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Surgeon's Approach to the Thyroid Gland: Surgical Anatomy and the Importance of Technique

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Abstract. The cornerstone of safe and effective thyroid surgery is thorough training in and understanding of thyroid anatomy and pathology. With appropriate techniques, total thyroid lobectomy and total thyroidectomy (which should be considered simply as a bilateral total thyroid lobectomy performed during the same operation) can be undertaken with minimal risk of damage to the recurrent laryngeal nerves, the external branches of the superior laryngeal nerves, and the parathyroid glands. Safe surgery requires a specific operative plan, progressing in a series of logical, orderly, anatomically based steps. Exposure of the thyroid gland is followed by careful dissection of the superior pole, utilizing the avascular plane between the superior pole and the cricothyroid muscle to identify and preserve the external branch of the superior laryngeal nerve. Medial retraction of the gland then allows dissection of the lateral aspect of the thyroid lobe. Protection of the recurrent laryngeal nerves and preservation of the blood supply to the parathyroid glands is best achieved by "capsular dissection," ligating the tertiary branches of the inferior thyroid artery on the gland surface. If a parathyroid gland cannot be preserved or becomes ischemic after dissection of its vascular pedicle, it should be immediately minced and autotransplanted into the ipsilateral sternocleidomastoid muscle. The current evolution of outpatient or short-stay thyroidectomy emphasizes the need to avoid complications by utilizing meticulous surgical technique. Minimally invasive thyroidectomy utilizing endoscopic techniques may also affect the practice of thyroid surgery. Even so, understanding the surgical anatomy of the thyroid gland and its possible variations is paramount to safe and effective surgery.

During the latter half of the nineteenth century a revolution in surgery and surgical technique occurred. Before that time, thyroid surgery was limited to treating only life-threatening conditions. With a reported mortality rate of more than 20%, the reputation of thyroid surgery was so poor that the French Academy of Medicine banned its practice in 1850. Indeed, when Greene reported his successful thyroidectomies in America, he warned that the operations should be used "*never*, for the relief of deformity or discomfort merely; *only*, to save life" [1]. However, by the time the Nobel Prize was awarded to Kocher in 1909, the mortality rate in his hands had been reduced to 0.18% [2].

The key to increasing safety of thyroid surgery was then, as now, a thorough understanding of thyroid anatomy and pathology. The general developments in surgical techniques and instrumentation, and the improvements in antisepsis and anesthetic techniques, were also crucial. When thyroidectomy became safe to perform, the specific complications of the procedure could be addressed, including prevention of injury to the recurrent laryngeal nerves and avoidance of accidental injury to, or removal of, the parathyroid glands. The surgical techniques developed at that time were, interestingly, often based on the same principle of capsular dissection widely practiced today, with minimal dissection of the recurrent laryngeal nerves and preservation of the blood supply to the parathyroid glands.

The first accurate description of this capsular technique was by Halsted, who recognized the importance of the inferior thyroid artery as the principal means of blood supply to the parathyroid glands. The technique he described utilized a method of ultradissection, avoiding damage to the parathyroid blood supply by ligating the tertiary branches of the inferior thyroid artery adjacent to the thyroid capsule. Avoidance of injury to the recurrent laryngeal nerve was generally appreciated, although specific techniques for avoiding injury varied. Many surgeons, including Kocher, Billroth, and Joll, tried to avoid the nerves by dissecting away from them; others, notably Bier, preferred to expose them deliberately [3]. The importance of the external branch of the superior laryngeal nerve was not appreciated until much later. Coller and Boyden in 1937 modified the approach to the superior pole, advocating preservation of the external branch of the superior laryngeal nerve by individual ligation of the branches of the superior thyroid artery after entering the avascular space between the superior pole and the cricothyroid muscle [4].

In 1973 Thompson et al. delineated the technique of capsular dissection by describing the development of a plane between the thyroid capsule and the inferior thyroid artery. Among 315 patients undergoing total lobectomy or subtotal thyroidectomy, none had permanent hypoparathyroidism or recurrent laryngeal nerve palsy. Among 96 patients undergoing total thyroidectomy, 2 had permanent hypoparathyroidism and 3 had recurrent laryngeal nerve injury [2]. Similar low incidences of complications have been reported by many other groups using a similar technique [5–7].

Total Thyroid Lobectomy and Total Thyroidectomy

The classification of thyroid procedures is thoroughly explained by Kebebew and Clark [8]. Total thyroid lobectomy (as distinct from

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nodulectomy or partial lobectomy) is the total extracapsular removal of one lobe and the isthmus, leaving behind viable parathyroid glands and intact recurrent laryngeal and superior laryngeal nerves. Total thyroidectomy (as distinct from near-total or subtotal thyroidectomy) is simply a matter of performing a total thyroid lobectomy on both sides during the same operation. Each procedure should be performed with a specific "game plan" in mind, progressing in a series of logical, orderly, anatomically based steps as follows:

1. Exposure of the thyroid gland
2. Dissection of the upper pole and superior laryngeal nerve
3. Dissection of the lateral aspect of the thyroid lobe, preserving the recurrent laryngeal nerve and parathyroid glands
4. Closure

These steps are now considered in relation to the relevant surgical anatomy.

