

Techniques, considerations and outcomes for surgical treatment of retrosternal goiter

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Abstract: Retrosternal goiter (RSG) occurs in 2–26% of thyroidectomies. We do not know why some goitres grow “outwards”, and others grow “inwards”. The features of RSG will be discussed, including the assessment and indications for surgery. Most RSGs can be removed trans-cervically. A novel shaver debulking technique is often effective, so sternotomy or thoracotomy is rarely required.

Keywords: retrosternal goiter, thyroidectomies, sternotomy, thoracotomy, larynx, multinodular goiter

Introduction

A goiter means an enlarged thyroid gland. The retrosternal goiter (RSG), (also called substernal, subclavicular, intrathoracic or mediastinal goiter) is defined as one that extends below the level of the sternal notch. RSGs occur in 2–26% of thyroidectomies (depending on how they are classified).

The actual etiology of RSGs is unknown. It would seem to be a combination of a low-lying larynx, enlargement of the inferior pole of a goiter, perhaps enhanced by gravity and negative intrathoracic pressure, as well as the cephalic and caudal movement of the larynx with swallowing (however, many of these factors are present in every person, whether they have a goiter or not).

The clinical presentation of a RSG ranges from being asymptomatic, or causing slight discomfort with swallowing or breathing. In some cases an RSG can cause major dysfunction in those activities, obstructive sleep apnoea, or even compression of large vessels. Because of the slow growth of goiters, patients can feel asymptomatic despite significant tracheal compression or oesophageal distortion, and often only realise how tight they were once the goiter has been removed.

There are three main types of substernal goiter²

- Type I - 85% - into the anterior mediastinum
- Type II - 15% - into the posterior mediastinum
- Type III - less than 1% - isolated mediastinal goiter with no connection to the normal gland.

The amount of retrosternal (intra-thoracic) extension is very individual, as is the extend of tracheal distortion and compression.

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Assessment of retrosternal goiter

Clinical examination can only assess the cervical component of the goiter. Inspection might reveal scars of previous neck surgery or venous distention. Palpation of the neck is useful to assess the cervical component of the gland, and assess for tracheal deviation, although that can be difficult as the thyroid notch and cricoid prominence are often impalpable due to the goiter. An assessment of retrosternal extension can be achieved by percussion of the sterno-clavicular joints, and with Pemberton's test,¹ raising the arms above the head, where a positive symptom is the patient feeling face or head pressure or shortness of breath, and a positive sign is facial plethora and venous engorgement.

As should be done in assessing all thyroid masses and goitres, and particularly before (and after) any thyroid surgery, the vocal cords should be examined (traditionally done with a mirror, but nowadays with fiberoptic trans-nasal laryngoscopy), looking for vocal cord paralysis or other distortions, including vocal cord edema. Vocal cord paralysis, in the absence of previous surgery, suggests malignancy, but benign goiters can very occasionally cause vocal cord palsy (I have had one case, where the nerve was stretched by a RSG which had enlarged suddenly due to a spontaneous intra-thyroid bleed, and the nerve recovered within 24 hrs of hemithyroidectomy). Examining the larynx prior to thyroid surgery is essential for this reason, but also for pre- and post-operative documentation of vocal cord movement for medico-legal reasons, even in a patient who has no voice change.

Although ultrasound is widely used to assess the cervical component of a goiter, and to assess nodules, it is unable to fully assess the extent of retrosternal extension, nor the amount of tracheal deviation or compression. As there is no radiation, it is useful on repeated studies for following the growth of the cervical component, but it is also limited by test-retest variability and operator-dependence.

Computerized tomographic (CT) scanning is best for assessing the mediastinal extension, and should be done with intravenous contrast injection as it displays the great vessels better, despite the use of iodine and the theoretical risk of delaying radio-iodine administration should a thyroid cancer be found at surgery, or of precipitation a thyroid crisis. Magnetic resonance imaging (MRI) with contrast enhancement is an alternative imaging modality, but is more expensive, and more prone to patient movement (because it takes longer to acquire the images), and of claustrophobia. Either imaging technique will show the extent of mediastinal

extension, the relationship to, and distortion of, the trachea, esophagus, and position of larger blood vessels.

