sides of the thyroid tissue and capsule. This ensures good haemostasis. We prefer this technique over the recommendation to suture the cut surface to the trachea.

The wound is closed with continuous suture in 3 layers - deep cervical fascia, platysma and subcuticular, with no drainage [8].

## Retrosternal Goitre

If retrosternal extension is suspected clinically, a CT scan with contrast must be done preoperatively. (Figures 12, 13)

This must be studied by the surgeon to ascertain the following:

1. Which lobe(s) extends retrosternally.
2. Depth of extension.
3. Relationship with innominate vein.
4. Any blood supply from within chest.
5. Relationship with trachea, aortic arch and great vessels.

In most retrosternal goitres the lower pole can be delivered by blunt mobilisation with a finger and the thyroidectomy performed with minimal alteration in technique.

While one should always be prepared for thoracotomy, this is particularly relevant when the intra thoracic portion reaches below the aortic arch, is too large to deliver through the thoracic inlet or where malignancy is suspected (and invasion of adjacent structures needs to be considered).

If the retrosternal extension cannot be easily delivered by sweeping the finger around the lower pole, then all suprasternal thyroid tissue must be fully mobilised. This is done by division of the superior pedicle, division of the LB and capsular dissection until the lobe has no attachment on the neck. The thyroid is held with gauze in one hand exercising gentle traction while the dissecting finger sweeps around the lower pole with great care to ensure that the plane is well defined and the pressure is directed against the thyroid, not on the mediastinal structures. If, in spite of these manoeuvres, the lobe cannot be delivered, the cervical leverage technique (using a US Army/Navy retractor) may be used [30]. If this fails, one may consider using the Marzouk technique or proceed to thoracotomy [31].

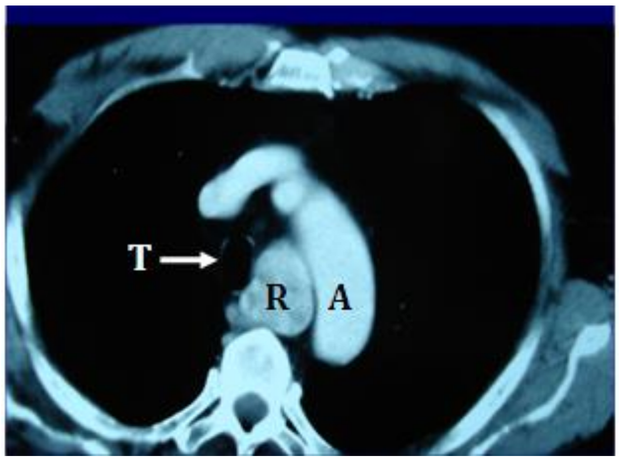


Figure 12. Retrosternal goitre (R) extending between the aortic arch (A) and trachea (T).

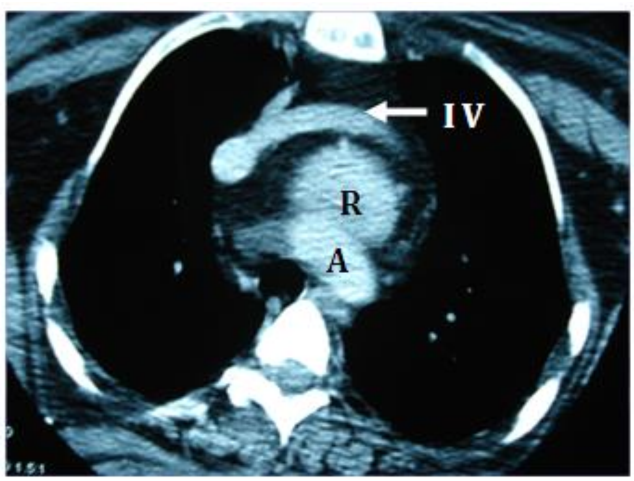


Figure 13. Retrosternal goitre (R) extending between the innominate vein (IV) and aortic arch (A).

### Central Node Dissection

Essentially, the central compartment node dissection involves all nodal structures below the hyoid bone, medial to common carotid vessels and superior to the innominate vessels [32, 33]. This is generally segment VI. It is important to identify and protect the recurrent laryngeal nerves inferiorly [32]. Sometimes it may be necessary to remove and re-implant the inferior parathyroids. However this has to be histologically confirmed by frozen section first. The size of the primary tumor guides the use of unilateral or bilateral central dissection with 1cm being the cutoff. A modified radical neck dissection is indicated if there are positive nodes present in segments II-IV [33]. This discussion however is outside the scope of this chapter.