Exposure of the Thyroid Gland

General Anatomy

The normal thyroid gland lies immediately caudal to the larynx and encircles the anterior and lateral aspects of the upper trachea. It weighs approximately 20 g and consists of two lateral lobes joined anteriorly by the isthmus. There may be a superior extension near the midline known as the pyramidal lobe. The two lateral lobes of the thyroid are roughly conical, approximately 5 cm long and 2 to 3 cm in the maximum transverse and anterioposterior dimensions. The lower margin of the lobe is at the level of the fourth or fifth tracheal ring. Each lateral lobe of the thyroid is bordered by the trachea and esophagus on the medial surface, the carotid sheath on the posterior and lateral aspects, and the sternocleidomastoid and strap muscles (sternohyoid, sternothyroid, and superior belly of the omohyoid) on the anterolateral surface. The sternothyroid muscle is closely applied to the gland, and the oblique upper insertion of the sternothyroid into the thyroid cartilage is the limiting factor preventing the lateral lobes from encroaching further toward the midline and onto the underlying thyrohyoid muscle. The upper pole of the lateral lobe is applied medially to the inferior pharyngeal constrictor complex and the posterior aspect of the cricothyroid muscle. The strap muscles are innervated by the ansa cervicalis (ansa hypoglossi) formed from the descendens hypoglossi (containing fibers of C1) and the descendens cervicalis (containing fibers of C2 and C3). The isthmus of the thyroid is approximately 1.25 cm in both transverse and vertical dimensions and commonly overlies the second and third tracheal rings. Its size and position is often variable. The pyramidal lobe may be present and extends for a variable distance from the upper border of the isthmus or adjacent lateral lobe (more commonly the left) toward the hyoid bone. A fibrous band, representing the obliterated thyroglossal duct, may descend from the hyoid bone to the pyramidal lobe. This band may be muscular; and when this configuration is present, it is referred to as the levator (levator glandulae superioris) of the thyroid gland.

The thyroid is entirely covered by a thin capsule, which is derived from pretracheal fascia. Near the cricoid cartilage and upper tracheal rings this capsule is condensed into the posterior suspensory, or Berry's, ligament. The capsule of the gland may extend into the parenchyma of the thyroid and divide the gland into irregularly sized masses. Small masses of thyroid tissue may exist distinct from the body of the gland itself within the vicinity of the lateral lobes, in the thyrothymic tract, or superior to the isthmus along the line of the thyroglossal duct tract.

Venous drainage is variable and occurs via a capsular network of freely intercommunicating vessels, which drains through three primary routes: the superior thyroid veins (adjacent to the superior thyroid artery) near the superior pole, the inferior thyroid veins leaving the inferior pole, and the middle thyroid vein(s), which travel laterally to drain directly into the internal jugular vein. The middle thyroid veins may be absent; or, conversely, there may be several.

Gland Exposure

The key to all successful surgery is adequate exposure. This is especially true during thyroid surgery. The patient is placed in a supine position with arms to the side, and a support is placed transversely underneath the shoulders, thereby extending the neck. The neck extension must not be too extreme as it increases postoperative pain and discomfort. After skin preparation and draping, a collar incision is made. It is a symmetric incision running in one of the skin creases of the neck if visible or in the direction of Langer's lines if no crease is appropriate. The level of the incision is crucial for a good cosmetic result. If the incision is made too cephalad, it is quite noticeable when wearing normal clothing. If made too caudad, there is an increased chance of keloid scar formation. In general, it should lie in an arc above the clavicular heads and suprasternal notch. The incision is carried through the platysma, and superior and inferior subplatysmal flaps are raised.

Routine division of the strap muscles is controversial, and it can be argued that such a maneuver is unnecessary for small glands, but it certainly facilitates the operation for large multinodular goiters. The division of the strap muscles enhances exposure of the cricothyroid space. Development of this space requires lateral retraction of the upper pole, which is otherwise restricted by its proximity to the insertion of sternothyroid into the thyroid cartilage. If the strap muscles are to be divided, it is important that the ansa cervicalis is preserved at the lateral border of the sternothyroid to preserve innervation of the strap muscles.

The gland itself is then grasped by applying hemostatic clips and the lateral lobe retracted medially. The lateral space between the thyroid and the carotid sheath is opened and extended until the prevertebral fascia is encountered. The cervical sympathetic chain may rarely be at risk of injury during this maneuver as it runs behind the carotid sheath. Damage may lead to a Horner syndrome. The first major vein to be encountered at this stage is the middle thyroid vein, which must be controlled and divided before the lateral space is extended to the prevertebral fascia.

At this stage it is useful to define the midline. If there is a pyramidal lode present, it is at this stage that it is mobilized and divided from the fibrous tissue of any remaining thyroglossal duct tract. The upper border of the isthmus is dissected off the trachea by dividing the superior suspensory ligament with any of its vessels, and the midline is identified. Similarly, the midline below the isthmus is defined with division of any centrally placed inferior thyroid veins. The thyroidea ima artery exists in approximately 3% of cases and may arise from the innominate artery or directly from the aorta. If present, it should be controlled and divided at this point. The isthmus may be elevated with a hemostatic clip passed over the tracheal surface. This step assists in retraction of the lobe and also marks the midline, which may be rotationally displaced during medial retraction of the thyroid lobe. This combination of maneuvers provides excellent exposure of the thyroid gland.