Raising the arms also raises the thoracic inlet over the thyroid gland, causing a RSG to extend further down into the chest, as in Pemberton's test. Neck extension will also modify the position of the goiter. A CT scan of the chest is routinely done with the arms raised, but a CT scan of the neck region is done with the arms down by the side. For this reason, it is recommended that CT assessment of a Goiter be specifically requested to be performed with the arms down.³

Thyroid function tests, along with assessment of calcium levels, should be performed. The goiter can be associated with normal, high or low thyroid function. Pre-operative hypercalcemia can alert the surgeon to incidental Hyper-parathyroidism, which should be investigated pre-operatively so it can be managed at the time of the thyroidectomy (as a revision operation is much more difficult).

A Barium swallow will show the amount of deviation of the pharynx and esophagus, but in the absence of dysphagia, this test is usually not essential. Spirometry and flow-loop respiratory studies can be insensitive to the amount of tracheal compression, unless it is extreme, and are only useful if they are abnormal (and in such a patient, they usually have obvious symptomatic airway restriction).

Any dominant lump in a multinodular goiter should be subject to fine-needle aspiration under imaging guidance (Ultrasound, CT or MRI), for cytological assessment, if it can be reached with a needle. This can pre-warn of the presence of malignancy.

Anesthesia in the retrosternal goiter patient

The RSG often creates significant anxiety in the surgical and anesthetic team prior to anesthesia because of the possibility of tracheal compression. Usually, the compressed airway poses no problem to intubation, nor endo-tracheal tube placement.^{4,5} Randolph mentions only 4 cases out of 200 which had difficult intubations.¹

Intubation of the larynx is usually not a problem, as the vocal cords will be lying immediately beneath the epiglottis, and once the anesthetist sees it, he/she can intubate through the vocal cords. Equipment readily available on the "difficult intubation trolley". Video-laryngoscopes like Glidescope™ or C-Mac™ are useful, and also aid in the adjustment of the

Nerve Integrity Monitored (NIM)TM EndoTracheal Tube (which I always do, in all thyroidectomies, even though it is not proven to increase recurrent laryngeal nerve preservation) once the neck is extended into the operative position.

The size of the endotracheal tube might need to be reduced 0.5–1.0. Most benign goiters are soft and the tube will slightly dilate the narrowed trachea as it is inserted. However, malignancies can be hard, and perhaps even invade the trachea, which might not expand.

Rarely, an awake fiberoptic intubation is required, but that actually can be more difficult to pass.

Since the vocal cords should have been visualised by a surgeon pre-operatively, the surgeon should be able to notify the anesthetist of any expected difficulties in finding the larynx. Once the trachea is intubated, the tube will just follow any deviation, so it does not matter if the trachea is not midline.

If there is any question of difficult airway, anesthesia can be induced with intravenous agents, and assessed to see that ventilation with a mask is possible prior to being paralysed and then intubated. Some anesthetists don't paralyse at all in thyroidectomy cases, and this improves vocal cord (NIM) monitoring.

At the end of thyroidectomy, the trachea should be palpated for tracheomalacia, in case the patient needs to be intubated for a couple of days postoperatively or have a tracheotomy (a very rare requirement).⁵ I do not routinely look at the vocal cords at the end of a thyroidectomy, but perform fiberoptic laryngoscopy on all patients a week after surgery.

Surgery for retrosternal goitre

Allo and Thompson⁶ explained the rationale for operative management on RSG:

1. There is no other non-surgical treatment for long-standing large multinodular goiters, so if treatment is required, some type of thyroidectomy is the only option.
2. Iodine 131, an alternative to operation for patients with large thyrotoxic goiters, can precipitate acute swelling reactions, especially in the elderly, and can result in respiratory obstruction.
3. A long history of having a large multinodular goiter does not preclude malignancy, hyperfunction, nor complications such as tracheal or esophageal compression.
4. Malignancy occurs in some of these lesions, which can be inaccessible to needle biopsy.
5. Nearly all RSGs can be removed through a cervical incision.

