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Substernal Goiter: When is a Sternotomy Required?

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The presence of substernal goiter is, per se, an indication for surgical management. Surgical approach of substernal goiter can most commonly be performed using the cervical access, but at times, a sternotomy or thoracotomy is necessary. The aim of this study was to identify the preoperative predictors of a sternotomy in the management of substernal goiter in order to provide better preoperative planning and patient consent. Between 2005 and 2012, 665 patients were referred to our clinic for thyroidectomy, 42 patients (6.3%) had substernal goiter and were included in this study. All substernal goiters were treated surgically, 38 (90.5%) by a cervical approach and 4 (9.5%) by full median sternotomy. All surgeries were successful, with no major postoperative complications. Minor postoperative complications of transient hypocalcemia and transient paralysis of the recurrent laryngeal nerve occurred in 5 (11.9%) and 2 (4.7%) cases, respectively. Indication of median sternotomy was as follows: extension of goiter below the aortic arch, large thyroid tissue extending towards tracheal bifurcation, and ectopic thyroid tissue in the mediastinum. Substernal goiter can be removed through a cervical incision, but on rare occasions, a median sternotomy may be required.

Key words: Sternotomy – Substernal goiter – Surgery – Treatment

Substernal goiter (SG) was first described by Haller in 1749 and first surgically removed by Klein in 1820.[1–4] There is no uniform definition of substernal goiter.[1–3] However, various different criteria have been suggested by authors. These include a thyroid gland extending 3 cm below the sternal notch or extension of the gland below the fourth thoracic vertebra.[5,6] An extension of the thyroid gland below the thoracic inlet has been defined as substernal, retrosternal, intrathoracic, or mediastinal goiter. Drawing upon the relationship of the intrathoracic extension of SG to the arcus aorta and the right atrium and findings from imaging methods, diagnostic classifications have been established that take into account the percentage of goitrous thyroid in the mediastinum.[7,8] Substernal

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goiters are common, with a reported incidence of 1–20% of all patients undergoing thyroidectomy.[3,5,9–14] Diagnosis of substernal goiter is most frequently made in the fifth or sixth decade of life, with a female/male rate of 4:1.[11,14,15] The vast majority of SGs (85–90%) are located in the anterior mediastinum with the remainder (10–15%) located in the posterior mediastinum.[1,10,16,17]

Substernal goiters show, in most cases, a slow-growing enlargement, which usually remain asymptomatic for many years; about 20–40% of substernal goiters are discovered as an incidental finding on a radiographic examination.[2,11,18] Patients with mediastinal goiter are rarely asymptomatic. The most common symptoms are related to compression of the airways and the esophagus, and represented by dyspnea, choking, inability to sleep comfortably, dysphagia, and hoarseness.[2,12,14,18] In the diagnostic management of mediastinal goiter, chest computed tomography (CT) was of the highest value. CT scanning is, at present, the most exhaustive examination for assessment of the extent of the goiter and compression effects on adjacent anatomic structures. A preoperative CT scan should be routinely performed in every suspicion of a substernal goiter.[12,19–21] Magnetic resonance imaging (MRI) adds little additional information to that obtained with CT and is not routinely used.[11]

Substernal goiter must be removed surgically due to relation to compressive symptoms, potential airway compromise, and the possibility of an association with thyroid malignancy.[17] There is a general consensus that most can be successfully removed via a cervical approach and that thoracic access is rarely necessary.[9,11,12] Various factors have been reported to increase the likelihood of a median sternotomy being required. These factors include involvement of the posterior mediastinum, extension of the goiter to the aortic arch, recurrent goiter, superior vena cava obstruction, malignancy with local involvement, and emergent airway obstruction.[6,10,12,16,17,19] In addition, inability to palpate the lowermost extent of the gland also is considered to be an indication for median sternotomy. The incidence of sternotomy in substernal goiter is variable, ranging between 0–11 %.[2,9,11,12] This wide range in incidence might be related to variation in the definition of substernal goiter.

In order to improve preoperative planning and patient consent, we aimed to identify the preoperative predictors of a sternotomy in the management of substernal goiter.