Dissection of Upper Pole and Superior Laryngeal Nerve

Anatomy of the External Branch of Superior Laryngeal Nerve and Superior Thyroid Artery

The external branch of the superior laryngeal nerve is a branch of the vagus nerve (inferior ganglion) and is the motor nerve to the cricothyroid muscle, an important tensor of the vocal cords. The internal branch of the superior laryngeal nerve is purely sensory and serves the mucosal lining of the supraglottic larynx. Injury to the external branch of the superior laryngeal nerve is a less well described than damage to the recurrent laryngeal nerve [9,10]. The nerve is at risk because of its close association with the superior thyroid artery. The relation of the nerve to the superior pole and artery is extremely variable, and a new classification of the distribution of the nerve has been proposed by Cernea et al. taking into account the risk of injury during thyroidectomy [11]. This classification is demonstrated in Figure 1. The type 2b occurs in 14% to 20% of normal individuals. It crosses the avascular space below the tip of the superior thyroid pole and is at particularly high risk of injury. Interestingly, the incidence of this type of nerve has been noted to be much higher (up to 56%) in patients with large goiters, presumably owing to the cephalad growth of thyroid tissue behind the vascular pedicle [12].

Voice changes that occur after superior laryngeal nerve injury are often of a subtle nature and may go unnoticed by patients unless they are professional singers or public speakers. Injury results in an inability to reach high pitches, the loss of ability to project the voice, or easy vocal fatigue during prolonged speech. Often the subtle vocal cord changes associated with injury can be demonstrated only on video-stroboscopic examination [13].

The superior thyroid artery is the first branch of the external carotid artery and arises immediately superior to the thyroid cartilage, descending on the inferior constrictor muscle to enter the upper pole of the thyroid. Prior to entering the lateral lobe of the thyroid, branches pass to the isthmus and the pyramidal lobe via a diagonal "crossing" vessel; frequently a branch to the superior parathyroid gland also exists.

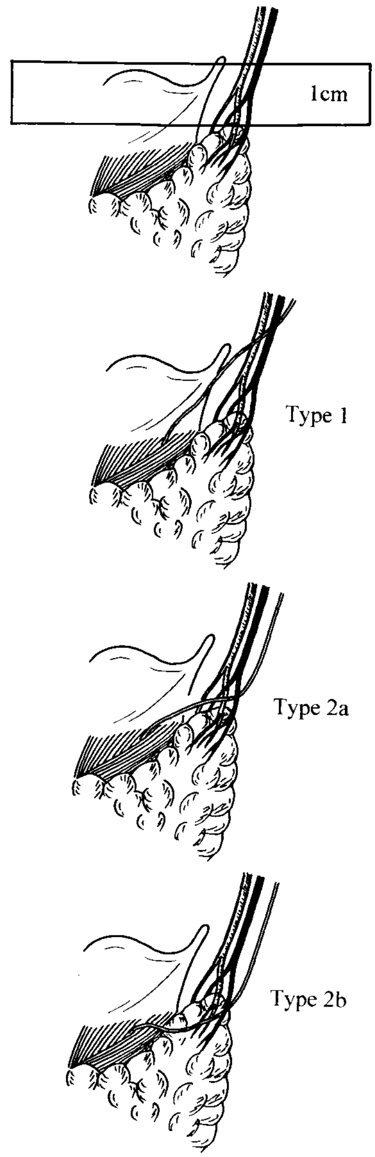

Fig. 1. Anatomic variations in the relation between the external branch of the superior laryngeal nerve and the superior thyroid artery. With type 1 anatomy, the nerve crosses the superior thyroid vessels $\geq$ 1 cm above the superior thyroid pole. With type 2 anatomy, the nerve crosses the vessels < 1 cm above (type 2a) or even below (type 2b) the superior pole. (Adapted from Cernea et al. [11].)

Dissection of the Superior Pole

To remove the superior pole of the thyroid safely and completely, the overlying strap muscle is dissected off the gland, taking care not to enter the subcapsular veins, which may bleed profusely if lacerated. The superior pole is gradually separated from overlying muscle, and the space between the thyroid gland and cricothyroid muscle is opened (cricothyroid space). This space is usually filled with areolar tissue only, although the "crossing branch" of the superior thyroid artery (described above) may have to be divided. Identification and dissection of this space is greatly assisted by traction of the thyroid in an inferior and lateral direction and counteraction of the sternothyroid muscle in a superior and medial direction. It is at this stage that the external branch of the superior laryngeal nerve may be seen. More importantly, by beginning in the avascular space and mobilizing cephalad, the nerve is avoided even if not directly viewed. In a recent series from our unit, 100 consecutive avascular cricothyroid spaces were carefully examined [14]. In 98 cases the space was easily demonstrated, but in two patients with Hashimoto's thyroiditis the space was not seen owing to adhesions and fibrosis. The external branch of the superior laryngeal nerve was identified in 46% of the cases, of which 41% were at risk of injury by close approximation to, or intertwining with, branches of the superior thyroid artery.

