Published online 2022 June 20 **Original Article**

The Effects of Thyroid Gland Volume and Weight on Surgical Approach Selection and Anesthesia Management in Retrosternal Goiter

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Received 2021 August 04; **Revised** 2021 September 22; **Accepted** 2022 March 15.

Abstract

Background: Retrosternal goiter surgery is a technically challenging procedure. Selecting the appropriate surgical approach is critical in preventing surgical and anesthesia complications.

Objectives: This retrospective clinical study aimed to investigate the role of thyroid volume and weight in the development of retrosternal goiter and the importance of special anesthesia management in patients with retrosternal goiter, which is a potentially difficult airway candidate.

Methods: Retrosternal goiter was detected in 125 patients through ultrasonography. Patients were divided into cervical surgery (CA) and sternotomy (ECA) groups. Volumetric measurements were performed ultrasonographically. Patients' demographics, preoperative thyroid ultrasonography features, American Society of Anesthesiologists (ASA) classifications, Mallampati classifications, intubation characteristics, perioperative and postoperative patient data, and postoperative thyroid specimen weights were recorded.

Results: A total of 106 patients (32 male and 74 female) were operated on for bilateral total thyroidectomy. Total thyroidectomy was performed with CA in 98 (92.5%) patients and with ECA in 8 (7.5%) patients. Malignancy was detected in 4 (3%) of 106 operated cases. All of the malignant cases were seen in patients with a cervical approach. When the volumetric measurements of both groups were compared, the volume values were significantly higher in the ECA group (P=0.032).

67 patients were ASA I and 39 patients were ASA II. 64 patients were defined as Mallampati Class I, 36 patients as Mallampati Class II, and 6 patients as Mallampati Class III. Intubation was performed on the third attempt for 5 patients and 8 patients with Mallampati I and Mallampati II, respectively. The rate of difficult intubation was statistically significant in the ECA group (P=0.019).

Conclusion: Predicting ECA requirement in the preoperative period is closely related to the preoperative volumetric analysis of the thyroid gland with three-dimensional ultrasonography. In addition, since anesthesia management is difficult in patients who need ECA, volumetric analysis has become even more critical.

Keywords: Airway management, Retrosternal goiter, Sternotomy, Thyroidectomy

1. Background

The incidence of palpable thyroid nodules and retrosternal goiter in the general population is between 4-7% and 0.02%, respectively. In addition, studies have shown that the incidence of thyroid nodules is up to 50% during an autopsy; however, most can not be detected (1). Retrosternal goiter, the first described in 1749 by Albrecht Von Haller as an extension of thyroid tissue during surgery, is now described as an extension of goiter under the upper chest. Generally, while the patient's neck is in extension, on neck and chest tomography, the thyroid tissue extends up to 2 cm below the manubrium (2). The diagnosis of substernal goiter is most common in the 5th or 6th decades, and the female to male ratio is 4/1. Around 85-90% of the cases are in the anterior mediastinum, and 10-15% are in the posterior mediastinum. They have remained asymptomatic for years and show slow growth. Approximately 20-40% of substernal goiters were detected coincidentally in radiographic examinations. Patients with mediastinal goiter are rarely symptomatic. The most common symptoms are exposure to the pressure of the airways and esophagus, dyspnea, feeling of drowning, insomnia, dysphagia, and dysphonia (3). For diagnosis, in addition to the clinical symptoms, palpation of the mass under the sternal notch in the physical examination, and the presence of fullness in superficial and jugular veins are necessary. Furthermore, two-way chest radiography, neck and thorax ultrasonography, and tomography are helpful for diagnosis, localization, and planning of the surgery. The causes of resection in substernal goiter may be insufficient suppressive treatment, risk of malignancy, difficulty in biopsy, presence of hyperthyroidism, or obstructive symptoms.

