Operative Techniques in Otolaryngology (2009) 20, 18-22

ELSEVIER

Operative Techniques in

Otolaryngology

Technique of total thyroidectomy for large substernal goiters

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KEYWORDS
Substernal goiter;
Thyroidectomy;
Multinodular goiter;
Retrosternal goiter;
Goitre

Large substernal goiters have presented a challenge to surgeons since the beginning of thyroid surgery. With the widespread use of cross-sectional imaging and high-resolution ultrasound, more thyroid pathology is identified every year. In the setting of compressive symptoms, refractory hyperthyroidism, cosmetic concerns, malignancy, or even prophylaxis, thyroidectomy is indicated for large substernal goiters. Our aims are to present (1) the rationale and an algorithm for a concise preoperative assessment for thyroidectomy and (2) a detailed stepwise description of the procedure—emphasizing safety—for a large substernal goiter. This description is complemented by a medical artist's illustrations to emphasize the salient points of dissection. With sound surgical technique, thyroidectomy, although still sometimes quite challenging, may be performed safely, with rare need for median sternotomy, providing great relief to the patient.

A goiter is defined as a thyroid gland that is enlarged to more than twice its normal size or weighing more than 40 g.[1] Because these glands enlarge as a result of either benign hypertrophy or malignant growth, the initial extension is typically outward as the overlying muscles and soft tissues expand. After this cervical enlargement, expansion may extend into the mediastinum, resulting in compression of the structures within the thoracic inlet. As the goiter descends into the mediastinum, 90% will descend into the anterior mediastinum, displacing the normal anatomical structures without invasion. The remaining 10% have a more posterior position within the upper mediastinum.[2] Primary growth of ectopic mediastinal thyroid tissue, separate from the cervical gland, will not be considered as these accounts for less than 1% of substernal goiters and are approached differently.[3]

Multiple definitions for large substernal goiters have been described. The 2 most common definitions are any thyroid mass that descends below the plane of the thoracic inlet[4] to more restrictive definitions requiring that more than 50% of the thyroid parenchyma reside inferior to the thoracic inlet.[5] Regardless of the definition, thyroidectomy often is required for relief of compressive symptoms. In regard to classification systems there are at least 2. The first grades mediastinal extension on a scale from one to four and the other grades goiters from 1 to 3 depending on the surgical approach required for thyroidectomy (1-cervical, 2-manubriotomy, 3-full sternotomy).[6,7]

In the general population, large substernal goiters occur in 1 in 5000. There is a 3:1 female predominance, with the highest incidence of 1 in 2000 in women older than the age of 45 years.[5]

Clinical presentation

Classically, patients present during the fourth and fifth decades of life with symptomatic goiters caused by one or a combination of the "3 Ds": dyspnea, dysphagia, and dysphonia. Of these 3, the most common complaint is dyspnea on exertion, which is present in 30% to 60% of patients.[8] The mass affect symptoms related to the goiter often are associated with positional changes that trap the gland within

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doi:10.1016/j.otot.2009.01.006

the inlet by either pulling it up or pushing it down into the thoracic inlet depending on where the bulk of the mass resides. Therefore, patients are more likely to become symptomatic when reclining to sleep or while bending at the waist. Severe compression of the trachea to a diameter less than 5 mm may be associated with stridor at rest and greatly exacerbated by even light exertion. Dysphonia when present should prompt preoperative vocal cord examination. The majority of patients have slow return of normal phonation postoperatively when the recurrent laryngeal nerve is simply stretched by a benign process. In addition to these symptoms of compression, there may be signs of hypothyroidism as with endemic iodine deficiency goiters or hyperthyroidism as with toxic multinodular goiters.

On physical examination, a substernal goiter should be suspected when the inferior margin of an enlarged thyroid gland is unable to be felt with the neck in extension. It should be noted that up to 20% of patients with large symptomatic substernal goiters may not have a palpable goiter in the neck. Distended neck veins and facial plethora are late findings in most cases yet these may be reproduced by having the patient raise both arms over head forcing the thyroid into the thoracic inlet, Pemberton's sign.[9] It is important during the examination to assess the patients cervical range of motion as full neck extension is vital to appropriate exposure and delivery of the gland through the thoracic inlet.