Once the medial and lateral borders of the superior pole have been mobilized, the superior pedicle is divided. This is achieved by individual ligation and division of the vessels of the pedicle near the thyroid capsule, effectively reducing the possibility of injury to the external branch of the superior laryngeal nerve when this is adherent to, or passing between, the branches of the superior thyroid artery. A superior parathyroid gland is identified in up to 2% of cases in this area [15]. If so, attempts are made to dissect the gland posteriorly off the thyroid, preserving the blood supply to the gland.

Dissection of the Lateral Lobe, Recurrent Laryngeal Nerves, and Parathyroid Glands

Anatomy

Recurrent Laryngeal Nerve and Role in Speech Production. The recurrent laryngeal nerve (inferior laryngeal nerve) is also a branch of the vagus nerve, which becomes recurrent by turning back on itself in the chest and running superiorly back into the neck as the motor nerve to the intrinsic muscles of the larynx. The left inferior laryngeal nerve recurs around the ligamentum arteriosum and the arch of the aorta. The right nerve recurs around the subclavian artery before classically ascending in the tracheoesophageal groove. The right nerve courses more obliquely as it is relatively more lateral in position than is the left nerve during their paths in the chest. Both nerves cross the course of the inferior thyroid artery on their way to the larynx; numerous variations of this relation have been described. The nerve may pass deep to, superficial to, or within the terminal branches of the inferior thyroid artery. The nerve then continues superiorly and medially to enter the larynx along the posterior aspect of the cricothyroid muscle. Along this portion of its route, the nerve is close to the capsule of the thyroid gland and may even appear to be buried within the parenchyma. Prior to entering the larynx, the nerve commonly divides into two branches to supply the abductor and adductor muscles of the larynx. This may occur at variable distances from the larynx, even prior to encountering the thyroid itself.

The recurrent laryngeal nerve may lie anterior or lateral to the tracheoesophageal groove and is at risk of injury during division of the inferior thyroid veins. The most common position of the nerve in relation to the inferior thyroid artery is deep to it. This is particularly true of the left nerve, as the right nerve more commonly runs anterior to the artery or between the branches of the artery. Nearly 30 variations in the relation between the recurrent laryngeal nerve and the inferior thyroid artery have been described. Despite this, in most cases the nerve is consistently found within a few millimeters of the artery and the ligament of Berry. The most common sites where a recurrent laryngeal nerve is at risk of injury are near the inferior thyroid artery, near the ligament of Berry, and at the inferior pole of the thyroid gland. A nonrecurrent inferior laryngeal nerve (usually associated with a retroesophageal right subclavian artery) is obviously at risk as well.

Speech is composed of both phonation, achieved by the larynx, and then articulation, by the structures in the mouth. The larynx possesses two vocal cords (or folds), which protrude into the airway from the lateral walls of the larynx. Immediately underneath the epithelium covering the cords is an elastic ligament called the vocal ligament, attached anteriorly to the thyroid cartilage and posteriorly to the vocal process of the arytenoid cartilage. The pitch generated by their vibration is determined by the degree of tension applied to the cords, the mass of their edges, and the approximation of the cords to each other. This is primarily achieved by movement of the arytenoid cartilages in relation to the other laryngeal cartilages. It occurs by rotation, abduction, adduction, and anterior and posterior movements. The cords may also be affected by the position of the thyroid and cricoid cartilages in relation to each other.

The musculature of the larynx is divided into extrinsic and intrinsic muscles. The extrinsic muscles pass from the larynx to neighboring structures (e.g., sternothyroid, thyrohyoid) and are innervated by the ansa cervicalis. The intrinsic muscles of the larynx are divided into two important groups. The adductors of the vocal cords include the paired lateral cricoarytenoid muscles, the paired internal and external thyroarytenoid muscles, and the single interarytenoid (transverse arytenoid) muscle. The abductors of the vocal cords are the paired posterior cricoarytenoid muscles. The whole of the intrinsic musculature of the larynx is supplied by the recurrent laryngeal nerve except for the cricothyroid muscles, which are supplied by the external branch of the superior laryngeal nerve.

If the recurrent laryngeal nerve is injured, the change in voice depends on whether the external branch of the superior laryngeal nerve was damaged at the same time. If one recurrent laryngeal nerve is completely transected, the cord is adducted toward the midline in a paramedian position. However, if the ipsilateral superior laryngeal and recurrent laryngeal nerves are damaged, the cord assumes an intermediate position.

Anatomy of Parathyroid Glands. Classically, there are four parathyroid glands in close association with the thyroid, although the number and positions of the glands may vary greatly among individuals. In a thorough anatomic study, Akerstrom et al. described a 13% incidence of a supernumerary fifth parathyroid and, at most, a 3% incidence of only three glands [15].

The superior parathyroid glands are derived from the fourth branchial pouch and are in close association with the developing lateral lobes of the thyroid. They have a short line of embryologic descent and remain close to the lateral lobe of the thyroid, along the posterior capsule in the region of the inferior thyroid artery. The inferior parathyroid glands are derived from the third branchial pouch and descend along with the developing thymus. Therefore they have a long line of descent; and, consequently, their position is much more variable. An inferior parathyroid gland can be carried, along with the developing thymus, into the anterior mediastinum or the pericardium. Conversely, it may be left behind high in the carotid sheath. Most inferior parathyroid glands, however, are found near the inferior pole of the thyroid in the vicinity of the thyrothymic tract. They frequently lie on the surface of the inferior pole of the thyroid, within the thyroid capsule. They may be found within clefts of thyroid tissue, giving an impression of being "intrathyroidal." Despite the variability in the anatomy of the parathyroid glands, there is frequently a symmetric arrangement between the position of the glands on the two sides of the neck. Symmetry of the superior glands is found in about 80% of cases and in 70% of inferior glands [15].