Despite the high prevalence, there are controversies about the conditions in which retrosternal goiter patients should undergo surgical intervention. While most endocrine surgeons have expressed their opinion on the operation of intrathoracic goiter, others have argued that only symptomatic patients or those with suspected cancer should be operated. In most cases, a collar incision is sufficient, and a complete consensus is provided on

the non-routine recommendation of sternotomy (4). In as few as 1% to 11% of cases, sternotomy is required to see the goiter fully and remove mediastinal compression. Moreover, Substernal goiters are usually benign. In the literature, the frequency of cancer in retrosternal goiters ranging between 2.5-19% has been reported (5).

2. Objectives

This retrospective clinical study aimed to investigate the role of thyroid volume and weight in the development of retrosternal goiter. Preoperative determination of thyroid volumetric measurements is important for the choice of surgical strategy and specific anesthesia management for patients with retrosternal goiter.

3. Methods

Between June 2015 and June 2019, 820 patients were operated on for thyroid diseases at Health Science University, Van Training and Research Hospital, General Surgery Clinic. Preoperative thyroid ultrasonography was performed in all patients, and retrosternal goiter was detected in 125 patients. A relevant statement of approval was taken from the ethics committee of the Health Science University, Van Training and Research Hospital. Patients with the following diseases were excluded from the study: collagen tissue disease, musculoskeletal disease, a history of radiation on the neck/mediastinum or surgery in these regions, and ASA III and IV. Finally, 106 patients were included in the study. All patients were evaluated according to the current "The American Thyroid Association Guidelines" at the time. The malignancy was diagnosed with thyroid fine-needle aspiration biopsies in the preoperative period. Patients were divided according to the surgical approach into classical cervical surgery (Group 1 - cervical approach - CA) and sternotomy (Group 2 - extracervical approach - ECA). Volumetric measurements were performed ultrasonographically in the supine position with a pillow between both shoulders while the head was hyperextended. All investigations were made by The Toshiba Aplio 500 Platinum 3D ® ultrasound device, which was designed in three dimensions with the 10 Mhz linear probes by the same radiologist. Volumes were calculated automatically with the software program on the device.

After the operation, the weight of the thyroid gland specimens was measured and recorded. From which lobe the enlargement of the thyroid gland originated and the postoperative histopathological findings of the thyroid gland were also recorded. Thyroid volumes of the patients who were evaluated preoperatively by ultrasonography and the ratio of thyroid weight after surgery were determined as thyroid density.

3.1. Anesthesia Management

Patients were evaluated by the anesthesia clinic preoperatively, and their ages, heights and weight values, ASA classifications, and Mallampati values were recorded. Mallampati IV patients were not included in the study because there was no fiberoptic intubation equipment. The surgery, anesthesia, and otolaryngologist teams always included the same doctors for standardization. As a standard, the vascular access was opened with 20 gauge brane from the left-hand dorsal, and then 0.9% NaCl infusion was started at the rate of 15 ml/kg/h in the premedication unit. Patients who received 0.04 mg/kg intravenous (iv) midazolam for premedication and sedation were taken to the operation room. Preoxygenation was performed with 8 L/min 100% O_2 for 3 min. All patients were monitored with a standard electrocardiogram, pulse oximetry, and non-invasive blood pressure monitoring. After administering 2 mg/kg propofol and 2 µg/kg fentanyl iv, 0.6 mg/kg rocuronium iv was given to patients who were comfortable with mask ventilation. After 2 min, all patients were intubated with spiral endotracheal tubes numbered 7-7.5 for women and 8-8.5 for men. For the possibility of difficult intubation, all available equipment (laryngeal mask, fast track, and gum elastic glove) was made available in the operation room. The location of the endotracheal tube was confirmed by auscultation and capnograph. Volume-controlled ventilation was started with the Mindray Wato Ex-65 anesthesia machine. Anesthesia was maintained with 2 L/min 2.5 MAC sevoflurane and 50% oxygen-50% air mixture. For patients with a mean duration of 2 h of anesthesia, 1 mg/kg tramadol was administered for postoperative analgesia. For antiemetic purposes, patients who received 10 mg of metoclopramide were deeply extubated with 4 mg/kg sugammadex.