6. The presence of a RSG is in itself an indication for operation, unless the patient has severe co-morbidities.

There is a range of operations for RSG, from subtotal or complete hemi-thyroidectomy, to sub-total or total removal of the gland (complete hemi-thyroidectomy or total thyroidectomy are my preferred options). This operation is usually done trans-cervically, but might require shaver debulking. Sternotomy or thoracotomy is rarely required, unless the intra-thoracic component of the RSG is not attached to the lower pole of the thyroid gland. Regardless of the surgical approach, such operations are challenging, and involve a high risk for the patient with an increased morbidity, especially if there is airway compromise, and if sternotomy is performed.

Because of the difficulties in re-operation for goitre, subtotal thyroidectomy is nowadays not recommended.⁷ I either perform a left hemithyroidectomy, a right hemithyroidectomy, or a total thyroidectomy. There is no advantage, in leaving a small remnant of thyroid. The supposed advantages are that the small remnant might be adequate to avoid the patient needing thyroid replacement therapy, but that is rarely worthwhile. Another purported advantage is that perhaps there is less dissection near the recurrent laryngeal nerve and the parathyroids, and hence there is less likelihood of vocal cord paralysis, bilateral vocal cord paralysis needing tracheotomy, and hypoparathyroidism. However, I do not think there is good evidence that there is a reduced complication rate. There certainly is a higher complication rate in revision thyroidectomy, where it can be much more difficult to save the recurrent laryngeal nerve or a functioning parathyroid because of scarring and distorted anatomy.

In multinodular goiter, if the contralateral lobe is not enlarged, I do a hemi-thyroidectomy of the problematic lobe and leave the contralateral node undisturbed, having divided the isthmus and using no dissection laterally. Should a completion thyroidectomy need to be performed in the future, there is no scarring near the important structures. In Randolph's series, he performed unilateral surgery in 63% of patients, bilateral surgery in 37%.¹

My surgical technique for retrosternal goitre

Many of the steps I take for RSG excision are the same as those I use in any thyroidectomy, and particularly for larger Multi-Nodular goiters.

I perform all of my thyroidectomies under a general anaesthetic, with the patient intubated with a Nerve Integrity Monitor™ on the endotracheal tube (Medtronic). Once the anesthetist has stabilised the patient, I insert a shoulder roll and then reassess the position of the NIM-ETT myself with Laryngoscopy (usually using a Glidescope™), as the tube position can move when the patient's neck is extended. I also test for a response of the NIM, by tapping on the larynx. I then raise the head of the bed to reduce venous pressure (and the anaesthetist raises the foot of the bed to reduce venous pooling). The patient has intermittent calf compression to reduce the risk of Deep Venous Thrombosis. I do not use peri-operative chemoprophylaxis with anticoagulants, nor antibiotics.

Unlike my short-incision technique for smaller thyroidectomies, for RSGs I use a wide collar incision, about midway between the cricoid cartilage and the sternal notch. Skin flaps are elevated directly over the strap muscles, down to the sternal notch, up to the hyoid bone, and extensively beneath them.

The thyroidectomy is performed with the aid of powered instrumentation, either a LigaSure (Small Jaw™) or a Harmonic scalpel (Focus™), as these will coagulate and cut blood vessels up to 5 mm in diameter. Rarely do I need to ligate any vessels during the case, but often I will use the addition of bipolar diathermy, particularly as I dissect around the parathyroids and Recurrent laryngeal nerve (RLNs). This saves time and aggravation in needing to stop dissection, changing instruments, and modifying retraction to ligate vessels. The operation is almost bloodless.

The strap muscles are divided vertically and separated in the midline, all the way down to the sternal notch and up to the level of at least the laryngeal prominence. I dissect down to the thyroid gland with the powered instrument being used almost bloodlessly for cutting and blunt dissection. I separate the strap muscles from the anterior and lateral walls of the thyroid capsule, by dissecting directly on the surface of the Thyroid capsule. The Sternothyroid muscle is transected at its cephalic end, close to the oblique line of the thyroid lamina, to free up the superior pole of the thyroid gland. I cut the fascial “envelope” that holds the Sternohyoid muscle which allows the muscle to be more easily retracted laterally and if need be, I transect that muscle as well (at the end of the case, I repair the muscles with 3–0 Vicryl suture). In particularly large goiters, the Sternocleidomastoid muscle needs to be transected at its sternal and even clavicular attachments (and later repaired).