Materials and Methods

In this retrospective study, we evaluated the medical records of 42 patients diagnosed with substernal goiter out of a total of 665 thyroidectomies performed in our clinic between 2005 and 2012. The goiter was defined substernal when extending at least 3 cm below the thoracic inlet, performed with hyperextension of the neck ascertained by preoperative imaging methods, and confirmed intraoperatively. In all those patients with clinical suspicion of substernal extension of the goiter (lower pole of the cervical goiter not palpable) or with findings of tracheal deviation or a mediastinal mass upon chest X-rays and ultrasound findings, neck and chest CT scans were obtained to get an accurate delineation of the goiter size and its relation to the adjacent structures. Each patient was subjected to preoperative chest X-ray to check for tracheal deviation and any mediastinal mass. Furthermore, various imaging methods such as thyroid ultrasound, neck and thorax CT, and thyroid scintigraphy were employed, depending on the case. Preoperative CT scan analysis has focused on maximal substernal area of the goiter and its relation to the trachea, esophagus, and major vessels. The surgical technique, intraoperative findings, and postoperative course were recorded for all patients. This study was approved by the Izmir Bozyaka Training and Research Hospital's institutional ethics committee.

Results

Of the 665 patients who underwent thyroidectomy, 42 (6.3%) had SG. Of these, 26 (62%) were female with a mean age of 50 years (24–68 years) and 16 (38%) were male with a mean age of 53 (18–76 years). The most common symptoms included a palpable cervical mass, dyspnea, and dysphagia. The duration of these symptoms was 2 months to 3 years. Diagnoses were made by chest X-ray, thyroid ultrasonography, neck and thorax CT and MRI, and thyroid scintigraphy, in addition to clinical examination, and were confirmed intraoperatively (Figs. 1, 2 and 3). The substernal extension was well below the aortic knuckle at the tracheal bifurcation in 3 patients who required sternotomy. Three sternotomy patients had radiologic evidence of tracheal deviation, compression, or both (Figs. 1, 2 and 3). All the patients had a euthyroid preoperative status. Each was preoperatively examined by indirect laryngoscopy and none had vocal cord paralysis. Fine-needle aspiration biopsy was used in 1 patient.

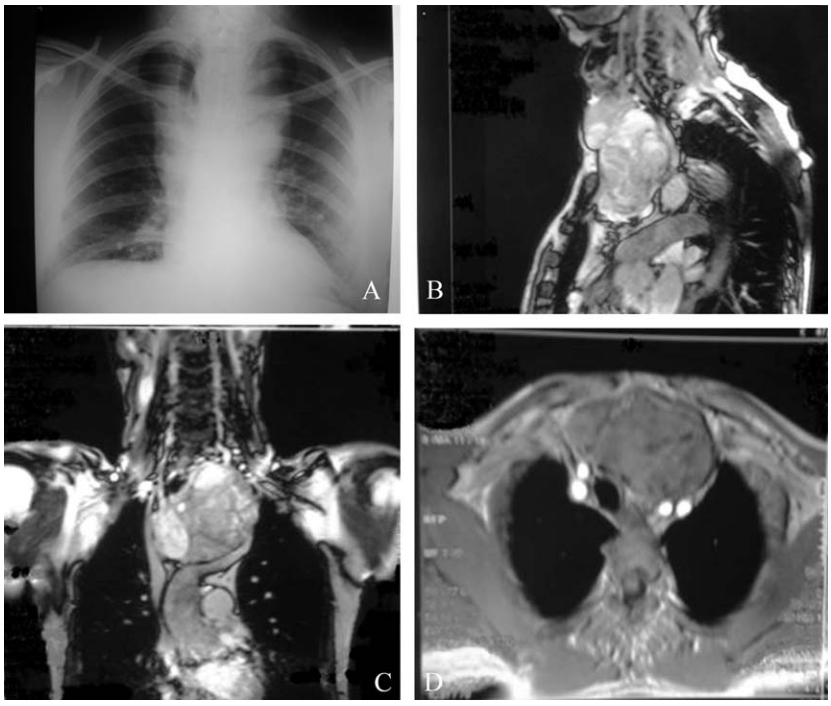

Fig. 1 (A) Chest X-ray showing deviated trachea. (B) Sagittal plain CT scan showing substernal goiter extension in to the anterior mediastinum. (C) Coronal plain CT scan showing substernal goiter displacement mediastinal structures. (D) Axial plain CT scan showing substernal goiter.