3.2. Statistical Analysis

Minitab® 17 Statistical Software (MinitabInc, 2010) package program was used in all statistical analyzes. The Shapiro-Wilk test was used to analyze the normality of the distribution of numerical variables. Numerical variables were given as mean ± standard deviation or median (minimum-maximum) and were compared with the Student's t-test or the Mann–Whitney U test. As appropriate, categorical variables were given as frequency (percentage) and analyzed using the Chi-square test or the Fisher's exact test.

In comparing demographic data, an independent 2-sample Fischer's t-test was performed. Mann Whitney U test was used to compare weight and volumetric measurements. A (P<0.05) was considered statistically significant.

4. Results

A total of 106 patients (32 male, 74 female) underwent bilateral total thyroidectomy. Total thyroidectomy was performed with CA and ECA in 98 (82.5%) and 8 (17.5%) patients, respectively. The demographic and surgical characteristics of the patients and postoperative complications are summarized in tables 1 and 2, respectively.

While the diversity of symptoms did not show much difference in both surgical approach groups, the rate of being symptomatic was higher in patients in group 2. This difference was not statistically significant (*P*=0.67). The growth pattern of the thyroid gland, the direction and localization of the growth, and the neighboring relations are effective in developing clinical symptoms. In our study, the thyroid gland was rarely bilaterally expanded. In both study groups, enlargement towards the thoracic inlet was more common in the right thyroid lobe.

Malignancy was detected in 4 (3%) of 106 operated cases. Three of the malignancies were follicular variants of papillary carcinoma, and one was anaplastic carcinoma. All of the malignant cases were observed in patients with a cervical approach. In patients with malignancy, functional lymph node dissection was performed in addition to bilateral total thyroidectomy.

When the volumetric measurements of the two groups were compared (Figure 1), the volume values were significantly higher in the ECA group (*P*=0.032).

When the postoperative thyroid specimen weights of the two groups were compared (Figure 2), the weight difference between the two groups was statistically significant in favor of group 2 (*P*=0.018). As expected, there was a direct correlation between the volume and weight of the thyroid tissue (Table 3). The median value of the thyroid gland weights of the patients in the ECA group was 650 g.

67 patients (43 female, 24male) were ASA I and 39 patients (27 female, 12 male) were ASA II. 64 patients (42 female, 22 male) were defined as Mallampati Class I, 36 patients (12 female,24 male) as Mallampati Class II (Figure 3). Intubation was attempted more than once in 32 patients (Table 1). Intubation was performed on the third attempt for 5 patients and 8 patients with Mallampati I and Mallampati II, respectively. Of the 13 patients with intubation difficulties, 8 were male and 5 were female. The patients with Mallampati III and without respiratory symptoms (2 males and 4