## Complications of Thyroidectomy

When Kocher first performed thyroid surgery in 1872 the mortality rate was 75%. At the time the operation was considered so dangerous that it was prohibited by the Academy of Medicine [34].

Fortunately thanks to advances in surgery mortality and morbidity is significantly reduced. However even with experienced surgeons and meticulous care complications still occur. The difficulty of the surgery increases with re-operative thyroidectomy and patients who present late with large infiltrative tumours [35, 36].

Proper preoperative screening, optimisation of patients, sound anatomy, good exposure, and meticulous attention to haemostasis, identification and preservation of the parathyroid glands and laryngeal nerves reduce morbidity and mortality. We will now discuss some of the common complications of thyroidectomy.

### Nerve Injury

Identification of the nerves is fundamental to avoid injury [19]. This may be difficult with sub sternal goitre, thyroid cancers, large multinodular goitre and where there are anatomical variations in the nerve’s course. Many centres use intraoperative nerve monitoring using electrical stimulation to determine physiological status of the nerve [19, 37]. After identifying and stimulating the nerve the thyroid gland is then removed.

If a recurrent nerve injury becomes apparent intraoperatively, attempts should be made to repair it. Injury of the recurrent laryngeal nerve (RLN) may result in immobile vocal cord, a husky voice, feeble bovine cough and a slightly restricted airway; bilateral RLN injury may present with severe dyspnoea and inspiratory stridor indicating airway obstruction and the patient may require a tracheostomy [24].

The external branch of the superior laryngeal nerve (EBSLN) may be damaged at time of ligation of superior thyroid artery. Injury may be asymptomatic or there may be changes in voice pitch, range and projection.

Transient neuropraxia resolves in weeks to months, while temporary paresis from pressure or traction takes 3 – 6 months to recover. If symptoms persist beyond one year they are likely to be permanent [24].

## Tracheal Collapse

This is a very rare complication but can occur when there is loss of elasticity of tracheal cartilage and tracheomalacia from a long standing goiter, with tracheal collapse post-operatively [24]. Treatment involves a tracheostomy.

## Hematoma

Post-operative neck hematoma is a surgical emergency [38]. The patient may present 6 to 8 hours post operatively with difficulty breathing and inspiratory stridor due to respiratory obstruction [24]. The hematoma should be evacuated immediately and the patient transferred to the operating room where the neck is explored with an aim to achieve haemostasis.

It should be noted that bilateral cord paralysis, tracheal collapse and hematoma all present with respiratory distress.

## Infection

Infection is rare because of good blood supply and perioperative antibiotics are seldom given in immunocompetent patients [24, 39].

## Hypocalcaemia Secondary to Hypoparathyroidism (Hungry Bone Syndrome)

Hypoparathyroidism may occur secondary to gland removal or damage to their blood supply, thus attempts should be made to identify and preserve the glands and the vascular pedicles. It is thought that temporary ischemia of the parathyroid gland may result in transient hypocalcemia but permanent hypoparathyroidism also occurs.

Loss of parathyroid hormone encourages rapid remineralisation of bone with precipitous drops in calcium, magnesium and phosphate levels. At end of surgery the specimen should be inspected for parathyroid glands and auto transplantation can be done. Following auto transplantation the patient should be on calcium and vitamin D (alfacalcidol/calcitrol) for 2 to 3 months [24].

Hypocalcaemia may result in tingling in extremities or lips, a positive Trousseau and Chvostek sign, nausea vomiting, thirst, irritability and QT prolongation on electrocardiogram.

Hypocalcaemia can be ascertained by clinical evaluation and serial calcium monitoring post operatively. More recently it has been shown that parathyroid level the morning after surgery was a good predictor for hypocalcaemia [40].

Hypocalcaemic patients should be started on oral calcium and alfacalcidol/calcitrol supplementation based on calcium and parathyroid levels. If calcium levels are very low or refractory to oral supplements intravenous calcium gluconate should be given. A low salt diet may reduce tubular reabsorption of calcium in the kidneys thereby minimising loss in urine[24]. Magnesium and phosphate levels should also be corrected.

## Thyroid Storm

Manipulation of the thyroid gland may lead to the release of hormones and precipitate a thyroid crisis. The patient may be distressed, dyspnoeic, tachycardia, hyperexic, with vomiting, diarrhoea, confusion and delirium [18].

Treatment entails intravenous propylthiouracil and propranolol administration under ECG monitoring, the use of super saturated potassium iodine (SSKI) or Lugol’s iodine and intravenous hydrocortisone. Supportive measures include intravenous fluids, cooling, oxygen and treatment of cardiac failure [18, 21].

