The Laryngoscope

The Surgical Management of Goiter: Part II. Surgical Treatment and Results

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Objectives/Hypothesis: Surgery for goiter embodies a unique challenge. Our objective is to provide a comprehensive analysis of cervical and substernal goiter data in two paired articles. This second article focuses on surgical management. The following null hypotheses regarding goiter excision have been tested: 1) there are no goiter-associated risk factors for difficult intubation; 2) there are no predictive risk factors for recurrent laryngeal nerve injury (RLN) or postoperative hypocalcemia; 3) there is no difference in RLN injury with neural monitoring versus without.

Study Design: A retrospective review of 200 consecutive thyroidectomies meeting inclusion/exclusion criteria for cervical or substernal goiter.

Results: Temporary RLN paralysis occurred in 1.8% of nerves at risk and was significantly lower with recurrent laryngeal nerve monitoring than without. Permanent hypoparathyroidism occurred in 3% overall. Bilateral cervical goiter emerged as a definitive risk factor for difficult intubation ($P = .05$, univariate), recurrent laryngeal nerve injury ($P = .002$), and postoperative hypocalcemia ($P = .001$). Female patients ($P = .04$) or patients with positive family history ($P = .01$) were more likely to need repeat surgery. There were no cases of tracheomalacia, and sternotomy was required in 1%.

Conclusions: In this series of patients with extensive goiter, primary and revision surgery were associated with low rate of complications. Surgical complications were associated with bilateral and large goiters suggesting increased caution in these patients.

Key Words: Goiter, substernal goiter, thyromegaly, thyroid surgery, thyroid disease management, thyroid neoplasm, recurrent laryngeal nerve injury, thyroidectomy.

Level of evidence: 3b.

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INTRODUCTION

"The extirpation of the thyroid gland for goiter typifies better than any operation the supreme triumph of the surgeon's art." —William Halstead.[1]

The natural history of goiter is one of progressive growth. Nonsurgical treatments are often imperfect. Thyroid hormone (T4) suppression has varying efficacy, especially in large goiters. It also requires lifelong treatment, as it is associated with very high relapse rates after discontinuation, and its effects may be blunted by noncompliance. Aggressive T4 suppression risks atrial arrhythmia in the elderly population and promotes osteoporosis.[2,3] Radioactive iodine may result in acute radiation thyroiditis and is associated in up to 10% of cases with the development of autoimmune thyroiditis.[4]

Surgical treatment effectively controls regional aerodigestive compressive symptoms and provides tissue for histologic analysis. Also, surgical treatment effectively controls subclinical hyperthyroidism and is well tolerated by most patients. Goiter surgery presents several challenges, given potential anatomic distortion and obscuring bulk of the well-vascularized thyroid. Recurrent laryngeal nerve injury rates with markedly enlarged or substernal goiters have been as high as 17.5%.[5] Despite the large existing population of patients with thyromegaly and the potential for surgical complications, detailed datasets describing such patients have been limited. We therefore have evaluated a large series of patients requiring surgery for both cervical and

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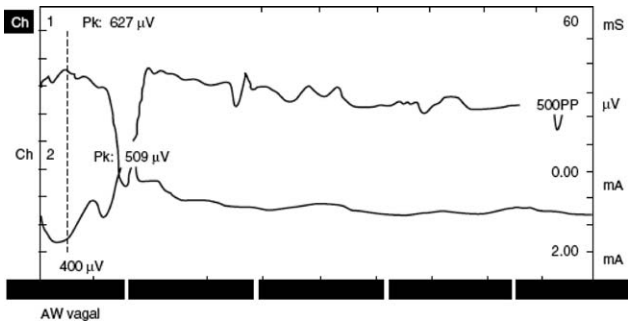

Fig. 1. EMG activity recorded in the thyroartenoid/vocalis muscle of the larynx during ipsilateral vagal nerve stimulation at 2 mA. Note the increased latency of the evoked response from vagal stimulation (as compared with RLN stimulation not depicted here). Stimulation artifact is represented by the vertical dotted line on the left.

substernal goiter, and have considered the following null hypotheses: 1) there are no risk factors for difficult intubation associated with goiter, 2) there are no predictive risk factors for recurrent laryngeal nerve injury (RLN), 3) there is no difference in RLN injury with neural monitoring versus without, 4) there are no risk factors for postoperative hypocalcemia.

METHODS

A retrospective review was performed of 200 consecutive thyroid procedures drawn from two surgical practices to select patients operated for large cervical and substernal goiters with institutional review board approval. Two hundred procedures were performed on 198 patients who met inclusion criteria. Inclusion criteria were created so that thyroid size was considered the predominant factor in the conduct of the surgery. Cases were included if the goiter extended substernally, or if a unilateral surgical specimen was at least 5 cm in greatest dimension on pathologic measurement (or >20 gram in weight) and if a bilateral surgical specimen was at least 9 cm in greatest dimension on pathologic measurement or (>40 gram in weight). Cases were excluded if the specimens had achieved larger sizes primarily due to preoperatively recognized malignant growth, although multinodular goiters containing small neoplastic foci were included, because the fundamental growth was not due to malignancy. Substernal goiter was defined as thyromegaly with extension through the thoracic inlet, extending below the clavicle, such that mediastinal dissection was required. Chart review was utilized to determine presenting symptoms, signs, imaging findings, preoperative laboratory evaluation, procedure type, operative findings, and surgical outcomes. Records encompassing a mean follow-up period of 10.7 months postoperatively were reviewed to determine patient's postoperative complications and their early postoperative course. Within the consecutive goiter population, neural monitoring was compared to cases without neural monitoring with regard to rates of nerve paralysis.