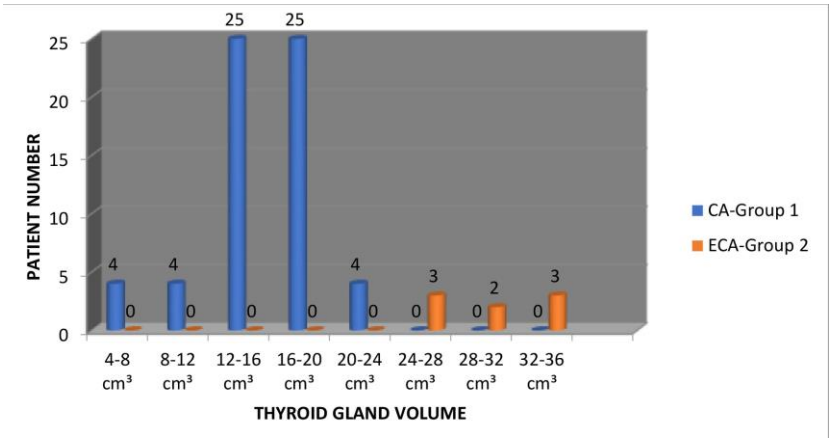

Figure 1. Relationship between thyroid gland volumes and surgical intervention

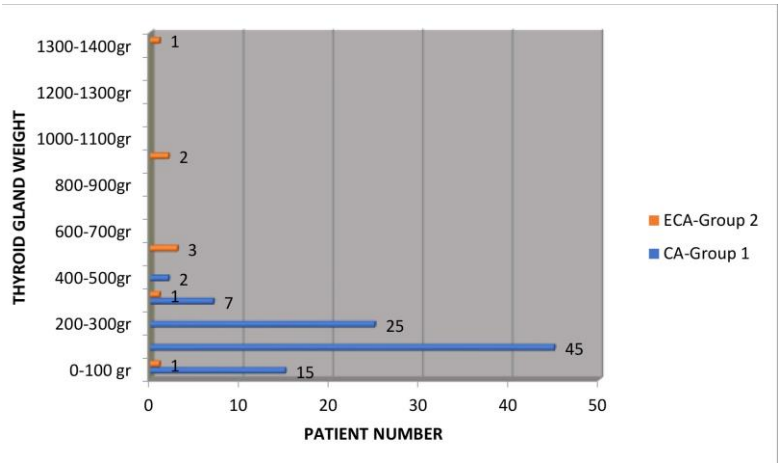

Figure 2. Relationship between thyroid gland weights and surgical procedures

Table 1. Demographic and surgical data of patients

	CA group (n=98)	ECA group (n=8)	*P*
Age	46 (64-33)	49 (52-35)	0.92
Gender	26 male (% 25.5)	6 male (% 75)	0.009
Symptomatic	Symptomatic 62 (%63)	Symptomatic 6 (%75)	0.67
Growth pattern	Right lobe 46 (%48) Left lobe 36 (%36) Bilateral 16 (%16,3)	Right lobe 4 (%50) Left lobe 2 (%25) Bilateral 2 (%25)	0.86 0.70 0.88
Operation time (min)	144 (76-288)	256 (186-442)	<0.0001
Blood loss (ml)	25 (10-220)	120 (50-400)	<0.0001
Malignancy	4 (%4)	0	
Intubation status			
• **Difficult**	22(%23.1)	4(%50)	0.019
• **W/indirect Laryngoscopy**	3(%3.3)	3(%37.5)	0.0011

Data is presented as No. (%) or median (Min-Max), and a *P*-value less than ($P \leq 0.05$) is considered statistically significant.

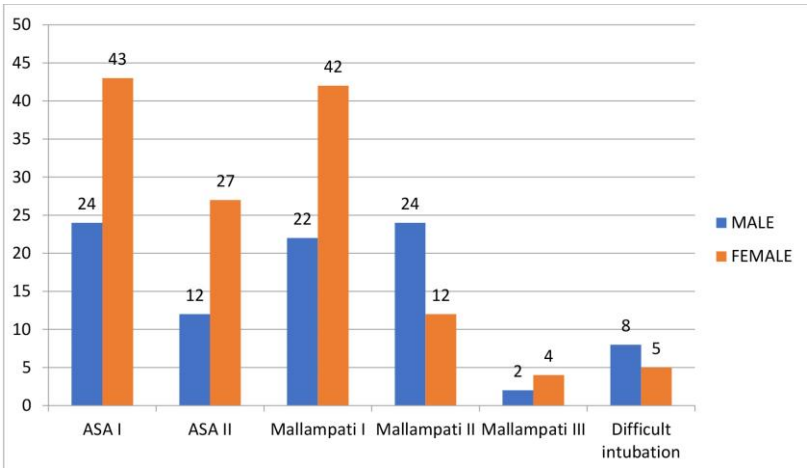

Figure 3. ASA, mallampati, and difficult intubation status in female and male patients

Table 2. Postoperative complications

	CA group (n=98)	ECA group (n=8)
Mortality	0	0
Pulmoner embolism	0	1 (%12)
Permanent Hypoparathyroidism	3 (3%)	0
Transient Hypoparathyroidism	12 (12%)	1 (12%)
Permanent RLN injury	2 (2%)	0
Transient RLN injury	6 (6%)	0
Hemorrhage*	4 (4%)	1 (12,5%)
Tracheostomy	0	0
Pneumothorax	0	0

RLN: Recurrent laryngeal nerve

*In the CA group, bleeding occurred from the left superior thyroid artery in three patients and from the right superior thyroid artery in one patient. The patient in the ECA group had bleeding from the sternal marrow.

