

The Surgical Management of Goiter: Part I. Preoperative Evaluation

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Objectives/Hypothesis: Our overarching objective is to provide a comprehensive analysis of goiter data in two paired articles. This first article focuses on the preoperative evaluation. The following null hypotheses have been tested: 1) there is no correlation between goiter size and preoperative symptoms, 2) there is no correlation between preoperative neck imaging abnormalities and preoperative symptoms, and 3) there are no predictors for goiter recurrence.

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

Results: The mean specimen size was 10.5 ± 4.8 cm and 142.9 ± 113.3 grams. There was a positive correlation between goiter size and preoperative shortness of breath ($P = .02$). The presence of substernal goiter was significantly correlated with tracheal deviation and tracheal compression ($P < .01$) on neck imaging. There was strong correlation between preoperative shortness of breath and tracheal compression ($P < .001$) on neck computed tomography (CT), but not tracheal deviation. The need for revision surgery was significantly associated with female gender (odds ratio 3.0; 95% confidence interval [CI] 1.5, 6.1, and a positive family history of thyroid disease (odds ratio 6.5 [2.4, 17.3]).

Conclusions: Goiter size is associated with increasing symptoms. Tracheal compression but not deviation was related to shortness of breath. Females and patients with a positive family history of goiter have an increased risk of goiter recurrence.

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

Level of Evidence: 3b.

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INTRODUCTION

The word goiter is derived from “guttur,” the Latin term for throat.¹ Surgery for goiter can be complex, as the normal neck base anatomy is distorted in sometimes predictable and occasionally unpredictable ways. Halstead² wrote that “the extirpation of the thyroid gland for goiter...provide[s] perhaps more than other opera-

tions the supreme triumph of the surgeons’ art.” The incidence of sporadic nontoxic goiter in North America has been estimated to be 5%.³ Iodine deficiency, which contributes to goiter development, affects nearly 30% of the world’s population or 1.5 billion people.⁴ Substernal goiter affects up to 1 in 5,000 patients.^{5,6} Studies on chest X-ray (CXR) radiographic screenings in Australia and the United States suggest substernal goiter occurs in 0.02% of the population.^{5,6} The natural history of goiter is one of progressive growth, which may result in progressive dyspnea, dysphagia, and untoward cosmetic changes. Substernal goiter prompts concern for progressive compression of vascular and airway structures and makes the gland less amenable to surveillance, including fine-needle aspiration. Thus, thyromegaly is a common problem that regularly requires surgical treatment.

Despite the large number of goiter patients and the potential for surgical complications, data available on such patients is relatively limited, especially regarding the appropriate preoperative symptomatic and radiographic assessment, as well as the perioperative airway management in such patients. We therefore present paired articles describing a large consecutive series of patients requiring surgery for cervical and substernal goiter. In this first of two articles, we focus on the preoperative presentation and evaluation of the goiter patient. The data collected was evaluated to test the following

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TABLE I.
Patient, Goiter, and Procedure Characteristics.

Goiter type: No. (Percentage)	All Goiters n = 200 (100%)	Cervical Goiters n = 42 (21%)	Substernal Goiters n=158 (79%)
Age in years: mean (range)	58.5 (22–89)	46 (22–86)	61 (22–89)
Gender: no. female (percentage)	130 (65%)		
Specimen length in cm: mean (SD)	10.5 (4.8)	9.7	10.7
Unilateral n = 120	9.1 (2.7)		
Bilateral n = 80	14.3 (5)		
Specimen weight in grams mean (SD)	142.9 (113.3)		
Unilateral n = 120	95.6 (83.4)		
Bilateral n = 80	188.6 (129)		
Revision procedure—(%)			
Total revision	20%		
2nd surgery	16%		
3rd surgery	2%		
4th surgery	1.5%		
Sternotomy	1%		

null hypotheses: 1) there is no correlation between goiter size and preoperative symptoms, 2) preoperative symptoms do not correlate with deviation or compression of aerodigestive structures on imaging, and 3) there are no clinical predictors for goiter recurrence and need for revision goiter surgery.