Surgical procedures were performed by two surgeons at the Massachusetts Eye and Ear Infirmary and Massachusetts General Hospital between 1976 and 1999. This case series evolved from the common conservative surgical philosophy and interest in associated goiter airway pathology shared by the two surgeons (H.G., G.W.R.) given their thoracic and otolaryngologic backgrounds, and represents an update of a previously reported smaller goiter series.[6] Unilateral surgery was offered when resolution of compression from one side of the thyroid was thought to be sufficient, while bilateral surgery was offered when significant bilateral goiter was present.

Potential risk factors for difficult intubation and postoperative complications were identified a priori, rather than a taking a "shotgun" approach, in order to prevent false positive information from multiple comparisons.

Operative Technique

The airway was managed jointly by the operating surgeon and anesthesiologist. Goiter excision was performed using previously described techniques.[4] Briefly, a standard collar incision was employed, with a vertical line extension into a "T" if sternotomy was necessary. Strap muscle division was performed at the discretion of the surgeon, and the carotid sheath was identified as a key landmark both for cervical anatomy and for extending dissection into the mediastinum. During the latter portion of the study period, from the early 1990s, electrophysiological neural monitoring was performed routinely by one surgeon (G.W.R.) (Fig. 1). Dissection of the carotid also facilitates confirmation of nerve monitor function, allowing for vagal stimulation, which can be utilized for the remainder of the surgery. A lateral or inferior approach to the nerve was used initially, with a superior approach reserved for use only when the goiter size and position prevented the more standard technique (Fig. 2).[4] The recurrent laryngeal nerve (RLN) was identified and dissected from the undersurface of the goiter, prior to ventral delivery, so as to avoid stretching or avulsion of a nerve tethered or splayed to the goiter's undersurface. Parathyroid glands were identified and preserved on a vascular pedicle. Glands that could not be spared were minced and autotransplanted to adjacent cervical musculature. Significant emphasis was placed on preserving the superior parathyroid, which are typically in a more constant position despite goiterous enlargement. Inferior

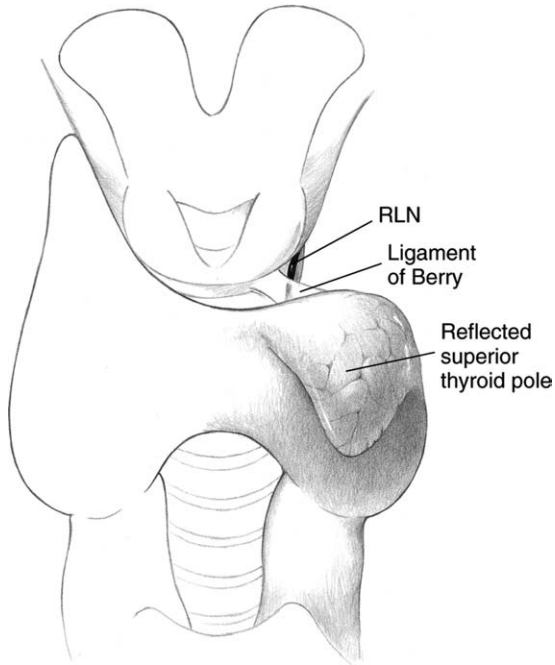

Fig. 2. The superior approach to the RLN involves identification at the nerve's most constant position in the neck, at the laryngeal entry point. The nerve can then be dissected retrograde from the undersurface of the goiter. (Reprinted with permission from Saunders.)

parathyroids were preserved using a strictly capsular dissection of the inferior pole. All thyroid specimens were meticulously examined prior to being sent off the field to identify and autotransplant any potential resected capsular parathyroid gland. Drains were placed in the majority of cases.

Although the surgeons practice in a tertiary care center with a high volume of complex and revision cases, both had a conservative surgical philosophy. Unilateral surgery was offered when one side of the thyroid was felt to be the primary surgical target for unilateral goiter and bilateral surgery when significant bilateral goiter was present. Subtotal thyroidectomy is defined as total lobectomy with a contralateral remnant approximately equivalent to a small normal lobe. A near total thyroidectomy is defned as when a several gram remnant is maintained in the contralateral bed typically adjacent to the RLN entry point.

Statistical Analysis

Continuous variables are summarized using means and standard deviations (SD). The Spearman rho correlation coefficient was used to measure the correlation between size and clinical symptoms. Fisher's exact test was used to compare binary proportions based on 2×2 tables. Outcomes included difficult intubation, abnormal RLN anatomy, postoperative complications (including hypocalcemia, recurrent laryngeal nerve injury, and hemorrhage), or need for revision surgery. Univariate and multivariate logistic regression analysis was conducted to identify variables associated with and independently predictive of each outcome.[7] The odds ratio (OR) and the 95% confidence interval (CI) were calculated as measures of risk for significant multivariate predictors. The final set of multivariate predictors was determined using stepwise forward selection procedure with the likelihood ratio test to assess significance. Sensitivity, specificity, and predictive values were calculated using standard formulas. Two-tailed values of $P < .05$ were considered significant. Statistical analysis was performed using the SPSS software package (version 16.0, SPSS Inc., Chicago, IL).