Enlarged goiters will abut and sometimes distort the carotid sheath, so the structures of the carotid sheath should be identified early, in particular the vagus nerve (which can then be stimulated with the NIM to ensure that the endotracheal tube is in the correct position). The carotid sheath can then be followed inferiorly, to help with its retraction and protect it, later on in the case.

The trachea can be difficult to identify, being hidden by the goitre and the oftentimes thickened isthmus, and perhaps its position distorted by an asymmetric goitre. If it is present, the pyramidal lobe is dissected out. Dissection above and below the isthmus will identify the cricoid cartilage and the trachea. With the powered dissectors the isthmus can be divided without ligation, so it is not essential to dissect around it first – it can just be cut to expose the trachea, and this will aid in retraction and mobilization of the gland. Any persistent bleeding vessels can be controlled with bipolar (or monopolar) diathermy, and very large (>5 mm diameter) vessels should be ligated (I use 3/0 vicryl).

The cephalic aspect of the thyroidectomy is performed as in any thyroidectomy, with careful capsular dissection, trying to preserve the superior parathyroid glands and their vascularity, and the superior laryngeal nerve (SLN).⁸

Unlike Cernea's description of Thyroidectomy, I do not routinely identify the SLN.^{7,8,13,14} With the Sternothyroid muscle transected, the thyroid gland can be retracted laterally, the larynx is retracted medially, and the superior pole of the thyroid is separated from the larynx, dissecting and cutting from below, in a cephalad direction, keeping close to the gland. With either the LigaSure or the Harmonic scalpel, the smaller vessels can be “cauterised” and transected directly on the gland capsule, and as the fascia is cut, the gland will mobilize down, preserving the SLN. My assistant retracts the upper pole with a ‘Sponge-holding forceps’, as it is less likely to tear the capsule than other tissue retractors. The caudal retraction needs to push the upper pole posteriorly as well, to give me ‘working space’ to visualize the upper pole. If the upper pole is bulky, it can be decompressed with the ‘shaver’, as will be described below.

Caudal dissection of the upper pole of the thyroid gland should not continue below the level of the cricoid, as the RLN can be damaged in this situation. In some cases, it is worthwhile to identify the RLN at this point, and dissect it retrograde (see below).

Recurrent laryngeal nerve

It can be extremely difficult to identify the recurrent laryngeal nerve (RLN) until the retrosternal component of the goiter has been delivered. Randolph¹ found that in 16% of cases, the RLN was entrapped over the surface of the gland by fascial bands, or splayed over the surface so that delivery of the gland would necessarily injure the nerve by stretching or avulsing it, and this could occur on either side.⁹ Randolph recommends in these cases that the RLN be identified superiorly and dissected retrograde off the thyroid gland, and that no fascial bands anterior to the gland be dissected prior to identifying the recurrent nerve. Finding the Recurrent Laryngeal nerve as it enters the larynx, and dissecting retrograde (caudally) through the Ligament of Berry is sometimes required. Fascia overlying the anterior face of the larynx should be dissected from medially, sweeping laterally in case the Retrosternal extension of the gland is deep to the RLN.

Retrosternal component of the goiter

The cervical component of the goiter is dissected in the usual way but then, as it extends down behind the clavicle and the sternum, dissection should continue on the capsule of the thyroid, working medially to take it off the trachea, anteriorly, sweeping fascia laterally and postero-laterally, using a blunt dissection technique with finger dissection, and with the powered instrument. The blood supply to the thyroid comes from the neck, and so the retrosternal extension is an avascular plane into which the goiter bulges.

There will be various adhesions around the thyroid and fibrous bands. They can often be taken off and be delivered up into the neck with the surgeon's finger and then should be tested with the nerve stimulator, or even gently pinched between the blunt blades of the dissector, watching and listening for a vocal cord response on the Nerve Integrity Monitor, to ensure they are not branches of the RLN. As the gland is dissected and mobilised it can eventually be delivered into the neck and then retracted medially, the RLN and the inferior parathyroid gland can be identified, and preserved.

Post-operative care afterwards is the same as for any other MNG, although I always put a drain tube in cases of RSG (size 14 or 15 Blake drain), one on each side that has had surgery, whereas I do not routinely use a drain in routine thyroidectomies that have been reasonably bloodless.