METHODS

A retrospective review of consecutive thyroid procedures drawn from two surgical practices to select patients operated for large cervical and substernal goiters was performed with institutional review board approval. Two hundred procedures were performed on 198 patients who met inclusion criteria. Inclusion criteria were prespecified so that thyroid size was considered the predominant factor in the conduct of the surgery. Specifically, cases were included if the goiter extended subinternally or if a unilateral surgical specimen was at least 5 cm in dimension on pathologic measurement (or >20 grams in weight) and if a bilateral surgical specimen was at least 9 cm in dimension on pathologic measurement (or >40 grams in weight). Cases were excluded if the index mass was clearly suspected to be malignant preoperatively, although multinodular goiters containing small neoplastic foci detected on postoperative pathology were included. 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. 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 (in terms of extent of thyroidectomy for benign goiter) and interest in associated airway pathology shared by the two surgeons (H.G., G.W.R.), and represents an update of a previously reported smaller goiter series.⁷

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.⁸ 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, Goiter, and Procedure Characteristics

During the study period, 200 procedures (performed on 198 patients) met the prespecified inclusion criteria. Patient and goiter characteristics are as detailed in Table I. Mean follow-up period was 10.7 months postoperatively.

Preoperative Symptoms and Signs

Detailed records of preoperative history, head and neck exam, and perioperative imaging were available for 195 patients. Symptoms at presentation are summarized in Table IIa, and had been present for a duration ranging from 3 days to 13 years. Preoperative physical exam findings are as described in Table IIb. Vocal cord paralysis was present preoperatively in 7 of 198 (3.5%) patients; none of these patients had malignancy on final pathology, but three of the seven did have a past history of surgery. Thus, 4 (2%) out of a total of 198 patients, presented with vocal cord paralysis in the setting of benign disease and in absence of prior neck surgery. A

TABLE II. History and Examination Findings:	
TABLE IIa Presenting History	
Symptom	Percentage
Shortness of breath	49.7%
Dysphagia	30.2
Self discovered mass	25.1
No reported symptoms	20.5
Voice change	12.8
Discomfort/pain	4.6
Globus	4.1
Hypothyroid symptoms	3.1
Hyperthyroid symptoms	2.6
Hemoptysis	1.0
TABLE IIb Presenting Physical Examination Findings	
Signs	Percentage
Palpable cervical mass	85
Tracheal deviation	25.1
Vocal cord paralysis	3.5
Positive Pemberton's maneuver	4.4
Dilated head and neck veins	1.5
No evidence of cervical goiter	
On physical exam	15

positive Pemberton maneuver and dilated head and neck veins were rare, although these findings were not necessarily elicited in all patients.

Preoperative Symptoms and Goiter Size

There was a positive correlation between thyroid size and presence of shortness of breath (SOB) ($P = .02$), globus sensation ($P = .02$), and symptoms of hyperthyroidism ($P = .04$), refuting the first null hypothesis that there was no correlation between goiter size and preoperative symptoms. There was, however, no correlation between goiter size and presence of dysphagia, local discomfort, change in voice, hemoptysis, or symptoms of hypothyroidism. There was no significant difference in the percentage of patients with airway symptoms between patients with purely cervical and patients with substernal goiter.

Imaging

Imaging was performed on all but nine patients. The most common study performed was CXR (89.5%) followed by computerized tomography (CT) of the neck (41.5%) and I^{131} scanning (33.3%). Barium swallow (20%), ultrasound (16.4%), magnetic resonance imaging (8.7%), and fluoroscopy (8.7%) were less commonly used. Results of these studies showed that tracheal deviation (68.7%) and tracheal compression (43.6%) were far more common than esophageal deviation (13.8%) and compression (8.2%). Thus, for both the trachea and esophagus, deviation was more common than compression, but devi-

ation was not a requisite for compression in cases of bilateral goiter with circumferential compression.

Imaging findings and preoperative symptoms.

Overall there was a good relationship between airway and esophageal imaging findings and preoperative symptoms.

Airway

There was a highly significant positive correlation between SOB and tracheal compression on preoperative imaging ($P < .001$, Fisher's exact test) for all patients, refuting the second null hypothesis that there was no correlation between preoperative symptoms and objective imaging findings. There was, however, no significant correlation between SOB and tracheal deviation ($P = .99$). However, SOB as a potential screening test for tracheal deviation or compression was found to be of limited value (Table III).