RESULTS

Patient and goiter characteristics are as described in Part 1 of this series.

Surgical Indications

Substernal extent was the surgical indication in the majority of cases (78%), as this factor alone is sufficient to warrant excision at our institutions. Additional surgical indications are as follows: compressive symptoms (49.5%), concern for cancer (17%), patient desire/cosmesis (3%), nonthyroid local neoplasm (1%), and other/nonspecified (1%).

Extent of Surgery

Unilateral surgery (lobectomy) was performed in 120 cases (63%), while bilateral surgery was performed in the remainder (37%)—subtotal thyroidectomy in 14%, near total thyroidectomy in 5.5%, and total thyroidectomy in 17.5%. The mean blood loss was 196 mL (range: 25–700 mL, SD 190 mL). Despite a large proportion of substernal goiters, only 1% of a patients required sternotomy.

Difficult Intubation

Only four patients (2%) had difficult intubations. Two of these patients were completely asymptomatic preoperatively, although the other two did present with shortness of breath. Two had received prior medical therapy, and the TSH was normal or low in all. One had a positive Pemberton's sign. All had imaging evidence of tracheal deviation and three had evidence of tracheal compression. Only one had substernal extension. Specimen sizes in these four patients were 5.1, 13, 18, and 25 cm.

The first patient failed multiple attempts at an awake fiberoptic intubation, but was successfully ventilated after a 6.0 endotracheal tube was inserted under direct vision with a standard anesthesia laryngoscope. The second patient required multiple attempts at intubation with a Miller blade. She required intubation with a 5.0 endotracheal tube, and ultimately received a tracheotomy. Both of these patients also had a recurrent laryngeal nerve, which was densely adherent to the goiter, with one nerve also splayed over the surface of the goiter. A third patient could not be ventilated during mask ventilation after general anesthesia was induced, and endotracheal intubation could not be obtained. A #7 rigid bronchoscope was urgently introduced. An attempt to replace the bronchoscope with an endotracheal tube was unsuccessful so the bronchoscope was reintroduced and she was maintained under general anesthesia in this fashion until the goiter was removed. After excision, the bronchoscope was replaced with an endotracheal tube without incident. The patient required temporary tracheotomy during her postoperative course. A fourth patient was intubated in the standard transoral fashion, but with difficulty by an experienced anesthesiologist.

Univariate and multivariate analyses were performed to test the null hypothesis that there were no patient characteristics that were predictive of a difficult intubation. Univariate analysis showed that the presence of bilateral goiter and increased goiter size (size as a continuous variable, $P = .05$) are predictors of difficult intubation. Subsequent multivariate analysis, however, suggested that there were no significant predictors of difficult intubation (size as a continuous variable, $P = .62$; bilateral surgery, $P = .28$). Difficult intubations were notably not predicted by size greater than 10 cm ($P = .29$ univariate, $P = .62$ multivariate), substernal extent ($P = .15$ univariate, $P = 0.73$ multivariate), presence of globus ($P = .065$ univariate, $P = .68$ multivariate), presence of positive preoperative Pemberton sign ($P = .69$ univariate, $P = .80$ multivariate), tracheal compression or deviation ($P = .16$ univariate, $P = .78$ multivariate), prior medical suppressive therapy ($P = 0.37$ univariate, $P = .15$ multivariate), or prior thyroid surgery ($P = .81$ univariate, $P = .92$ multivariate).

Surgical Complications

Recurrent laryngeal nerve injury. The 200 procedures placed 275 nerves at risk. There were no cases of permanent recurrent laryngeal nerve injury, but there

TABLE I.
RLN Paralysis and Goiter Surgery.

	Temporary paralysis	Permanent Paralysis
A. All patients	2.5% procedures 1.8% nerves at risk	0
B. Goiter surgery without RLN monitoring	11.7%	0
C. Goiter surgery with RLN monitoring	1.7%	0

Logistic regression RLN Monitoring associated with decreased RLN risk by 87% (odds ratio 0.13, likelihood ratio test 5.4, P = .02).

were five cases of transient unilateral vocal cord paralysis lasting between 2 weeks and 7 months (mean = 4.3 months). The transient nerve paralysis rate represented 2.5% of the total number of goiter procedures and 1.8% of nerves at risk. There were no cases of temporary or permanent bilateral cord paralysis.

Postoperative nerve injury was compared in patients who underwent goiter excision with versus without electrophysiologic laryngeal monitoring. The risk of temporary paralysis was significantly lower with monitoring (1.7% vs. 11.7%). Logistic regression indicated the use of neural monitoring was associated with decreased risk of RLN paralysis by an estimated 87% (OR 0.13, likelihood ratio test 5.4, P = .02; Table I).

A series of potential risk factors were evaluated to test the null hypothesis that there are no predictors of RLN injury during goiter surgery (Table II). Only bilateral goiter surgery predicted RLN injury on both univariate (P = .002) and multivariate (P = .001; OR 13.6, 90%, CI 5.1–36.2). Although size ≥10 cm was predictive on univariate analysis (P = .02), it was not so when a multivariate analysis was performed. Gender, presence of globus, prior medical suppressive therapy, revision surgery, and substernal extension all failed to predict RLN injury (Table II).