Preoperative testing

All patients with a goiter should have a serum thyroid-stimulating hormone (TSH) level checked regardless of symptoms to detect subclinical thyroid dysfunction. High resolution ultrasound has certainly been proven to be the examination of choice for evaluation of the thyroid within the neck but is unable to evaluate the substernal extension. Computed tomography (CT) or magnetic resonance imaging (MRI) should be used to better define the extent of the substernal component. Of these 2, we favor a noncontrast CT of the neck and chest for its exceptional precision, resolution, and availability in a brief low-risk examination. If better delineation of the vascular anatomy is required, intravenous contrast is administered. Nuclear medicine thyroid scanning is rarely indicated and provides little value in the setting of a symptomatic substernal goiter.

Pulmonary function testing demonstrates a blunted flow volume loop in the setting of a fixed mechanical upper airway obstruction and may be beneficial in documenting the absence of underlying pulmonary dysfunction. Likewise, video barium esophagrams document esophageal compression from a goiter but add little to the evaluation when resection is already clinically indicated.

Fine-needle aspiration biopsy of discrete suspicious lesions or in the setting of rapidly enlarging glands may provide useful information in the rare cases of thyroid lymphoma or anaplastic thyroid cancer. However, thyroidectomy in the presence of a substernal goiter is nearly always indicated based on symptoms and/or pulmonary dysfunction and rarely on fine-needle aspiration cytology. For prophylaxis in suitable patients, thyroidectomy prevents the development of atrial fibrillation in older patients from an unsuspected multinodular goiter with toxicity. Not to mention, the technical aspects become more difficult as the goiter enlarges down into the mediastinum.

Procedural technique

The operative technique is described in a step-wise approach that is supplemented by medical artist (DAF) drawings.

Positioning

The patient is induced with a general anesthetic and orotracheally intubated, which may require fiber optic techniques. We do not use intraoperative laryngeal nerve monitoring; thus, long-acting muscle relaxants may be used to facilitate retraction and exposure. The patient is positioned with both arms tucked by his/her sides in a "beach chair" position with a folded blanket behind the scapula to allow for maximal passive cervical extension. The endotracheal tube is secured away from the operative field.

Incision and exposure

A 6- to 10-cm transverse Kocher incision is centered 2 fingerbreadths above the sternal notch. The platysma is divided sharply and a superior subplatysmal flap is raised to the thyroid cartilage. A smaller inferior flap is dissected to the sternal notch. The "midline" of the strap muscles is then identified which is often deviated by an asymmetric goiter as illustrated (Figure 1B). These strap muscles are separated in the midline from the sternal notch to the thyroid cartilage protecting the anterior jugular veins. The anterior surface of both thyroid lobes is then exposed by blunt dissection. Often as the sternohyoid muscles are retracted the sternothyroid muscles may be divided without consequence as they are often very thin and attenuated (Figure 1C).

Thyroid isthmus division

The thyroid isthmus is exposed by ligating the arborizing venous network on the superior and inferior aspect of the isthmus. The avascular plane is developed posterior to the isthmus at the midline of the deviated trachea with a curved clamp. The isthmus is then divided with electrocautery with the clamp beneath the gland protecting trachea. If this is unusually vascular, the isthmus is clamped, transected and ligated.

Superior pole ligation

In contrast to our usual technique of securing the superior thyroid artery later in the dissection, it may be advan-

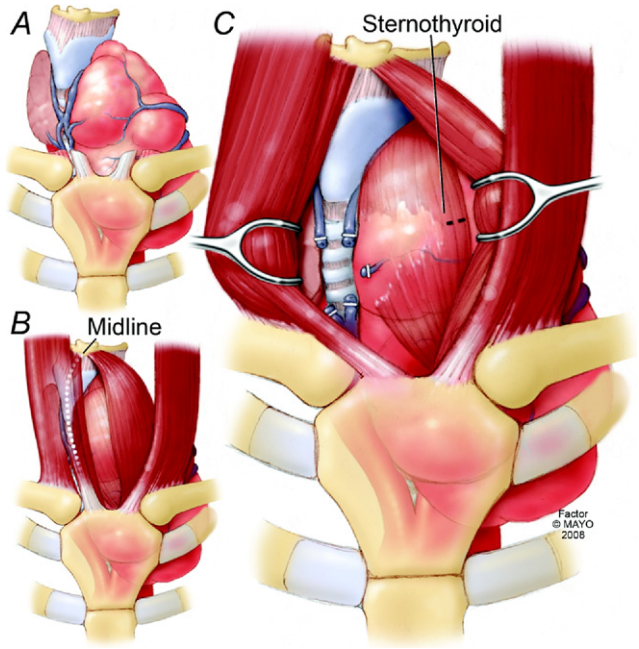

Figure 1 (A) Artistic depiction of an asymmetric substernal goiter with the left lobe extending inferiorly to the aortic arch. (B) The midline of the strap musculature and trachea are deviated away from the goiter. (C) The thyroid isthmus has been isolated and divided. The often-attenuated sternothyroid muscle is shown as it is divided before exposure of the superior thyroid pole. (Color version of figure is available online.)