Esophagus

There was a significant positive correlation between the presence of preoperative dysphagia and the presence of esophageal compression and deviation ($P = .02$, $P = .014$, Fisher's exact test), again refuting the second null hypothesis that there was no correlation between preoperative symptoms and imaging findings. Dysphagia as a screening test for esophageal deviation or compression had a strong negative predictive value and somewhat strong specificity. The positive predictive value and sensitivity, however, were poor (Table III).

Substernal Goiter and Airway Findings

When the large group of patients of substernal goiter were compared to the group of purely cervical goiter, substernal extent was highly associated with tracheal deviation ($P < .001$) and tracheal compression ($P = .01$). In fact, substernal masses were four times more likely to be associated with tracheal deviation (odd ratio 4.3, $P < .001$) and over twice as likely to be associated with tracheal compression (OR 2.5, $P = .01$) compared to purely cervical masses.

Preoperative Thyroid Function Tests, I^{123} Scanning, and FNA

Radioactive scanning revealed cold nodules in 46.1% of those who had I^{123} scans. Only 19.3% of patients had abnormal function tests on presentation. Of these 38 patients, 13 had altered TSH because of suppressive therapy and one had thyrotoxicosis secondary to iodine exposure. Thus, only 24 patients (8.25%) had noniatrogenic causes of abnormal thyroid function testing. Of these patients, the vast majority (87.5%) were without reported symptoms of thyroid dysfunction. Only two patients with abnormal thyroid function testing reported symptoms of hypothyroidism and only one patient reported symptoms of hyperthyroidism. Forty-nine needle aspirations were performed prior to the 200 procedures.

TABLE III. Relationship between SOB and Tracheal Deviation (TD).	
SOB and TD	P = .99 NS
SOB as screening test for TD	
• Sensitivity 49% • Specificity 53% • PPV 68% • NPV 34%	
Relationship between SOB and Tracheal Compression (TC)	
SOB and TC	P < .0001
SOB as screening test for TC	
• Sensitivity 67% • Specificity 65% • PPV 59% • NPV 73%	
Relationship between Dysphagia and Esophageal Deviation (ED)	
Dysphagia in ED	P = .014
Dysphagia as a screening test for ED	
• Sensitivity 52% • Specificity 74% • PPV 24% • NPV 91%	
Relationship between Dysphagia and Esophageal Compression (EC)	
Dysphagia and EC	P = .02
Dysphagia as a screening test for EC	
• Sensitivity 69% • Specificity 74% • PPV 19% • NPV 96%	
SOB = shortness of breath; PPV = positive predictive value; NPV = negative predictive value.	

Previous treatment: Medical

TSH suppressive therapy with T4 was attempted in 57 patients (28.5%) for a duration ranging from six months to 31 years. Fourteen patients (7%) underwent previous radioactive iodine therapy. In total, 66 patients or 1/3 of the study population had failed medical management.

Previous Treatment: Surgical

When evaluating patients undergoing revision surgery, by univariate and multivariate analysis, there was no significant correlation between revision cases and preoperative shortness of breath, dysphagia, tracheal deviation or compression, esophageal deviation or compression, presence of substernal goiter, size greater than 10 cm, previous radioactive iodine treatment, or final pathology type (Table IV).

DISCUSSION

In this series, the mean goiter size was 10.5 cm and the mean weight was 143 grams, with 80% having substernal extension. The definition of goiter, although empiric, has great significance when studying the topic and may be based on preoperative imaging diameters or postoperative weight in grams. The latter, used frequently, has the disadvantage that it is difficult to estimate preoperatively. The definition of goiter has markedly varied among reports, with some authors suggesting any thyroid specimen of over 40 grams represents a goiter. McHenry⁹ suggested 80 grams, Russell¹⁰ 100 grams, whereas Clark⁹⁻¹³ proposed 200 grams as the threshold value. Lobectomy specimens in our study were 2 to 8 times normal (based on weight) and total thyroidectomy specimens 5 to 20 times normal (based on weight). A variety of substernal goiter definitions have also been proposed and are reviewed elsewhere.¹¹ We defined substernal goiter as goiter associated with substernal extension such that the thoracic component extends below the clavicles and requires mediastinal dissection to facilitate extraction and have previously proposed a substernal goiter classification scheme that takes into account important features that must be appreciated for safe extraction.¹¹