No patient had a history of previous thyroid surgery. Of the 42 patients, thyroidectomy was performed on 38 (90.5%) through a cervical incision, while in 4 patients (9.5%), a full median sternotomy had to be performed in addition to the cervical incision. In operation, the substernal component was seen on the left in 25 (60%) patients, on the right in 12 (28.6%) patients, and on both sides in 4 (8.6%)

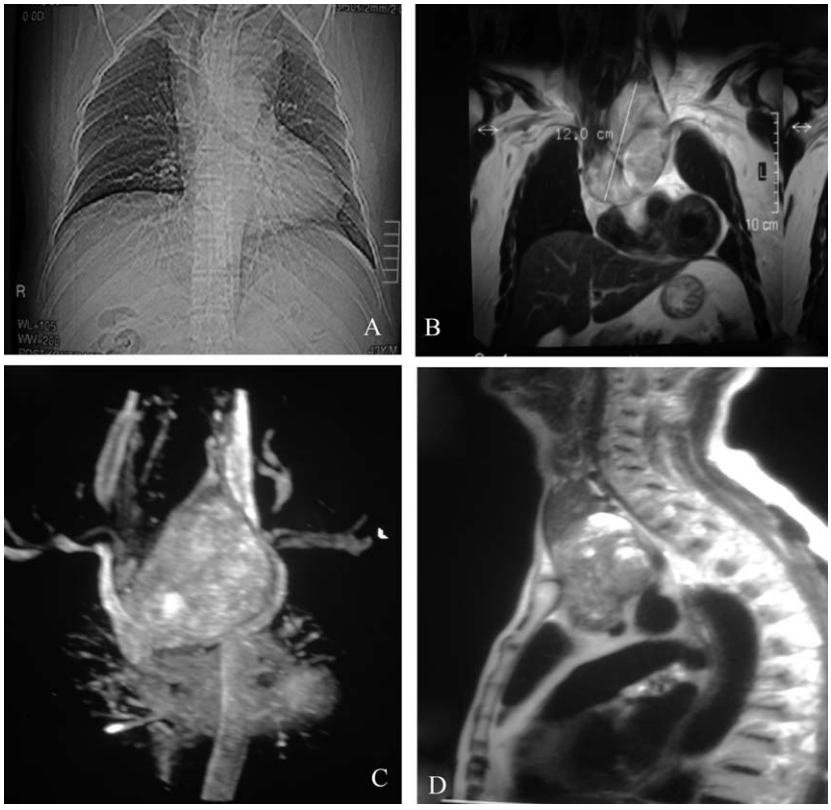

Fig. 2 (A) Coronal CT scan showing substernal goiter exerting significant tracheal deviation. (B) Coronal plain MRI scan showing substernal goiter. (C) MR angiography showing major vessels displacement by a substernal goiter. (D) Sagittal plain MRI scan showing substernal goiter.

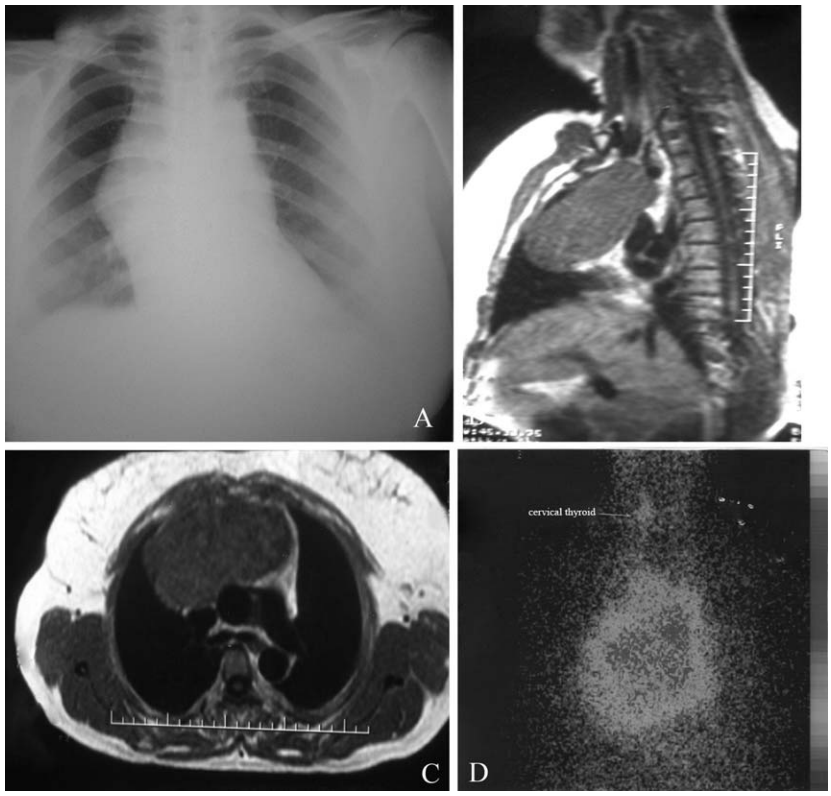

FIG. 3 (A) Chest X-ray showing enlarged upper mediastinum due to substernal goiter. (B) Sagittal plain CT scan showing substernal goiter in the anterior mediastinum. (C) Computed tomography showed that the substernal thyroid mass extends distal to the tracheal bifurcation. (D) Thyroid scintigraphy showing large intrathoracic goiter.