Table 3. Relationship between thyroid volume and weight

	CA group	ECA group	P
Thyroid Weight (gr)	120 (40-465)	650 (190-1400)	0.018
Thyroid Volume (cm^3)	14 (5-23)	31 (26-35)	0.032

CA: Cervical approach; ECA: Extracervical

Data is presented as No. (%) or median (Min-Max), and a *P*-value less than ($P \leq 0.05$) is considered statistically significant.

females) were preoperatively evaluated with indirect laryngoscopy by otolaryngologists.

No patient required reintubation and intraoperative transfusion. However, the rate of difficult intubation was statistically significant in ECA group's patients (*P*=0,019).

5. Discussion

Retrosternal goiter is a surgery that requires more attention and experience. Evaluation of thyroid gland dimensions in the preoperative period is vital in predicting the need for an approach other than the

classical cervical approach. The present study aimed to predict the need for ECA by measuring the volume of the thyroid gland with three-dimensional ultrasonography in the preoperative period. Thyroid gland volume and weight were more significant in the ECA group than in the CA group. It was observed that the duration of the operations was longer and the amount of bleeding was higher in the ECA group. The number of patients who had difficult intubation was higher in the ECA group, and indirect laryngoscopy was required more during the intubation.

Substernal goiter is when more than 50% of the volume of the thyroid gland is below the sternal notch. This is due to the progression of the gland towards the thorax, depending on the weight, negative intrathoracic pressure, respiratory movements, and neck shortening. Substernal goiters should be separated from the aberrant goiter. Aberrant goiter, completely independent of the normal thyroid gland, is detected as a separate tissue and does not supply blood from the neck veins; therefore, they are evaluated as a separate clinic. Patients with aberrant goiter are treated according to the localization of their thyroid gland (6). Retrosternal goiters usually occur as a result of diffuse growth of the gland, and growth usually occurs as the development of both lobes (7). The growth of the thyroid gland in the patients in both surgical approach groups was the growth of the right thyroid lobe rather than the total gland.

In line with the literature, the obtained demographic data showed that the need for a surgical approach with sternotomy was independent of age (8).

Diagnosis can be made clinically in patients who have neck mass. At the entrance of the thorax, because of the possibility of staying between the manubrium sterni and vertebrae, oesophageal and tracheal compression and constriction-related symptoms are common.

There may be nonspecific findings such as dyspnea, dysphagia, and snoring. Moreover, there may be clinical findings of syndromes such as V.cava superior and Horner, which occur due to compression of large vessels and neural structures by 8-9 % (3). In our study, most of the patients with retrosternal goiter were symptomatic; no statistically significant difference was found between the two groups regarding symptoms.

We recommend removing the tumor from the cervical incision by widening the incision as much as possible before median sternotomy or thoracotomy is performed, especially in the surgery of large glands. In the substernal goiter, publications are suggesting median sternotomy and thoracotomy. Considering that the intervention of vascular injuries originating from the inferior thyroid artery may be complex, publications suggest median sternotomy and thoracotomy in substernal goiter (9). In the present study, there was no need for sternotomy due to vascular complications. The current study significantly contributes to predicting the need for sternotomy in surgical treatment during the preoperative period.

Mercante et al. reported that the need for sternotomy in patients with malignant retrosternal goiter was 12-fold higher than in benign ones (10). Median sternotomy or thoracotomy may be required in invasive carcinomas, especially behind the thoracic inlet. We think these approaches are used to avoid complications that may occur during blunt dissection, especially in giant thyroid tumors reaching the aortic background. All four malignant cases in our study were operated on with the cervical approach, and there was no need for an ECA.

The need for surgical intervention with sternotomy has been shown to be more frequent in patients with recurrence retrosternal thyroid (11). Recurrent cases were excluded from our study.

Rafaelli et al. compared 355 patients with cervical goiter and retrosternal goiter. Sternotomy was required for two patients. For the remaining 353 patients, the cervical surgical approach was sufficient. The most important result obtained from this study for the necessity of sternotomy is that the thyroid tissue in the thorax is the primary factor (12).