tageous to address this vessel early in a large goiter. The artery is often elongated and more readily delineated with modest dissection of the strap muscles superiorly. The superior pole of the thyroid is then exposed to isolate (gently dissecting the external branch of the superior laryngeal nerve away from the vessels), clamp, divide and ligate the superior thyroid vessels (Figure 2). To further emphasize, care must be taken to create a window medial to the superior thyroid vasculature immediately adjacent to the thyroid to avoid injury to the superior laryngeal nerve. Gentle lateral retraction of the upper portion of the gland with a Kocher or Lahey clamp will further improve visualization. In extremely large goiters the strap musculature may have to be divided completely but this is uncommon in our experience. With the superior vasculature divided the gland becomes more mobile improving exposure, diminishing the considerable vascularity of the gland, and facilitating subsequent delivery out of its bed.

Substernal mobilization

Once the superior pole has been mobilized (if the anatomy has been favorable to proceed with this step initially), the remaining mass of the gland is delivered into the wound by carefully dissecting the strap muscles off of the goiter, developing the avascular areolar plane anterior to the common carotid artery throughout the entire length of the exposure. The only significant anatomic structure to cross the carotid artery over this segment is the middle thyroid vein which is isolated and divided. The surgeon's finger is insinuated under the strap muscles and immediately against the thyroid, "hooking" around the inferior aspect of the substernal component, separating its loose attachments in the mediastinum, and delivering it into the neck (Figure 3). This may have to be performed in advancing, successive steps with additional superior retraction by placement of Lahey clamps to facilitate careful advancement of a finger around the entirety of the gland. Rarely, a spoon may also be utilized to facilitate this delivery.[10]

Exposure of the recurrent laryngeal nerve

With the goiter delivered into the field, out of its bed, and retracted by the assistant, the common carotid artery and lateral aspect of the trachea are exposed. The surgeon must be aware that the recurrent laryngeal nerve (RLN) may be located more anteriorly than expected as the goiter and trachea are rotated (Figure 4). There also may be a portion of thyroid that has insinuated itself between the RLN and the trachea. For these reasons we believe that it is safest to identify the RLN rather low in the neck, allowing for it to be traced cephalad to the thyroid.

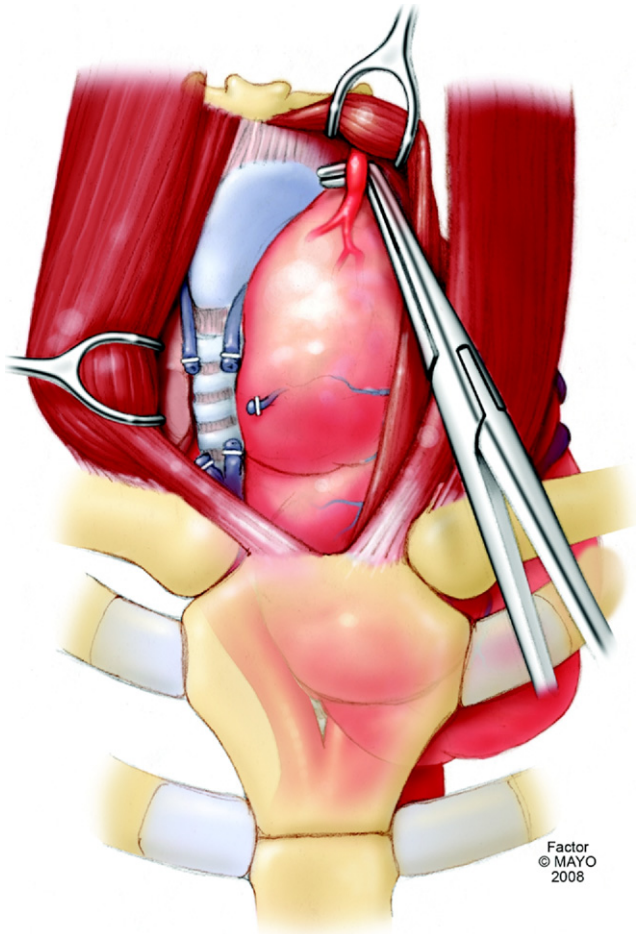

Figure 2 The sternohyoid muscle is retracted laterally as the superior thyroid vessels are divided while protecting the superior laryngeal nerve which lies posterior and medial to the superior thyroid vessel as illustrated. (Color version of figure is available online.)