Each parathyroid gland generally has its own miniscule, end-artery. There is a single arterial supply in 80% of parathyroid glands, a dual arterial supply in 15%, and multiple arteries in the

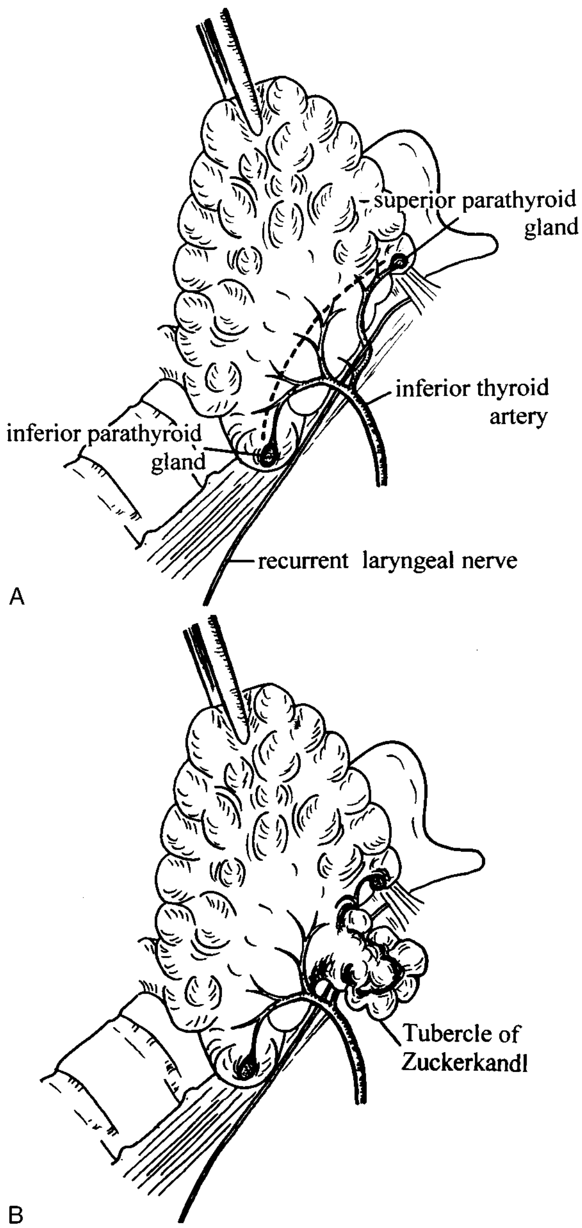

Fig. 2. A. Capsular dissection ligating individual tertiary branches of the inferior thyroid artery while preserving the blood supply to both parathyroid glands. The dashed line indicates the plane of capsular dissection. (From Delbridge et al. [18], with permission.) **B.** Relation of the recurrent laryngeal nerve and inferior thyroid artery to an enlarged tubercle of Zuckerkandl.

remaining 5% [16]. In most cases these arteries originate from the inferior thyroid artery, although in 20% of cases the superior parathyroid is supplied by a branch from the superior thyroid artery, sometimes associated with an anastomotic branch running between the superior and inferior thyroid artery territories [17].

The tubercle of Zuckerkandl is present in all thyroid glands and is represented as a thickening where the ultimobranchial body fuses into the principal median thyroid process. When enlarged, it may develop into a nodular process, with the recurrent laryngeal nerve passing medial to it in a fissure (Fig. 2B). This constant anatomic relation was stressed in a recent study of thyroidectomy technique that emphasized use of the tubercle to locate the recurrent laryngeal nerve [19]. In a study of 100 consecutive thyroid operations in our unit, an enlarged tubercle of Zuckerkandl was noted in 41 of 161 thyroid lobes examined (25%) [20]. In 37 of the 41 cases (97%), the recurrent laryngeal nerve was seen to lie in a fissure between the tubercle and the body of the thyroid or the tracheal surface. The nerve was located on the lateral aspect in only four cases.

Dissection of the Lateral Aspect of the Thyroid Lobe

Preservation of the blood supply to the parathyroid glands and protection of the recurrent laryngeal nerves is best achieved at this point by capsular dissection, as demonstrated in Figure 2A [18]. The thyroid lobe is retracted medially and elevated out of the wound. The tertiary branches of the vessels lying on the thyroid capsule are individually ligated and divided, progressing in a posterior direction toward the region of the inferior thyroid artery and the recurrent laryngeal nerve. During this process the superior and inferior parathyroid glands should be mobilized and reflected posterolaterally along with their vascular pedicle if technically possible. The recurrent laryngeal nerve is then "encountered" in the region of the ligament of Berry. The nerve is best identified by the presence of the vasa nervorum on its surface. It is not dissected out in its entirety but allowed to remain covered with a connective tissue sheath to minimize injury to its blood supply. The dissection continues medially, dividing the capsule of the thyroid. Once the nerve is seen to be free of overlying thyroidal tissue, it is allowed to fall back away from the area of dissection into the tracheoesophageal groove. Care must be taken while dissecting near the recurrent laryngeal nerve to preserve anterior branches of the nerve, which may divide a considerable distance away from the larynx.