Miscellaneous complications reported include seromas, hypertrophic and keloid scars, Horner's syndrome, chyle fistula and tracheal and oesophageal injury [18, 41, 42].

## Advances in Thyroidectomy

Thyroid disease is classically a disease affecting mostly female patients and this has fueled the desire for more cosmetically appropriate approaches [43]. This is of special importance in the dark skinned population where the likelihood of keloid and hypertrophic scarring is increased. Conventional open thyroidectomy has average skinfold incision length of 5-6cm; in minimally invasive open thyroid surgery the average incision length is 3.5 to 4.5cm; compared to endoscopic minimally invasive video assisted thyroid surgery with an incision length less than 2cm [44-47].

In 1997 the first endoscopic approach to thyroid surgery was described by Huscher [48]. In 2000 Miccoli described video assisted techniques using incisions of about 15mm placed 1cm above the sternal notch with CO2 inflation [49]. Since then minimally invasive video assisted thyroid surgery (MIVAT) has been explored by many different studies using a variety of approaches with varying results.

Endoscopic access has been attempted via cervical, axillary and breast approach, with bilateral breast access being favoured as it provides wider access, more range of movement and better cosmetic outcome, as there is no scarring above the neck [40]. Tan et al. reported that the extra-cervical approaches have been associated with longer operating times, increased perioperative morbidity and longer hospital stay. Other centres have found an increase in transient vocal cord palsy and increased transient hypocalcaemia but similar rates in other complications compared to open thyroidectomy [40].

Robotic technology has also been applied to thyroid surgery using a gasless unilateral axillo-breast or axillary approach with a Da Vinci robotic system (described by Kang et al) [50]. Robotic surgery has proven itself to be a reasonable and safe alternative to open and endoscopic procedure however there is increased cost.

One key factor to consider when evaluating the benefit of endoscopic or robotic surgery is the competency of the surgeon with the equipment. The learning curve for performing these procedures is significantly greater than open thyroidectomy and operating time can be significantly increased when performed by inexperienced surgeons, however they may have better cosmesis, less postoperative pain, and reduced hospital stay [44, 47].

In conclusion as with most things in medicine each case must be evaluated holistically. With the right patient selection and in competent hands endoscopic and robotic technology are reasonable minimally invasive options for thyroid surgery and can provide cosmetically favourable results.

## References


[1] Contin P, Goossen K, Grummich K, et al. ENERgized vessel sealing systems versus CONventional hemostasis techniques in thyroid surgery--the ENERCON systematic review and network meta-analysis. *Langenbeck's archives of surgery / Deutsche Gesellschaft fur Chirurgie.* Dec 2013; 398(8):1039-1056.

[2] Cheng LHH, Hutchison IL. Thyroid surgery. *The British journal of oral & maxillofacial surgery.* 2012; 50(7):585-591.

[3] Dorairajan N, Pradeep PV. Vignette Thyroid Surgery: A Glimpse Into its History. *International Surgery.* 2013/02/01 2013; 98(1):70-75.

[4] Shuja A. History of Thryoid Surgery. *The Professional Medical Journal* June 2008 2008; 15(02):295-297.

[5] Dubhashi SP, Subnis BM, Sindwani RD. Theodor e. Kocher. *The Indian journal of surgery*. Oct 2013; 75(5):383-384.

[6] Halsted W. *The Operative Story of Goitre*1920.

[7] Gemsenjäger E. Milestones in European Thyroidology: Theodor Kocher (1841-1917) *European Thyroid Association.*

[8] Daniel O, Robert U. Surgery of the Thyroid and Parathyroid Glands. In: Daniel O, Robert U, eds: Springer Berlin Heidelberg; 2007.

[9] Hessman C, Fields J, Schuman E. Outpatient thyroidectomy: is it a safe and reasonable option? *The American Journal of Surgery*. 5// 2011; 201(5): 565-569.

[10] Tan GH, Gharib H. Thyroid incidentalomas: management approaches to nonpalpable nodules discovered incidentally on thyroid imaging. *Annals of internal medicine.* Feb 1 1997; 126(3):226-231.

[11] Perros P. Guidelines for the Management of Thyroid cancer (Third Edition). *British Thyroid Association.* 2014.

[12] Fish SA, Langer JE, Mandel SJ. Sonographic imaging of thyroid nodules and cervical lymph nodes. *Endocrinology and metabolism clinics of North America.* Jun 2008; 37(2):401-417, ix.