Hypoparathyroidism. Postoperative hypoparathyroidism occurred in 20 cases. Most were transient,

TABLE II.
Predictors of RLN Injury.

Variable	Univariate P Value	Multivariate P Value	Odds Ratio	95% Confidence Interval
Gender	.50	.52		
Globus	.31	.55		
Substernal extent	.82	.20		
Bilateral goiter	**.002**	**<.001***	**13.6**	**5.1–36.2**
Prior medical suppressive therapy	0.13	0.30		
Revision number	0.42	0.23		
Size ≥10 cm	0.02	0.99		

*Significant multivariate predictor of RLN injury.

TABLE III.
Predictors of Postoperative Hypocalcemia.

Variable	Univariate P Value	Multivariate P Value	Odds Ratio	95% Confidence Interval
Gender	.27	.25		
Globus	.98	.83		
Substernal extent	.40	.74		
Bilateral goiter	**<.001**	**<.001***	**10.2**	**3.8–27.2**
Prior medical Suppressive therapy	.37	.65		
Revision	.43	.30		
Size >10 cm	<.001	.24		

*Significant predictor of postop hypocalcemia.

with 14 of 20 cases lasting less than 6 months and resolving spontaneously. Permanent hypocalcemia occurred 8.1% of patients having bilateral surgery (3% of patients overall) requiring supplementation for more than 6 months. Statistical analysis was performed to determine what factors were associated with increased risk of postoperative hypocalcemia (Table III). Multivariate analysis revealed that only bilateral surgery (P < .001) was independently predictive of postoperative hypoparathyroidism. Previous thyroid surgery, gender, revision number, cervical size, and substernal extent were not significantly associated with postoperative hypoparathyroidism.

Tracheotomy. Tracheotomy was required in 3% of patients. We had a low threshold for temporary tracheotomy in cases where there was concern for laryngeal edema associated with the patient's initial intubation or in cases of known preoperative unilateral vocal cord dysfunction where the contralateral vocal cord integrity was in question during surgery. There were no cases of tracheotomy for tracheomalacia in our series.

Revision surgery. Overall, 40 of the study procedures (20%) represented revision procedures. Of these revision procedures, 33 (16%) represented the patient's second thyroidectomy (i.e., first revision). Four represented the patient's third thyroidectomy (2%), and three represented the patient's fourth thyroidectomy (1.5%). For these revision cases all except three of the initial procedures were performed at other institutions. Recurrence after our surgery occurred in three of 200 procedures (1.5%). A variety of variables were investigated for this revision group (Table IV). Univariate analysis showed that revision cases were more likely to be female (P = .04), have a family history of thyroid disease (P = .01), and have had a trial of medical suppressive therapy (P = .03). Multivariate analysis again showed significant correlation between the need for revision and female gender (P = .02), OR (3.0), and a positive family history (P = .009, OR 6.5). Overall, females were found to be three times more likely and those with a positive family history of thyroid disease six times more likely to require revision surgery. In both univariate and multivariate analysis, there was no

TABLE IV.
Analysis for Patients Undergoing Revision Surgeries.

Variable	Univariate P Value	Multivariate P Value	Odds Radio	95% Confidence Interval
Gender	***.04***	***.02***	***3.0***	***1.5–6.1***
DOB	.29	.46		
Dysphagia	.66	.38		
Family history	***<.01***	***<.01***	***6.5***	***2.4–17.3***
Tracheal deviation	.81	.66		
Tracheal compression	.81	—		
Esophageal deviation	.25	.27		
Esophageal compression	.58	—		
Size >10 cm	.55	.61		
Pathology	.12	.17		
Complications	.70	.90		
Prior medical Suppressive therapy	.03	.20		

significant correlation between revision surgery and presence of substernal goiter, shortness of breath, dysphagia, tracheal deviation or compression, esophageal deviation or compression, size greater than 10 cm, previous radioactive iodine treatment, presence of postoperative complications from the first surgery, or final pathology (Table IV). Revision cases whether unilateral or bilateral, second, third, or fourth revisions were not more likely to be associated with postoperative complications than first time surgery in our series (Tables II and III).

Other complications. Other complications included one episode of hemorrhage requiring ligation of a bleeding vessel in the operating room and one occurrence of postoperative subglottic stenosis eventually requiring tracheotomy in a multiple revision patient. Further complications were limited to one case of transient postoperative atrial fibrillation in a preoperative euthyroid patient, two cases of dysphagia following removal of masses causing esophageal deviation or compression, one wound seroma, one suture granuloma, and one wound infection.

Sternotomy and Mediastinal Vascular Supply

Despite nearly 80% of patients having substernal extension, our sternotomy rate was only 1%. These low numbers did not permit statistical analysis. One sternotomy was required for a 12-cm 237-gram mass, whereas the other was required for a 10-cm, 176-gram mass. Both patients presented with shortness of breath and had benign follicular adenoma on final pathology. In the majority of cases, even large goiters could be removed transcervically (Fig. 4). In two cases the blood supply to the thyroid mass removed was provided by vessels of intrathoracic origin. In both cases the final pathology was adenomatous goiter.