The anatomy of the recurrent laryngeal nerve may be distorted by an enlarged tubercle of Zuckerkandl. If so, it is important that the plane of dissection continues along the surface of the tubercle, elevating it progressively. The recurrent laryngeal nerve is then generally located in a fissure medial to the tubercle on the lateral tracheal surface. The ligament of Berry and its surrounding terminal branches of the inferior thyroid artery can then be divided from the tracheal surface. In situations where the gland is associated with inflammatory change and fibrosis, such as Hashimoto's thyroiditis, there may not be a distinct plane between the ligament of Berry and the tracheal surface. A small tracheal perforation may occur at this point of the dissection; if so, it should be closed with interrupted absorbable sutures.

It may not be possible to preserve the blood supply to one or more of the parathyroid glands simply by virtue of their location, or else a gland may become ischemic after dissection of its vascular pedicle. In this case, the gland should be immediately autotransplanted into a bloodless pocket in the ipsilateral sternocleidomastoid muscle and the site marked with a permanent suture or clip. Routine autotransplantation of parathyroid glands has been advocated in patients undergoing radical head and neck surgery including total thyroidectomy. In our unit, we routinely autotransplant at least one parathyroid gland during every total thyroidectomy; the incidence of permanent hypoparathyroidism after this maneuver has been reduced to nearly zero [21]. The adequacy of the blood supply to a dissected parathyroid gland cannot always be assessed solely by its appearance. Further measures, such as incising the capsule to observe arterial

Table 1. Thyroid procedures (1978–1998).

Procedure	No.
Total thyroidectomy	2110
Bilateral subtotal thyroidectomy	962
Thyroid lobectomy	2606
Total lobectomy + partial lobectomy	582
Other thyroid procedures	442
Total	6702

Table 2. Indications for surgery in patients having total thyroidectomy (1978–1998).

Indication	No.
Compression	1128
Risk of a thyroid cancer	668
Thyrotoxicosis	181
Substernal position	81
Other indication	52
Total	2110

bleeding, or more advanced methods (e.g., Doppler assessment of blood flow) may be employed [22, 23].

Closure

After careful hemostasis, the wound is closed. Drains are no substitute for hemostasis, and a number of studies have demonstrated that there is no advantage to routine drainage following thyroidectomy [24, 25]. Prior to closure of the strap muscles, the wound should be filled with irrigant to remove any blood clots and to check for a small tracheal perforation. If the strap muscles have been divided, they should be reapproximated with absorbable sutures and the skin closed with a subcuticular suture. It is not necessary to reapproximate the platysma; by not doing so, it is our impression that the cosmetic results are superior.

Results of Capsular Dissection

Capsular dissection, as described, has been employed within our unit since the mid-1970s. Table 1 shows the number and type of thyroid procedures performed in the unit over the past 20 years (1978–1998) during the time that this technique has been firmly established. The ultimate test of the technique is the incidence of complications that arise when it is utilized during total thyroidectomy (i.e., when the true incidence of parathyroid damage can be assessed). Table 2 shows the number of total thyroidectomies performed during that period and the indications for those procedures. The incidence of permanent or major complications after total thyroidectomy is reported in Table 3. The overall incidence of permanent hypoparathyroidism requiring lifelong calcium/calcitriol supplementation (0.3%) and that of permanent recurrent laryngeal nerve paralysis (0.7%) is acceptably low using this thyroidecetomy technique. To determine the true incidence of recurrent laryngeal nerve paralysis, all patients are independently assessed with indirect laryngoscopy by an otolaryngologist.

Future Directions

Thyroidectomy is an operation for which the major technical details have changed little for nearly 100 years. Although there have been improvements in anesthesia, surgical instruments, and technique, the fundamentals of capsular dissection and preservation of the recurrent laryngeal nerves and parathyroid glands have been appreciated, even if not fully developed, since Kocher's era. The evolution of anesthetic techniques is already seeing thyroid surgery done under local anesthesia [26, 27]. With the impetus of cost containment, many thyroid resections may eventually become outpatient procedures [28]. Surgical instrumentation continues to improve, and the possible impact of ultrasonic dissection for thyroid surgery has now been reported [29].

One of the major advances that has the potential to affect thyroid surgery as we enter the new millennium is the development of minimally invasive surgery and its application to thyroidectomy. Although undergoing constant evolution, endoscopic techniques for dissection within extraperitoneal and retroperitoneal planes are well advanced, with extraperitoneal inguinal herniorraphy and retroperitoneal adrenalectomy already established in the surgical armamentarium. Endoscopic parathyroidectomy under CO_2 insufflation has been demonstrated to be technically feasible [30, 31]. Although it is not yet an accepted technique, some surgeons are even attempting a similar procedure through inframammary ports to enable thyroidectomy to be undertaken without any cervical scars at all. Whether such techniques can ultimately enable surgery for large multinodular goiters, thyroid cancers, and thyrotoxicosis to be undertaken endoscopically or the technique will remain restricted in its application to small benign thyroid nodules remains to be seen. Regardless, the importance of a detailed understanding of, and training in, surgical anatomy and surgical pathology of the thyroid gland remain the foundations of excellent technique.