Cohen investigated the surgical approach for retrosternal goiters in their study of 113 patients with retrosternal goiter. According to this study, 5 patients required sternotomy, and the remaining patients were treated with a cervical approach. In this case series, it was concluded that the factor most influencing the need for sternotomy is malignancies invading the surrounding tissue (e.g., extending the aortic arc and posterior mediastinum) (7).

Cichon et al. reported a case series of 88 patients, 61 were operated on with a cervical approach, and 27 were operated on with sternotomy. It has been concluded that the major factors determining the need for sternotomy statistically are recurrent goiter, ectopic mediastinal goiter, and posterior mediastinal goiter (13).

Bartin et al. concluded that thyroid ultrasonography might help determine etiology in patients with retrosternal goiter in their study. For example, retrosternal goiter formation may be due to a hydatid cyst, and preoperative ultrasonography is vital to determining the need for sternotomy. This study emphasized the importance of determining the necessity for sternotomy by measuring thyroid gland volume, weight, and location in posterior mediasten preoperatively using ultrasonography (14, 15). These features of the thyroid gland and the current clinical pictures were evaluated preoperatively, and accordingly, predicting the need for sternotomy is critical for the surgeon. In the literature, it is seen that cervical and thoracic computed tomography are generally used for preoperative evaluation of the

possibility of sternotomy. In our study, these evaluations were performed with a more non-invasive method; three-dimensional ultrasonography. During the computed tomography examination, patients are exposed to radiation and are at risk for nephrotoxic/allergic complications due to the use of intravenous contrast material. In addition, computed tomography has higher economic costs compared to three-dimensional ultrasonography. The advantages of three-dimensional ultrasonography over computed tomography are the reduction of health expenditures and the fact that patients are not exposed to radiation/intravenous contrast material. In the present study, the volume of the thyroid and the effect of gland weight on predicting the possibility of sternotomy was evaluated, and the results were significant.

In our study, all cases were evaluated, and experienced anesthesiologists performed laryngeal intubation. If the laryngeal intubation procedure can be performed in a single trial with a standard tube, this can be called a normal or easy intubation. If it can be performed with a smaller size tube and guide wire, this can be called difficult intubation; if it can be achieved with indirect laryngoscopy and fiberoptic bronchoscopy, this can be classified as indirect laryngoscopic or very difficult intubation. Tracheal deviation was generally associated with larger thyroid gland volume and more prominent palpation of the lower manubrium sterni.

The neck masses, especially in the anterior part of the neck, are essential because they can cause tracheal compression and airway difficulty. Providing a safe airway is the primary task of anesthesiologists, and guides and algorithms are important for difficult airways. However, most patients have no expected respiratory distress and tracheal collapse, and the most appropriate intubation approach is still being discussed in such cases (16). Studies detailing anesthetic management of retrosternal goiter are limited to isolated cases and small case series (17). A careful preoperative evaluation, and meticulously preparation for intubation and anesthesia management can provide optimal results. The cooperation between experienced surgeons and anesthesiologists is of prime importance. In this context, for difficult airway management, existing equipment (such as a rigid bronchoscope, fiberoptic intubation device, video laryngoscope, and laryngeal mask) must be available in the operation room (18). In the present study, although there were many problems relating to preoperative devices, there was no problem with coordination between anesthesiologists and surgeons. Additionally, position change can help alleviate the mass effect. Respiratory and hemodynamic changes before surgery can be reduced by appropriate position, and decompensation can be corrected or minimized (19). As a matter of fact, in this study, patients were seated at 45 degrees angle. No respiratory or hemodynamic negativity was observed.

6. Conclusion

Retrosternal goiters are essential in terms of anesthesia management and surgery. Preoperative predictions of surgical intervention with sternotomy have close relations between volumetric analysis and large thyroid volumes, as seen in the present study. Furthermore, the beneficence of the three-dimensional ultrasound for measuring volumetric analysis preoperatively to determine the surgical approach has been shown.

Acknowledgments

None.

Footnotes

Conflicts of Interest: None to declare.
Funding/Support: None to declare.

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