Pathologic Diagnoses

The final pathology was most often benign adenomatous goiter (53.3%) or follicular adenoma (34%). Hashimoto's thyroiditis was found in 6.6%, well-differentiated thyroid carcinoma in 7.1% (papillary in 5.1%, follicular carcinoma 2.0%) (Table V).

DISCUSSION

Extent of Surgery

Decisions regarding the extent of surgery relate to the balance between operative complications and the risk of recurrence. Long-term studies show rates of recurrence that range from 15% to 42%.[8–10] Some suggest total thyroidectomy for goiter,[11,12] some suggest a more conservative initial surgical plan,[6] while some, such as Kraimps,[26] suggest a selectively aggressive surgical treatment plan based on extent of disease. Complication rates must be kept extremely low in the setting of treatment of benign thyroid disease. Therefore, we suggest a conservative philosophy tailoring the extent of surgery to the initial disease with the minimum procedure being a total unilateral lobar resection, reserving bilateral surgery for significant bilateral goiter. This surgical philosophy resulted in unilateral surgery in 63% of patients and bilateral surgery in 37% and only a 1.5% recurrence rate (in patients undergoing initial surgery at our center). Female gender and a positive family history for goiter were significantly associated with presenting for revision surgery, similar to the work of Berghout,[13] but selection bias may confound this finding.

Airway Management

We discuss all information regarding preoperative laryngeal exam, including edema, deviation, and vocal cord mobility with experienced anesthesia personnel. Transoral intubation has been straightforward in the majority of cases. Typically, a compressed tracheal segment opens to an endotracheal tube with stylet, despite preoperative compression in the setting of benign goiter. If there is malignant infiltration of the trachea, however, such opening may not occur.

In the setting of a large, bilateral cervical goiter, the larynx can, however, develop significant and long-

TABLE V.
Final Pathology Report.

Pathology	Percentage of Patients
Adenomatous goiter	***53.3***
Follicular adenoma	34.0
Hashimoto's	6.6
Papillary carcinoma	5.1
Follicular carcinoma	2.0
Graves	0.5
Paratracheal schwannoma	0.5
Squamous metaplasia	0.5

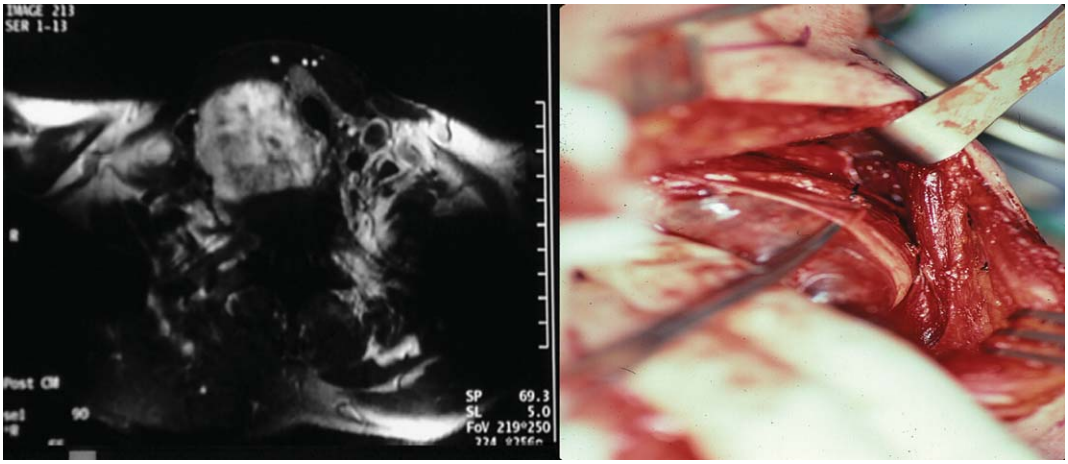

Fig. 3. Large retro tracheal goiter excavates the region posterior to the RLN, bringing the nerve into a high-risk ventral position relative to the thyroid, just under the strap muscles.

lasting edema if multiple traumatic intubation attempts occur. The larynx in this setting likely has reduced venous and lymphatic drainage in the setting of large, bilateral, constricting goiter as emphasized by Hassard.[14] Awake fiber optic intubation is a reasonable option if there is any question regarding the adequacy of a mask ventilation, particularly if the larynx is significantly deviated by the cervical component of the goiter. Newer video laryngoscopes are also an excellent adjunct for intubation in such patients. Given size and location, an emergent tracheotomy through the mass is typically not a viable option.

Although multivariate analysis failed to show size, substernal extension, presence of preoperative compressive symptoms, positive Pemberton's sign, radiographic finding of tracheal deviation or compression, revision or bilateral surgery predicted difficult intubation, regression analysis may have been limited by the small number of difficult intubations. Vigilance and recognition of nonthyroid factors such as jaw and tongue size, anteriorly positioned larynx, and available degree of head extension is required by surgery are also important determinants of difficult intubation.