Table 3. Permanent and major complications in 2110 patients having total thyroidectomy (1978–1998).

Complication	No.
Permanent hypoparathyroidism	5 (0.2%)
Permanent recurrent laryngeal nerve paralysis	14 (0.7%)
Early reoperation for hemorrhage	28 (1.3%)
Wound hematoma	18 (0.9%)
Wound infection	11 (0.5%)
Tracheostomy	3 (0.2%)
Death	3 (0.1%)

Résumé

La clé d'une chirurgie de la thyroïde sûre et efficace est l'apprentissage et la compréhension approfondis de l'anatomie et de la pathologie de la thyroïde. La dissection "capsulaire" de la thyroïde a été décrite pour la première fois par Halsted en 1907 et reste la base de la technique chirurgicale la plus sûre. Avec une technique appropriée, la lobectomie totale et la thyroïdectomie totale (qui est en fait une lobectomie totale bilaérale rélaisée pendant la même opération), peuvent être effectuées avec un risque minimal pour les nerfs récurrents, les branches externes des nerfs laryngés supérieurs et les parathyroïdes. La chirurgie sûre nĉessite un plan opératoire spécifique, progressant par une série d'étapes logiques, ordonnées, et basées sur l'anatomie. L'exposition de la thyroïde doit être suivie d'une dissection soigneuse du pôle supérieur, utilisant le plan avasculaire situé entre la pôle supérieur et le muscle cricothyroïdien pour identifier et préserver la branche externe du nerf laryngé supérieur. Par une rétraction sur la ligne médiane de la glande, on peut alors disséquer l'aspect latéral du lobe de la thyroïde. Par la

technique de la dissection dite «capsulaire», en liant les branches tertiaires de l'artère thyroïdienne inférieure sur la surface de la glande, on protège au mieux les nerfs laryngés récurrents et on préserve la vascularisation des parathyroïdes. Si l'on ne peut préserver une des parathyroïdes et/ou si l'une d'elles devient ischémique après la dissection de son pédicule vasculaire, il fault immédiatement la découper en petits morceaux et l'autotransplanter dans le muscle sternocléidomastoïdien homolatéral. La tendance thérapeutique actuelle vers la pratique de la thyroïdectomie ambulatoire ou de court séjour hospitalier souligne la nécessité d'une chirurgie sans complications par une technique méticuleuse. La thyroïdectomie par les techniques mini-invasives vidéo-endoscopiques peut également influencer l'impacte de la chirurgie de la thyroïde. De même, une compréhension complète de l'anatomie de la thyroïde et de ses variations possibles est essentielle pour réaliser une chirurgie sûre et effective.

Resumen

La clave de la cirugía tiroidea efectiva reside en una adecuada capacitación y una buena comprensión de la anatomía y patología de la glándula tiroides. La "disección capsular" de la tiroides fue descrita por primera vez por Halsted en 1907 y se mantiene como fundamento de seguridad de la técnica quirúrgica (1). Mediante técnicas apropiadas, se puede realizar lobectomía total o tiroidectomía total (que es simplemente una lobectomía total bilateral realizada en el mismo acto operatorio) con mínimo riesgo en cuanto a lesión de los nervios laríngeos recurrentes, las ramas externas de los nervios laríngeos recurrentes, las ramas externas de los nervios laríngeos superiores o las glándulas paratiroides. La seguirdad de la cirugía exige un plan operatorio específico, el cual se debe ejecutar en forma progresiva mediante pasos lógicos y ordenados, siempre basados en consideraciones anatómicas. Luego de la exposición de la glándula, sigue una cuidadosa disección de polo superior, aprovechando el plano avascular entre el polo superior y el músculo cricotiroideo con el fín de identificar y preservar la rama externa del nervio laríngeo superior. La retracción de la glándula hacia la línea media permite la disección del aspecto lateral del lóbulo tiroideo. La debida protección de los nervios laríngeos recurrentes y de la irrigación de las glándulas paratiroides se logra mediante la técnica de "disección capsular", ligando las ramas terciarias de la arteria tiroidea inferior sobre la superficie de la glándula. Cuando no sea posible preservar una glándula paratiroides, o cuando resulte isquémica luego de disecarla de us pedículo vascular, ésta debe ser seccionada de inmediato y autotrasplantada en el músculo esternocleido-mastoideo ipsilateral. La política actual de tiroidectomía ambulatoria o de corta estancia hace aún más pertinente el evitar complicaciones mediante meticulosa técnica quirúrgica. La tiroidectomía mínimamente invasora utilizando técnicas endoscópicas puede modificar la práctica de la cirugía tiroidea. Aun así, un detallado conocimiento de la anatomía quirúrgica de la glándula tiroides y de sus posibles variaciones es fundamental para el logro de una cirugía efectiva y segura.