In our series, patients with cervical goiter were found to be on average 15 years younger than that of patients with substernal goiter, consistent with the work of Torre,¹² suggesting that substernal goiter may evolve from preexisting cervical goiter in many cases. This may occur through the repetitive forces of deglutition, respiratory dynamics, negative intrathoracic pressure, and gravitational forces in the setting of permissive mediastinal and neck fascial planes.

Miller¹³ and Gittos¹⁴ have shown that upper airway obstruction occurs in about one-third of patients with goiter seen in general medical endocrinology clinics, emphasizing the importance of optimal airway evaluation in goiter patients. Common presenting symptoms in

TABLE IV.
Analysis for Patients Undergoing Revision Surgeries.

Variable	Univariate P-Value	Multivariate P-Value	Odds Ratio	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		

our series included SOB (approximately 50%) and dysphagia (approximately 50%), emphasizing the effect of cervical and substernal goiter on the adjacent cervical viscera. Although earnest symptomatic assessment at presentation is crucial in patients with cervical and substernal goiter, clinical experience suggests subjective symptomatic assessment of the upper aerodigestive tract compressive symptoms in patients with goiter can be quite problematic. The sensitivity, specificity, and predictive value of SOB for tracheal deviation or compression in our dataset were limited. For the airway, symptomatic assessment alone may therefore be inadequate in goiter patients. In the setting of large cervical or substernal goiters one cannot purely rely on the presence or absence of shortness of breath for assessment of true tracheal compromise, without routine axial CT scanning assessment for tracheal compression.

Multivariate analysis showed that the presence of SOB was related to goiter size. Furthermore, the presence of SOB was significantly related to the imaging finding of tracheal compression ($P < .0001$) but not to tracheal deviation consistent with the work of Mackle.¹⁵ Thus, clearly there is a relationship between SOB, goiter size, and tracheal compression. Because of this relationship between SOB and the objective CT scan radiographic finding of tracheal compression, tracheal compression appears to be an important radiographic finding. We therefore feel that the preoperative radiographic finding of tracheal compression is an appropriate surgical indication.

In this series, the radiographic finding of tracheal deviation and compression was two to four times more likely for substernal goiter compared to cervical goiter. Bucky¹⁶ reported that the maximum tracheal impact for substernal goiter is generally at the level of the thoracic inlet. The relationship between tracheal compression and substernal extension is one of the main factors leading to substernal extension representing a routine surgical indication in our center.

CT scanning. The majority of patients undergoing imaging in this study underwent CXR, with nearly half undergoing axial CT scanning of the neck, to evaluate the preoperative airway. According to some reports, the plain CXR air column may underestimate tracheal narrowing.^{7,17-21} Within our own patients, we also found that the plain CXR might show no narrowing, whereas significant narrowing was appreciated on the axial CT (Fig. 1). This potential plain CXR underestimation may occur in the setting of bilateral cervical goiter, where bilateral growth may result in compression yet lack of deviation of the CXR air column. The functional impact of airway narrowing diagnosed via CT scan remains controversial. Barker and others^{13,22,23} have noted that when CT scans show more than 50%–75% tracheal narrowing, airway symptoms are expected. However, Melissant and others^{19,24} have found little correlation between lung function and CT scan defined degree of tracheal obstruction.