[13] American Thyroid Association Guidelines Taskforce on Thyroid N, Differentiated Thyroid C, Cooper DS, et al. Revised American Thyroid Association management guidelines for patients with thyroid nodules and differentiated thyroid cancer. *Thyroid : official journal of the American Thyroid Association.* Nov 2009; 19(11):1167-1214.

[14] Perros P, Thyroid Cancer Guidelines Update G. Introduction to the updated guidelines on the management of thyroid cancer. *Clinical medicine.* Aug 2007; 7(4):321-322.

[15] Townsend C, Beauchamp R, Evers B. The biological Basis of Modern Surgical Practice 19th Ed *Sabiston Textbook of Surgery Elsevier* 2012.

[16] American Thyroid Association Guidelines Task F, Kloos RT, Eng C, et al. Medullary thyroid cancer: management guidelines of the American Thyroid Association. *Thyroid : official journal of the American Thyroid Association.* Jun 2009; 19(6):565-612.

[17] Chen H, Sippel RS, O'Dorisio MS, Vinik AI, Lloyd RV, Pacak K. The North American Neuroendocrine Tumor Society consensus guideline for the diagnosis and management of neuroendocrine tumors: pheochromocytoma, paraganglioma, and medullary thyroid cancer. *Pancreas.* Aug 2010; 39(6):775-783.

[18] Lennard T. *Endocrine Surgery* 4th ed: Elsevier; 2009.

[19] Chandrasekhar SS, Randolph GW, Seidman MD, et al. Clinical practice guideline: improving voice outcomes after thyroid surgery. *Otolaryngology--head and neck surgery : official journal of American Academy of Otolaryngology-Head and Neck Surgery*. Jun 2013; 148(6 Suppl):S1-37.

[20] Langley RW, Burch HB. Perioperative management of the thyrotoxic patient. *Endocrinology and metabolism clinics of North America.* Jun 2003; 32(2):519-534.

[21] Bahn RS, Burch HB, Cooper DS, et al. Hyperthyroidism and other causes of thyrotoxicosis: management guidelines of the American Thyroid Association and American Association of Clinical Endocrinologists. *Endocrine practice : official journal of the American College of Endocrinology and the American Association of Clinical Endocrinologists.* May-Jun 2011; 17(3):456-520.

[22] Danner K, Becker HG, Best B, Madler C. [Prophylaxis of nausea and vomiting after thyroid surgery: comparison of oral and intravenous dolasetron with intravenous droperidol and placebo]. *Anasthesiologie, Intensivmedizin, Notfallmedizin, Schmerztherapie : AINS.* Jul 2001; 36(7): 425-430.

[23] Zhou H, Xu H, Zhang J, Wang W, Wang Y, Hu Z. Combination of dexamethasone and tropisetron before thyroidectomy to alleviate postoperative nausea, vomiting, and pain: randomized controlled trial. *World journal of surgery*. Jun 2012; 36(6):1217-1224.

[24] Shaheen O. *Thyroid Surgery*: The Parthenon Publishing Group 2003.

[25] Douglas S, Sonia L. Surgery in the Treatment of hyperthyroidism: Indications, preoperative preparation, and post operative followup *UpToDate*. 2014.

[26] Cornelis J. Approach to Therapy in Multiple Endocrine Neeoplasia Type 2. *UpToDate*. 2012.

[27] Nixon IJ, Ganly I, Shah JP. Thyroid cancer: surgery for the primary tumor. *Oral oncology*. Jul 2013; 49(7):654-658.

[28] Yalçın B, Ozan H. Detailed Investigation of the Relationship Between the Inferior Laryngeal Nerve Including Laryngeal Branches and Ligament of Berry. *Journal of the American College of Surgeons*. 2// 2006; 202(2):291-296.

[29] Friedman M, LoSavio P, Ibrahim H. SUperior laryngeal nerve identification and preservation in thyroidectomy. *Archives of Otolaryngology–Head & Neck Surgery*. 2002; 128(3):296-303.

[30] Naraynsingh V, Ramarine I, Cawich SO, Maharaj R, Dan D. Cervical leverage: A new procedure to deliver deep retrosternal goitres without thoracotomy. *International Journal of Surgery Case Reports*. // 2013; 4(11):992-996.

[31] Rathinam S, Davies B, Khalil-Marzouk JF. Marzouk's Procedure: A Novel Combined Cervical and Anterior Mediastinotomy Technique to Avoid Median Sternotomy for Difficult Retrosternal Thyroidectomy. *The Annals of Thoracic Surgery*. 8// 2006; 82(2):759-760.