Figure 3 The surgeon's left index finger follows the areolar plane anterior to the common carotid artery and is "hooked" around the tip of the substernal component. (Color version of figure is available online.)

Once the RLN is in clear view, all of the remaining vascular and soft-tissue attachments anterior to the nerve and around to the divided thyroid isthmus in the midline may be divided. Although it may be difficult to locate, the inferior parathyroid gland is sought and often cannot be retained in situ. It is biopsied for identity confirmation, then immediately minced and autotransplanted into the sternocleidomastoid muscle. The RLN is then able to be followed cephalad to its laryngeal insertion by dividing the vascular attachments coursing anterior to the nerve. As the dissection over the nerve nears the thyroid capsule the superior parathyroid gland is identified and the tiny branches from the typically large inferior thyroid artery are preserved (Figure 4). Just before insertion into the larynx, the RLN will arc slightly posteriorly. The nerve may be gently pushed more posteriorly at this point to aid in visualizing the remaining thyro-tracheal attachments. Attention is returned to the midline where the tracheal attachments may be divided with a combination of cautery, bipolar cautery, and hemostatic clips as the dissection proceeds laterally toward the identified insertion of the RLN into the larynx. Once this pedicle is dissected down to the last few millimeters, a 2-0 silk ligature is secured around the pedicle which is divided with a scalpel releasing the last attachment of the enlarged thyroid lobe. The contralateral side is removed in an identical fashion and is often more easily exposed because there is now more room for mobilization and exposure.

Closure

A single 7-French soft silastic drain is placed coursing through both thyroid beds exiting just lateral to the edge of the skin incision. If the strap muscles were divided, they are reapproximated with figure-of-eight 3-0 Vicryl sutures. The strap muscles are reapproximated in the midline with interrupted 3-0 Vicryl suture. Care is taken to leave an inferior opening to allow for subcutaneous decompression of any central neck hematoma in the event of postoperative hemorrhage. The platysma is reapproximated with interrupted 3-0 Vicryl suture and the skin is closed with a running 4-0 subcuticular Vicryl suture without knots. Steri-strips are applied with a loose bandage.

Conclusion

Since first described by Haller in 1749 and first resected by Klein in 1820, large substernal goiters continue to challenge thyroid surgeons today.[11,12] However, when the surgeon recommends proceeding, the description above provides a

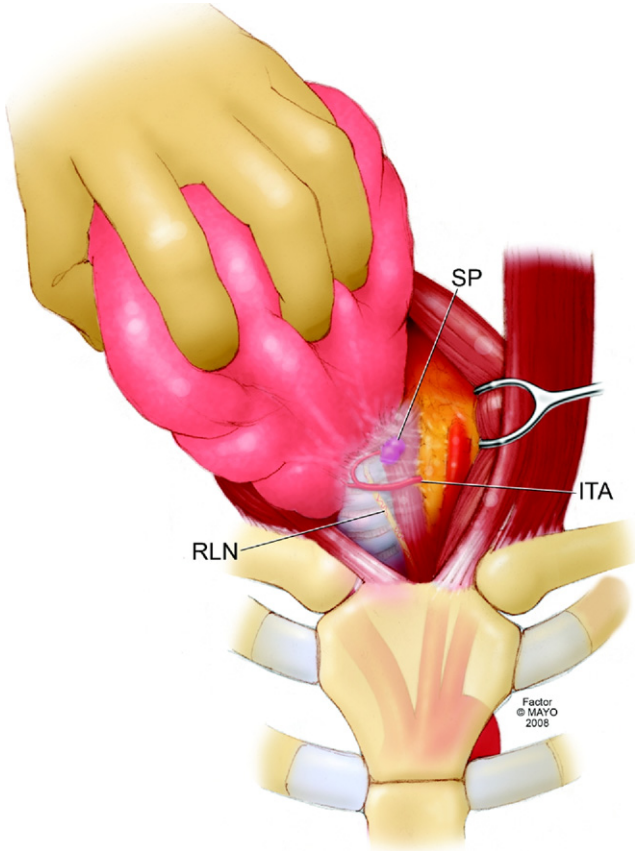

Figure 4 With the gland delivered into the wound the recurrent laryngeal nerve, inferior thyroid artery and superior parathyroid are identified. Note the more superior position of the recurrent laryngeal nerve as the retracted lobe has rotated the trachea. (Color version of figure is available online.)

stepwise, efficient, and safe method for total thyroidectomy. The incidence of laryngeal nerve injury when this method is employed is <1% and permanent hypoparathyroidism occurs in 1% to 2%.[13]

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