CT can be performed safely (i.e., without the Jod-Basedow phenomena) in patients with thyroid disease, if TSH is not found to be suppressed. We are more likely

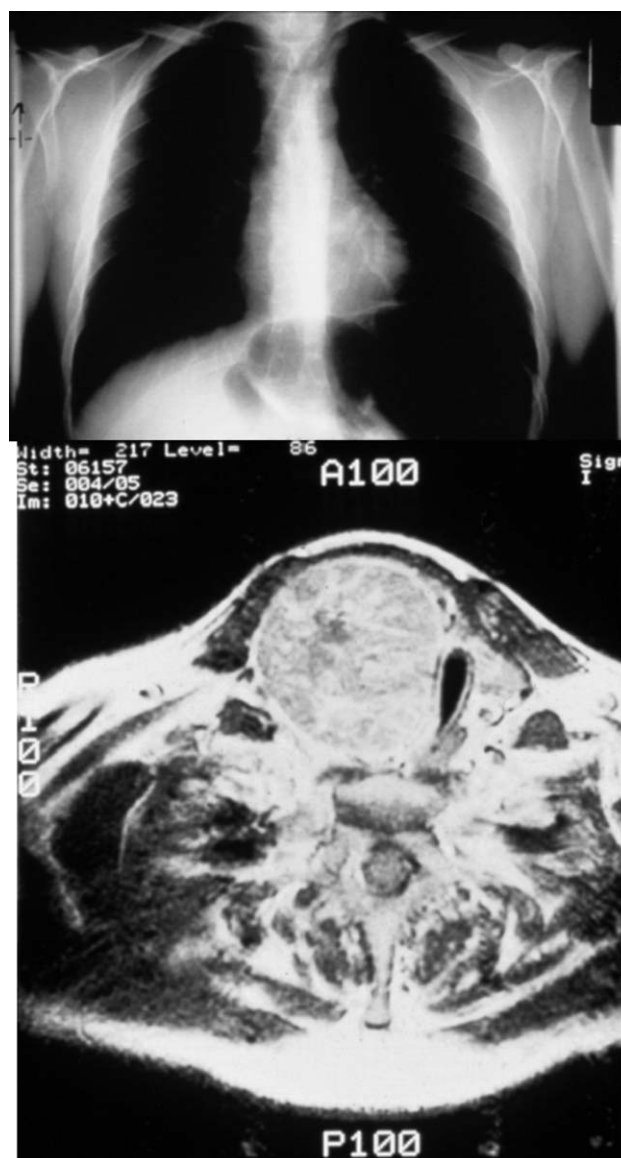


Fig. 1. Patient with a benign nodule acutely enlarged through central hemorrhage, with plain film air column deviation without significant compression seen. Axially scanning, however, revealed significant airway compression in this acutely symptomatic patient.

to obtain CT if the clinical exam suggests that the goiter is large, symptomatic, bilateral, substernal, or if malignancy is suspected based on vocal cord paralysis or regional lymphadenopathy. Axial CT provides objective, reproducible measures of tracheal caliber. Thyroid tissue in the mediastinum is identified as likely thyroid based on high attenuation of 15 Hounsfield units or 25 units or greater postcontrast and is higher than for mediastinal lymphoma or thymoma.^{4,16} CT also helps to exclude nodal disease and other correlates of malignancy such as irregular margin or fine calcification seen in some papillary and medullary cancers. Most importantly, axial CT scan defines the extent of substernal goiter and the relationship of the goiter to the trachea, esophagus, and great vessels.²⁵⁻²⁷ The relationship between the



Fig. 2. Large posterior mediastinal goiter extending into the left and right thorax, located between the trachea and esophagus. CT provided information regarding surgical approach and the potential for a ventrally displaced recurrent laryngeal nerve.

substernal goiter and surrounding cervical viscera may affect the choice of intubation and surgical approach, especially when posterior mediastinal goiter is identified (Fig. 2). CT may, in fact, help to determine surgical candidacy, most typically by documenting substernal extension or tracheal compression.²⁸

Flow volume loops. Flow volume loops have been utilized to define airway compromise in goiter patients. In our center, flow volume loop analysis is not routinely utilized in goiter patients, and in our series few patients had flow volume loop testing. Goiter weight is not well correlated with flow volume loop results.¹³ Bonnena²⁴ has also reported that overall flow volume loop results do not correlate well with tracheal caliber. Only 30% to 40% of those with flow volume loop abnormalities have symptoms, and among those with normal flow volume loops, up to 60% may have airway symptoms. Furthermore, it is known that in patients without goiter, tracheal size is inconsistently related to lung function indices.^{29,30} Flow volume loops can detect tracheal stenosis when tracheal diameter is reduced to less than 5 mm,³¹ but may not be affected in less severely affected airways.