[32] Hughes DT, Doherty GM. Central neck dissection for papillary thyroid cancer. *Cancer control : journal of the Moffitt Cancer Center*. Apr 2011; 18(2):83-88.

[33] American Thyroid Association Surgery Working G, American Association of Endocrine S, American Academy of O-H, et al. Consensus statement on the terminology and classification of central neck dissection for thyroid cancer. *Thyroid : official journal of the American Thyroid Association*. Nov 2009; 19(11):1153-1158.

[34] Chiesa F. The 100 years Anniversary of the Nobel Prize Award winner Emil Theodor Kocher, a brilliant far-sighted surgeon. *Acta otorhinolaryngologica Italica : organo ufficiale della Societa italiana di otorinolaringologia e chirurgia cervico-facciale*. Dec 2009; 29(6):289.

[35] Gopalakrishna Iyer N, Shaha AR. Reoperative Thyroid Surgery. *Thyroid Surgery*: John Wiley & Sons, Ltd; 2012:105-110.

[36] Lefevre JH, Tresallet C, Leenhardt L, Jublanc C, Chigot JP, Menegaux F. Reoperative surgery for thyroid disease. *Langenbeck's archives of surgery / Deutsche Gesellschaft fur Chirurgie.* Nov 2007; 392(6):685-691.

[37] NICE. Intraopertive Nerve Monitoring During Thyroid Surgery. *National Institute for Health and Clinical Excellence.* March 2008 2008.

[38] Williams RT, Angelos P. Postoperative Bleeding. *Thyroid Surgery*: John Wiley & Sons, Ltd; 2012:199-207.

[39] Avenia N, Sanguinetti A, Cirocchi R, et al. Antibiotic prophylaxis in thyroid surgery: a preliminary multicentric Italian experience. *Annals of surgical innovation and research.* 2009; 3:10.

[40] Dhepnorrarat RC, Witterick IJ. New technologies in thyroid cancer surgery. *Oral oncology*. Jul 2013; 49(7):659-664.

[41] Alon EE, Urken ML. Management and Prevention of Laryngotracheal and Oesophageal Injuries in Thyroid Surgery. *Thyroid Surgery*: John Wiley & Sons, Ltd; 2012:151-160.

[42] Kus LH, Freeman JL. The Rare Ones: Horner's Syndrome, Complications from Surgical Positioning and Post-Sternotomy Complications. *Thyroid Surgery*: John Wiley & Sons, Ltd; 2012:237-248.

[43] Giannopoulos G, Kang SW, Jeong JJ, Nam KH, Chung WY. Robotic thyroidectomy for benign thyroid diseases: a stepwise strategy to the adoption of robotic thyroidectomy (gasless, transaxillary approach). *Surgical laparoscopy, endoscopy & percutaneous techniques.* Jun 2013; 23(3):312-315.

[44] Timon C, Rafferty M. Minimally invasive video-assisted thyroidectomy (MIVAT): technique, advantages, and disadvantages. *Operative Techniques in Otolaryngology-Head and Neck Surgery.* 3// 2008; 19(1): 8-14.

[45] Rafferty M, Timon C. Minimal incision thyroidectomy. *Operative Techniques in Otolaryngology-Head and Neck Surgery.* 3// 2008; 19(1): 2-7.

[46] Brunaud L, Zarnegar R, Wada N, Ituarte P, Clark OH, Duh QY. Incision length for standard thyroidectomy and parathyroidectomy: when is it minimally invasive? *Archives of surgery (Chicago, Ill. : 1960).* Oct 2003; 138(10):1140-1143.

[47] Miccoli P, Berti P, Raffaelli M, Materazzi G, Baldacci S, Rossi G. Comparison between minimally invasive video-assisted thyroidectomy and conventional thyroidectomy: A prospective randomized study. *Surgery*. 12// 2001; 130(6):1039-1043.

[48] Hüscher CS, Chiodini S, Napolitano C, Recher A. Endoscopic right thyroid lobectomy. *Surgical endoscopy*. 08/ 1997; 11(8):877.

[49] Miccoli P, Berti P, Bendinelli C, Conte M, Fasolini F, Martino E. Minimally invasive video-assisted surgery of the thyroid: a preliminary report. *Langenbeck's Arch. Surg.* 2000/07/01 2000; 385(4):261-264.

[50] Kang S-W, Lee SC, Lee SH, et al. Robotic thyroid surgery using a gasless, transaxillary approach and the da Vinci S system: The operative outcomes of 338 consecutive patients. *Surgery*. 12// 2009; 146(6):1048-1055.