References

1. Greene, W.W.: Three cases of bronchocele successfully removed. Am. J. Med. Sci. *121*:80, 1871
2. Thompson, N.W., Olsen, W.R., Hoffman, G.L.: The continuing development of the technique of thyroidectomy. Surgery *73*:913, 1973
3. Welbourne, R.B.: The thyroid. In The History of Endocrine Surgery, Welbourn, R.B., editor, New York, Praeger, 1990, p. 19
4. Coller, F.A., Boyden, A.M.: The development of the technique of thyroidectomy: presentation of method used in University Hospital. Surg. Gynecol. Obstet. *65*:495, 1937
5. Perzik, S.L.: The place of total thyroidectomy in the management of 909 patients with thyroid disease. Am. J. Surg. *132*:480, 1976
6. Clark, O.H.: Total thyroidectomy: the treatment of choice for patients with differentiated thyroid cancer. Ann. Surg. *196*:361, 1982
7. Khadra, M., Delbridge, L., Reeve, T.S., Poole, A.G., Crummer, P.: Total thyroidectomy: its role in the management of thyroid disease. Aust. N.Z. J. Surg. *62*:91, 1992
8. Kebebew, E., Clark, O.H.: Differentiated thyroid cancer: "complete" rational approach. World J. Surg. *24:*942, 2000
9. Droulias, C., Tzinas, S., Harlaftis, N., Akin, J.T., Gray, S.W., Skandalakis, J.E.: The superior laryngeal nerve. Am. Surg. *42*:635, 1976
10. Lennquist, S., Cahlin, C., Smeds, S.: The superior laryngeal nerve in thyroid surgery. Surgery *102*:999, 1987
11. Cernea, C.R., Ferraz, A.R., Nishio, S., Dutra, A., Hojaij, F.C., Medina dos Santos, L.R.: Surgical anatomy of the external branch of the superior laryngeal nerve. Head Neck *14*:380, 1992
12. Cernea, C.R., Nishio, S., Hojaij, F.C.: Identification of the external branch of the superior laryngeal nerve (EBSLN) in large goiters. Am. J. Otolaryngol. *16*:307, 1995
13. Teitelbaum, B.J., Wenig, B.L.: Superior laryngeal nerve injury from thyroid surgery. Head Neck *17*:36, 1995
14. Abdullah, H., Bliss, R., Reeve, T.S., Delbridge, L.: Recognition of an avascular space medial to the upper pole of the thyroid. Aust. N.Z. J. Surg. *68*:A63, 1998
15. Akerstrom, G., Malmaeus, J., Bergstrom, R.: Surgical anatomy of human parathyroid glands. Surgery *95*:14, 1984
16. Flament, J.B., Delattre, J.F., Pluot, M.: Arterial blood supply to the parathyroid glands: implications for thyroid surgery. Anat. Clin. *3*:279, 1982
17. Herrera, M.F., Gamboa-Dominguez, A.: Parathyroid embryology, anatomy, and pathology. In Textbook of Endocrine Surgery, Clark, O.H., Duh, Q.Y., editors, Philadelphia, Saunders, 1997, pp. 277–283
18. Delbridge, L., Reeve, T.S., Khadra, M., Poole, A.G.: Total thyroidectomy: the technique of capsular dissection. Aust. N.Z. J. Surg. *62*:96, 1992
19. Pelizzo, M.R., Toniato, A., Gemo, G.: Zuckerkandl's tuberculum: an arrow pointing to the recurrent laryngeal nerve (constant anatomical landmark). J. Am. Coll. Surg. *187*:333, 1998
20. Reeve, T.S., Delbridge, L.: The tubercle of Zuckerkandl: a guide to thyroid and parathyroid surgery. Aust. N.Z. J. Surg. *68*:A59, 1998
21. Zedenius, J., Wadstrom, C., Delbridge, L.: Routine autotransplantation of at least one parathyroid gland during total thyroidectomy may reduce permanent hypoparathyroidism to zero. Aust. N.Z. J. Surg. *69*:794, 1999
22. Ander, S., Johansson, K., Smeds, S.: Blood supply and parathyroid hormone secretion in pathological parathyroid glands. World J. Surg. *20*:598, 1996
23. Ander, S., Johansson, K., Smeds, S.: In situ preservation of the parathyroid glands during operations on the thyroid. Eur. J. Surg. *163*:33, 1997
24. Ayyash, K., Khammash, M., Tibblin, S.: Drain vs. no drain in primary thyroid and parathyroid surgery. Eur. J. Surg. *157*:113, 1991
25. Wihlborg, O., Bergljung, L., Martensson, H.: To drain or not to drain in thyroid surgery: a controlled clinical study. Arch. Surg. *123*:40, 1988
26. Saxe, A.W., Brown, E., Hamburger, S.W.: Thyroid and parathyroid surgery performed with patient under regional anesthesia. Surgery *103*:415, 1988
27. Hochman, M., Fee, W.E.: Thyroidectomy under local anesthesia. Head Neck Surg. *117*:405, 1991
28. Lo Gerfo, P., Gates, R., Gazetas, P.: Outpatient and short-stay thyroid surgery. Head Neck *13*:97, 1992
29. Voutilainen, P.E., Haapiainen, R.K., Haglund, C.H.: Ultrasonically activated shears in thyroid surgery. Am. J. Surg. *175*:491, 1998
30. Gagner, M.: Endoscopic subtotal parathyroidectomy in patients with primary hyperparathyroidism. Br. J. Surg. *83*:875, 1996
31. Yeung, G.H.: Endoscopic surgery of the neck: a new frontier. Surg. Laparosc. Endosc. *8*:227, 1998