Esophagus

Dysphagia was significantly associated with both radiographic esophageal deviation and compression. As a screening test, the presence of dysphagia for esophageal compression showed a negative predictive value of 96%. Therefore, we feel that patients without dysphagia likely do not have esophageal involvement (in contrast to patients without SOB who may still have airway narrowing) and do not require further esophageal imaging.

Preoperative Physical Exam

Our data showed that 2% of goiter patients presented with vocal cord paralysis in the setting of benign disease and no prior neck surgery and 3.5% of preoperative goiter patients overall. This paralysis may be the result of nerve stretching from progressive goiter enlargement. These data underscore the importance of

preoperative laryngeal exam. Symptomatic assessment of voice, like symptomatic assessment of the airway, does not predict objective findings in goiter patients. In our patient series, voice change was reported preoperatively in 12.8%, but vocal cord paralysis was present in only 3.5%, consistent with the work of Michel, emphasizing that glottic function cannot be predicted by voice assessment.²⁵ We therefore recommend laryngoscopy preoperatively in all patients who undergo goiter surgery.³² If the goiter patient does not have a preoperative laryngeal exam, the surgeon begins the case with a baseline unrecognized 3.5% rate of vocal cord paralysis.

Although the majority (85%) had a cervical mass identified on physical exam, no cervical finding was present in nearly 15% of patients. In one-fourth of patients, tracheal deviation was noted on physical exam. Given the potential airway compromise associated with goiter, we routinely identify the thyroid notch, cricoid anterior arch, and tracheal position during the preoperative thyroid exam. Laryngeal or tracheal shift suggests potential airway compromise and prompts neck and chest CT scan in our practice. Pemberton's sign, which has been described as a sign of substernal goiter, was found to be present in only 4.4% of patients, although this sign may not have been uniformly evaluated in all patients. Jugular distention and subcutaneous venous redistribution implies neck base venous obstruction, but true superior vena cava (SVC) syndrome virtually identifies neck base/mediastinal malignancy and warrants very careful scanning and preoperative evaluation.⁷ In our population of large cervical and substernal goiter we found 25% were preoperatively asymptomatic.

Additional Preoperative Studies

I¹²³ radioactive iodine scanning was obtained in 41% of patients, mainly in the early portion of this study and was found not to contribute substantially to the evaluation of the patient and is no longer obtained. Noniatrogenic cases of abnormal thyroid function testing occurred in only 8.3% of patients, with only a single patient having thyrotoxicosis secondary to iodine exposure.

Fine-needle aspiration, although routinely performed in our center for standard thyroid nodular disease, was performed in only 20% of these patients being operated for goiter. Fine-needle aspiration was typically not performed if the physical exam, history, and CT scan argued strongly for benign goiter that required surgery, especially if there was airway compromise. Thus, if there was no evidence of airway invasion, if the goiter had a smooth margin without lymphadenopathy and physical exam showed normal cord motion and a soft thyroid mass, needle biopsy was not typically performed. Certainly, if there were any suspicious findings on physical exam, history, or radiographic evaluation of malignancy, fine-needle aspiration should be strongly considered.

Prior Failure of Medical Therapy

Overall, one-third of surgical patients had failed medical management with either thyroid hormone (T4) or

radioactive iodine. Failure of these medical treatments did not increase surgical complication rates. T4 suppression has variable efficacy in goiter size, and this treatment cannot be offered aggressively in an elderly population due to the potential development of atrial arrhythmias and bone loss. T4 treatment is also limited in patients with subclinical hyperthyroidism, and is characterized by a high regrowth rate of goiter when T4 is discontinued.¹¹ Radioactive iodine as a treatment for large goiter with compressive symptoms has become more commonplace in Europe. A small fraction of goiter patients treated with radioactive iodine may develop radioactive iodine induced thyroiditis with potential airway compromise in patients with borderline airway, and some patients so treated may develop radioactive iodine-induced hyperthyroidism. High-dose radioactive iodine used for this purpose does increase the estimated lifetime risk of cancer outside the thyroid gland by 1.6% overall.^{33,34}

Nygaard and others^{35–37} have shown transient increase in goiter size in 7% of patients treated for goiter with radioactive iodine with increases ranging from 11% to 60%. Bonnema²⁴ found a decrease in tracheal cross-sectional area of 9.2% within 1 week of radioactive iodine treatment. Although we did not see increase in surgical complication after such treatment, we appreciate that such treatment could potentially increase scarring and vascularity at the level of the thyroid capsule, which may present a challenge in subsequent surgery.