In the literature, about 1% of RSGs are said to require a sternotomy, so in a significant case, a thoracic surgeon should be on standby, unless the surgeon doing the thyroidectomy is experienced in this manoeuvre.

Shaver debulking of the goiter, obviating the need for sternotomy

A technique that I found useful was described by Gady Har-El,¹⁰ who published a case series on this technique, and I have published on it, twice since.^{11,12}

It involves the use of a "sinus shaver" which ENT (and orthopedic/arthroscopic) surgeons are quite familiar with. It is a surgical device with a 3 mm diameter shaft that has suction and irrigation. Just before the distal end is a window, and internally to that is a cutting device that oscillates back and forth. Soft tissue is sucked into this window, which the shaver device amputates. The suction then clears it, aided by saline irrigation ([Video S1](#)).

Surprisingly, although the capsule of the thyroid gland is quite vascular, the internal part of the thyroid gland is usually not. This technique of debulking RSGs is not new, and was supposedly described by Kocher in 1889, and Lahey in 1921, but I cannot find the articles.^{13, 14}

A hole is diathermied in the anterior wall of the thyroid gland and a shaver blade inserted. The thyroid gland is debulked from within. The important thing in using this device is that the non-dominant hand should always be situated between the thyroid capsule and the mediastinal structures, and the shaver be always directed toward the finger of the opposite hand. The shaver cuts on the side, near the tip, not like a drill, so that as I begin to feel the shaver getting closer to the capsule, I use my non-dominant dissecting hand to push tissue into the shaver. This combined effect affords a degree of safety so that the capsule should not be penetrated, and is usually left with 1 cm or so of tissue. As the gland is debulked, it is much easier to then dissect and then retract and deliver the retrosternal component up into the neck. Fingers of the non-dominant hand assist in pushing the thyroid up into the neck, which is not difficult once the gland is decompressed.

There is sometimes steady oozing of blood from the centre of the gland, so I have a second sucker available for my assistant or nurse to use, and will sometimes use sponge-holding forceps to retract or squeeze on the cut edge of the gland to control bleeding.

Randolph does not support this option in his textbook,¹ but I have found it quite useful. Other surgeons, particularly

general or thyroid/endocrine surgeons, who have never used the shaver for sinuses, have expressed fears of the dangers of this technique. I suggest they practise using the shaver on a melon, and then on non-RSG, just to get the feel for the technique, in a more controlled manner under direct vision.

Sternotomy

Randolph's series had a 1% sternotomy rate.¹ Resection of the medial one third of the clavicle can also be used to increase the thoracic inlet space.

The decision as to whether to perform a sternotomy depends on various factors, obviously most particularly the amount of the intrathoracic thyroid.

Other factors which might predispose to recommending a sternotomy would be known or suspected malignancy (and the malignancy in otherwise appearing multinodular goiters is 5%), posterior mediastinal goiter with contralateral extension (type 2B), Superior vena cava syndrome, recurrent retrosternal goiter, or isolated Type III mediastinal goitre with no cervical attachment.

In cases with the more severe amounts of retrosternal extension, I have a thoracic surgeon "on-standby", in case I need a sternotomy. I have never needed to call a sternotomy.

Tracheomalacia

Tracheomalacia has been said to occur in 0.001–1.5% in cases. Other large series have found no cases of tracheomalacia.^{1,4}

Once the thyroidectomy is completed, the trachea should be palpated to see if it is softened. Bronchoscopy is not required to assess it.

The standard management of a suspected tracheomalacia is to leave the patient intubated for a couple of days, and it is difficult to understand of what benefit that would be, as the trachea is not going to become more rigid in such a short time. Other options that have been considered would be tracheotomy, Marlex mesh of the trachea, tracheal grafting or tracheopexy.

In summary

Retrosternal extension of a multinodular goiter is not an uncommon problem, is often asymptomatic, but also often

the patient has become unaware of symptoms that have developed slowly (over more than 10 years). It can compress the trachea. It can almost always be removed transcervically, without sternotomy nor via thoracotomy, particularly when the goiter is decompressed with a "sinus surgical shaver".

Disclosure

The author reports no conflicts of interest in this work.

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