In none of the cases, trachea was found insufficient postoperatively, despite some cases of a chronic and significant tracheal deviation and compression with remodeling. In our experience, true tracheomalacia caused by benign goiter is rare. Cases referred to our practices with a transferring diagnosis of tracheomalacia after goiter surgery has ultimately have been diagnosed as bilateral vocal cord paralysis. A number of large series have failed to document any clear-cut case of tracheomalacia.[2,15–18] Bennett's[19] comprehensive review of the surgical literature also suggests that tracheomalacia is a rare entity.

Tracheotomy in our series was performed in only 3% of patients, and was done electively at the time of thyroidectomy, not for tracheomalacia, but because there was either concern about laryngeal edema from multiple intubation attempts or in the case where vocal cord function was in question especially if one vocal cord was known to be paralyzed preoperatively. With neural monitoring greater certainty now is available as to the functional status of both nerves during surgery.

RLN and Parathyroid Complications

In this series, the mean goiter size was 10.5 cm and the mean weight was 143 grams, with 80% having substernal extension and 20% undergoing revision surgery. Although size certainly relates to risk of surgical complications, we also found that a number of other factors are important in the conduct of surgery, including degree of capsular blood vessel engorgement and friability, goiter consistency, and compressibility.

RLN injury. RLN permanent paralysis rate was zero with five cases of transient paralysis representing a transient paralysis rate of 2.5% of procedures and 1.8% nerves at risk all resolving between 2 weeks and 7 months (mean = 4.3 months). Laryngeal nerve monitoring was associated with a decreased risk of RLN paralysis by 87%. However, monitoring was performed by only one of the two surgeons and only during the

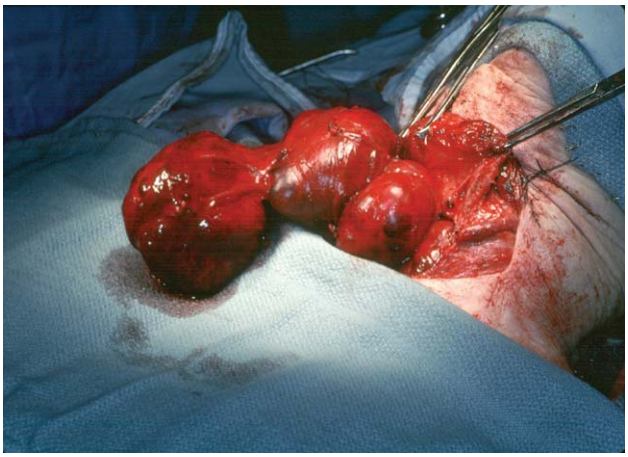

Fig. 4. Substernal goiter delivered transcervically.

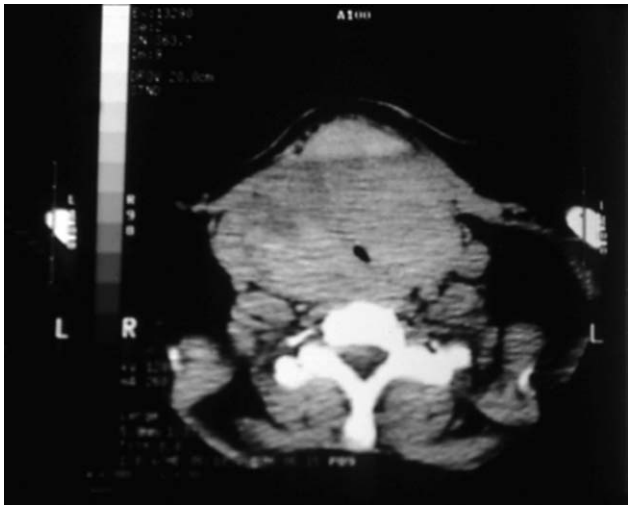

Fig. 5. CT scan of a patient presenting with stridor after two previous bilateral thyroidectomies. Nerve monitoring was used during third revision total thyroidectomy and was found valuable. No tracheomalcia was present, airway symptoms resolved postoperatively, and tracheotomy was not needed. Cord motion was normal after surgery.

later portion of the study period, which may confound the association of lower RLN rates of paralysis and monitoring. Multivariate analysis of RLN paralysis during goiter surgery found that increased RLN risk was predicted by the presence of bilateral cervical goiter, but not by size, presence of revision surgery, substernal extension, or preoperative compressive symptoms.

Retrotracheal goiter and posterior mediastinal goiter, when identified on preoperative CT scan, can help predict a ventrally displaced RLN where it is at extremely high risk. This position can be predicted by close attention to preoperative CT scanning through identification of retrotracheal or posterior mediastinal elements (Fig. 3).

Rates of paralysis can be low in expert hands during goiter surgery,[20] but vary significantly. For example, Sinclair,[5] while showing an overall rate of paralysis of 1.1% in 767 thyroid surgeries, revealed a rate of 17.5% in a subset of patients operated for substernal goiter. In a German multicenter study of 7,266 patients with benign goiter, Thomusch[21] found through logistical regression that RLN paralysis was related to the extent of surgery, consistent with our results. He also reported that RLN injury was associated with recurrent goiter and failure to identify the recurrent laryngeal during surgery. Shen,[22] in a surgical series of 60 patients with a substernal goiter, found 12% had airway complications postoperatively but did not provide information regarding postoperative laryngeal examination in these patients. Rios-Zambudio,[23] in 301 patients with goiter operated on by experienced endocrine surgeons, found that RLN injury was more likely if the patient was hyperthyroid, in larger and substernal goiters and occurred in 8.6% of their surgical patients, but again, routine larngoscopy was not preformed.