Surgical Indications

Surgery represents a rational treatment option for many patients with goiter. Based on our experience, patients can be reasonably considered for cervical goiter surgery in the following situations: 1) if a patient has clear-cut regional upper aerodigestive tract symptoms without other cause. Such symptoms may first manifest with positional provocation or nocturnally; 2) if radiographic evaluation through axial CT scanning shows evidence of tracheal compression; 3) for masses greater than 5 cm or masses with significant cosmetic issues. Our experience is that regional symptoms typically emerge when the mass is 5 cm or greater. Fine-needle aspiration is less accurate to exclude malignancy in a mass of this size or greater; 4) goiter patients with subclinical hyperthyroidism; 5) patients in whom carcinoma is suspected or proven; 6) all patients with substernal extension. The presence of substernal goiter in general in our practice is a surgical indication because of the strong association of tracheal compression and substernal growth, and because the mediastinal component is difficult to follow on physical exam or with fine-needle aspiration.

CONCLUSIONS

Airway Symptoms and CT

SOB and dysphagia were present in approximately half of all goiter patients preoperatively. Multivariate analysis showed goiter size was related to the symptom of SOB but not to dysphagia, pain, or voice change. CT

finding of tracheal compression was found significantly related ($P < .0001$) to the symptom of SOB. We therefore feel that the preoperative radiographic finding of tracheal compression on CT is a valid and objective surgical indication. Despite the relationship between SOB and tracheal compression, the sensitivity, specificity, and predictive value of preoperative SOB as a screening test for objective airway compromise in this dataset was however limited. For the airway, symptomatic assessment alone may therefore be inadequate in goiter patients. In the setting of large cervical or substernal goiters one cannot purely rely on the presence or absence of shortness of breath for assessment of true tracheal compromise, without routine axial CT scanning assessment for tracheal caliber.

Substernal Goiter

Substernal extension was associated with increasing respiratory symptoms and with a two- to fourfold increase in tracheal abnormality on CT compared to cervical goiter. Substernal goiter presented on average 15 years after cervical goiter leading credence to the concept it evolves from preexisting cervical goiter.

Dysphagia

Dysphagia as a screening test for esophageal deviation or compression had a strong negative predictive value and somewhat strong specificity. Thus, when dysphagia is absent there is likely to be no radiographic esophageal changes.

Voice

Voice complaints did not relate to goiter size. In our population 3.5% of patients presented with preoperative vocal cord paralysis while voice change was reported preoperatively in 12.8%. Because glottic function cannot be predicted by voice assessment we recommend laryngoscopy preoperatively in all patients who undergo goiter surgery.³²

IN MEMORIAM: HERMES C. GRILLO, MD

Hermes C. Grillo, MD, was a thoracic surgeon at Massachusetts General Hospital and Professor of Surgery Emeritus at Harvard Medical School. He is widely recognized as the father of modern-day tracheal surgery. Dr. Grillo died in an automobile accident October 14, 2006, near Ravenna, Italy. Boston born in 1923, he attended Brown University then Harvard Medical School joining Massachusetts General Hospital in 1947. Dr. Grillo developed several original tracheal operations, published over 350 scientific articles, and published the definitive lower airway textbook "Surgery of the Trachea and Bronchi." His knowledge of laryngeal anatomy and function and its relationship to his tracheal work was impressive. Although his technical ability was profound he always endeavored toward a conservative surgical approach; an approach embodied in this series of thyroidectomy. Although Dr. Grillo's talents were wide ranging, he impressed many, above all else, as a thinking

surgeon, always meticulously considering all aspects of a case preoperatively as well as during surgery. We appreciate Dr. Grillo's work in this series; his contributions to this work were significant. As we reviewed our results, he was pleased that through careful surgical work these complex thyroid cases can be met with success.

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