Hypoparathyroidism. We found permanent hypoparathyroidism in 8% of patients undergoing bilateral surgery and in 3% overall in our group overall, which was characterized by a 20% revision group. Thomusch[21] found that in benign goiter surgery long-term hypoparathyroidism was related to extent of resection. Their analyses also showed an association with recurrent goiter, older age, female gender, and Graves' disease.

Revision Surgery

In our series, revision surgery was not associated with an increased complication rate compared to first time surgery. In the literature, risks for revision goiter surgery range from permanent RLN paralysis (3%–18%) and permanent hypoparathyroidism (0%–25%).[20,24–27] Preoperative evaluation should include review of prior operative notes, laryngeal exam, and low threshold for CT scanning in euthyroid patients. The RLN may be identified from an inferior approach below past surgical scarring, or through a superior approach depending on

TABLE VI.
Substernal Goiter Classification.

Type	Location	Anatomy	Prevalence	Approach, comment
I	Anterior mediastinum	Anterior to great vessels, trachea, RLN	85%	Transcervical (sternotomy, only if intrathoracis goiter diameter > thoracic inlet diameter)
II	Posterior mediastinum	Posterior to great vessels, trachea, RLN	15%	As above, Also consider stemotomy or right posterolateral thoracotomy if type IIB
IIA	Ipsilateral extension			
IIB	Contralateral extension			
B1	Extension posterior to both trachea and esophagus			
B2	Extension between trachea and esophagus			
III	Isolated mediastinal goiter	No connection to orthotopic gland; may have mediastinal blood supply	<1%	Transcervical or stemotomy

RLN, Recurrent laryngeal nerve.
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the extent of past surgery. A posterior remnant from prior surgery may regrow and displace the RLN (see Figs. 3 and 5).

Substernal Goiter

Substernal goiter delivery is performed only after the recurrent laryngeal nerve is identified. Digital dissection on a capsular plane and slow, incremental hemostatic delivery is recommended. Strict capsular level dissection is essential. Substernal goiter is the product of the neck, with its blood supply typically deriving from the neck and only rarely from mediastinal vessels such as the thyroid IMA, subclavian, or internal mammary artery. It is best to cauterize only thin transparent fascial bands generated by goiter mobilization and clamp thicker bands after recurrent laryngeal nerve and vagus locations are completely understood. We recommend goiter mobilization always after RLN identification.

With these techniques, large substernal goiters can be safely delivered into the neck without sternotomy (Fig. 4). We consider sternotomy in the following circumstances: malignancy extending into the mediastinum, including cases of true superior vena cava (SVC) syndrome, in cases of large posterior mediastinal goiter (where sternotomy versus right thoracotomy should be considered), cases of substernal goiter with mediastinal blood supply (including substernal goiters type 3; Table VI), large recurrent substernal goiters, cases where the intrathoracic component's diameter is substantially greater than the diameter of the thoracic inlet, and cases where substantial hemorrhage or goiterous adhesions to adjacent mediastinal vessels or pleura are identified.

CONCLUSIONS

Intubation

Only four patients (2%) had difficult intubations, and although univariate analysis suggested size and bilaterality of goiter was predicative, multivariate analysis suggested that there were no significant predictors of difficult intubation. An experienced anesthesia staff and the close interaction and sharing of information regarding preoperative laryngeal exam, CT results between the anesthesia staff and the surgeon, is essential at the time of intubation. Transoral intubation (with or without fiberoptic laryngoscope) is straightforward in the majority of cases with the compressed tracheal segment opens to an endotracheal tube with stylet. Awake fiber optic intubation should be kept as a reasonable second option.

RLN Injury

The transient nerve paralysis rate was 1.8% of nerves at risk (with no cases of permanent RLN paralysis) and was significantly lower with electrophsyiologic monitoring (1.7% vs. 11.7%), decreasing risk of RLN paralysis by an estimated 87%. Although it is the belief of the surgeon employing monitoring that it is associated with improved rates of paralysis, the confounding factors of two different surgeons working over different time frames makes this to difficult to prove.

Parathyroid Injury

Bilateral cervical goiter emerged as a definitive risk factor for difficult intubation ($P = .05$), recurrent laryngeal nerve injury ($P = .002$), and postoperative hypocalcemia ($P = .001$). Multivariate analysis revealed that only bilateral surgery ($P < .001$) was independently predictive of postoperative hypoparathyroidism. Previous thyroid surgery, cervical size, and substernal extent were not significantly associated with postoperative hypoparathyroidism.

Extent of Surgery

We suggest a conservative philosophy tailoring the extent of surgery to the initial disease with the minimum procedure being a total unilateral lobar resection, reserving bilateral surgery for significant bilateral goiter. Need for revision surgery may be more likely in females with a family history of goiter.

Revision Surgery

In our series, revision surgery was not associated with an increased neural complication rate compared to first-time surgery. We recommended aggressive preoperative evaluation with laryngeal exam, low threshold for CT scanning in euthyroid patients, and review of prior operative notes.

There were no cases of tracheomalacia, and sternotomy is rarely required, even in cases of large substernal goiters.

BIBLIOGRAPHY

1. Halstead WS. Operative story of goiter: the author's operation. *Johns Hopkins Hosp Rep* 1929;19:71.
2. McHenry CR, Piotrowski JJ. Thyroidectomy in patients with marked thyroid enlargement: airway management, morbidity, and outcome. *Am Surg* 1994;60:586–591.
3. Burgi U, Hans JP, Gerber H. Clinical manifestations and management of nontoxic diffuse and nodular goiter. In: Braverman LE,Utiger RD, eds. *Werner and Ingbar's The Thyroid: A Fundamental and Clinical Text*, 7th ed. Philadelphia, PA: Lippincott-Raven; 1996:896–900.
4. Randolph GW. Surgery of cervical and substernal goiter. In: Randolph GW, ed. *Surgery of the Thyroid and Parathyroid Glands*. Philadelphia, PA: Saunders; 2003:70–99.
5. Sinclair IS. The risk to the recurrent laryngeal nerves in thyroid and parathyroid surgery. *J R Coll Surg Edinb* 1994;9:253–257.
6. Katlic N, Grillo H, Wang CA. Substernal goiter: analysis of 80 patients from Massachusetts General Hospital. *Am J Surg* 1985;149:283.
7. Hosmer DW, Lemeshow S. Interpretation of the fitted logistic regression model. In: Hosmer DW, Lemeshow S, eds. *Applied Logistic Regression*, 2nd ed. New York: Wiley; 2000:47–90.
8. Bistrup C, Nielsen JD, Gregersen G, et al. Preventive effect of levothyroxine in patients operated for non-toxic goitre: a randomized trial of one hundred patients with nine years follow-up. *Clin Endocrinol (Oxf)* 1994; 40:323–327.
9. Hegedus L, Nygaard B, Hansen JM. Is routine thyroxine treatment to hinder postoperative recurrence of nontoxic goiter justified? *J Clin Endocrinol Metab* 1999;84:756–760.
10. Rojdmark J, Jarhult J. High long term recurrence rate after subtotal thyroidectomy for nodular goitre. *Eur J Surg* 1995;161:725–727.
11. Delbridge L, Guinea AI, Reeve TS. Total thyroidectomy for bilateral benign multinodular goiter: effect of changing practice. *Arch Surg* 1999;134: 1389–1393.
12. Perzik S. The place of total thyroidectomy in the management of 909 patients with thyroid disease. *Am J Surg* 1976;132:480–483.
13. Aasted A, Bertelsen S. Superior venal caval syndrome in benign mediastinal goiter. *Acta Chir Scand* 1981;147:405.

14. Hassard AD, Holland JG. Benign thyroid disease and upper airway obstruction: case presentations, pathophysiology, and management. *J Otolaryngol* 1982;11:77–82.
15. Hillerdal G, Aust R, Dubiel WT, et al. Intrathoracic goitre with the superior vena cava syndrome, hoarseness and acute stridor. *ORL J Otorhinolaryngol Relat Spec* 1979;40:340–345.
16. Rodriguez JM, Hernandez Q, Pinero A, et al. Substernal goiter: clinical experience of 72 cases. *Ann Otol Rhinol Laryngol* 1999;108:501–504.
17. Shaha AR, Burnett C, Alfonso A, et al. Goiters and airway problems. *Am J Surg* 1989;158:378–380; discussion 80–81.
18. Huysmans D, Hermus A, Edelbroek M, et al. Radioiodine for nontoxic multinodular goiter. *Thyroid* 1997;7:235–239.
19. Bennett AM, Hashmi SM, Premachandra DJ, et al. The myth of tracheomalacia and difficult intubation in cases of retrosternal goitre. *J Laryngol Otol* 2004;118:778–780.
20. Reeve TS, Delbridge L, Brady P, et al. Secondary thyroidectomy: a twenty-year experience. *World J Surg* 1988;12:449–453.
21. Thomusch O, Machens A, Sekulla C, et al. Multivariate analysis of risk factors for postoperative complications in benign goiter surgery: prospective multicenter study in Germany. *World J Surg* 2000;24: 1335–1341.
22. Shen WT, Kebebew E, Duh QY, et al. Predictors of airway complications after thyroidectomy for substernal goiter. *Arch Surg* 2004;139:656–659; discussion 59–60.
23. Rios Zambudio A, Rodriguez Gonzalez JM, Torregrosa Perez NM, et al. [Hypoparathyroidism and hypocalcemia following thyroid surgery of multinodular goiter. Multivariant study of the risk factors]. *Med Clin (Barc)* 2004;122:365–368.
24. Greenbon JP, Frolund L. Recurrence of non-toxic goiter with and without postoperative thyroxin medication. *Clin Endocrinol (Oxf)* 1984; 21:529.
25. Pappalardo G, Guadalaxara A, Frattaroli FM, et al. Total compared with subtotal thyroidectomy in benign nodular disease: personal series and review of published reports. *Eur J Surg* 1998;164:501–506.
26. Kraimps JL, Marechaud R, Gineste D, et al. Analysis and prevention of recurrent goiter. *Surg Gynecol Obstet* 1993;176:319–322.
27. Roher HD, Goretzki PE. Management of goiter and thyroid nodules in an area of endemic goiter. *Surg Clin North Am* 1987;67:233–249.