patients, and in 1 (2,8%) patient, ectopic location. All the patients underwent bilateral total thyroidectomy. There was no operative mortality, blood transfusion requirement, need for tracheostomy, or wound infection. To prevent hematoma development, a meticulous surgical technique, good hemostasis, and negative pressure drainage for 48 h were used. All patients evaluated by an ENT exam postoperatively. Postoperative complications occurred in 7 (16.6%) patients, 5 (11.9%) of whom developed transient hypocalcemia, and 2 (4.7%) of whom developed transient RLN paralysis. The patients who developed transient hypocalcemia were treated with oral calcium. Following this treatment, their serum calcium levels reverted to normal and no other medications were needed. The patients who developed transient RLN paralysis received anti-edema treatment and their clinical condition improved after 7 d. The duration of hospital stay of the patients was 3 d on average. Those with transient hypocalcemia stayed for an additional 2 d and those with transient RLN paralysis had an additional stay of 5 d. Postoperative histopathologic examinations revealed malignancy in 9 (21%) of 42 patients. Of these 9 patients, it was found that 5 had papillary carcinoma, 4 had follicular carcinoma, while in the remaining 33 patients (79%) a benign multinodular goiter was discovered. One of patient with follicular carcinoma had performed full median sternotomy. Patients were followed up for an average of 2 years (6–40 months), and no recurrence was observed.

Discussion

Substernal goiters can cause respiratory distress, dysphagia, vascular compression, and even sudden death. They are not uncommon and carry a risk of malignancy between 3–21%.[9,14] Because there is no effective treatment other than surgery and because thyroidectomy is felt to be both safe and effective, the presence of substernal extension is an indication for surgery in an otherwise healthy patient, even in the absence of clinical symptoms.[9] Surgical removal of substernal goiter can be performed by a cervical approach in the majority of patients.[9,11,12] It has been reported that skilled surgeons, with good thyroid surgery experience, need to perform an extracervical approach in 2–5% of thyroidectomies for substernal goiters, but some authors have reported an incidence of sternotomy in 29% of patients.[9,12] In our study, sternotomy was required in 4 patients (9.5%). This variability could be correlated with the lack of

uniformity in definition of substernal goiters.[9,11] Crile defined mediastinal goiters as those that extend to or are inferior to the aortic arch, whereas Lahey required that the greatest diameter of the goiter be inferior to the thoracic inlet on chest X-ray. Others have used a more liberal definition of substernal, including goiters with any degree of extension into the thoracic inlet.[1,9,11] Substernal goiter was defined by de Souza and Smith as a goiter with a portion of its mass $\geq$ 50% situated in the mediastinum.[11] More precise definitions of substernal goiter have been suggested, namely a goiter lying 2 fingerbreadths below the thoracic inlet with the patient in a supine position, a goiter reaching the aortic arch, or the carina tracheae, a goiter with its inferior pole passing through the cervico-thoracic isthmus below the subclavian vessels.[11]

In our study, we considered as substernal those goiters showing an extension of at least 3 cm below the cervico-thoracic isthmus, at CT scan, performed with hyperextended neck, excluding from the study all the many other goiters showing a less mediastinal extension.

Mediastinal goiters can remain asymptomatic until compression of the structures located in the thoracic inlet occurs. Life-threatening mechanical compression can occur because of the limited space below the thoracic inlet. The most common symptoms are dyspnea, dysphagia, cough, and hoarseness. Some patients present with superior vena cava syndrome.

There is general consensus that the vast majority of substernal goiters can be successfully extracted through a cervical approach. However, in patients in whom the gland cannot be safely removed through a cervical incision, thyroidectomy may require a sternotomy. In our series, SG could be removed, using a standard cervical approach, in 38/42 patients (90.5%), despite the large size and depth of the mediastinal extension of the goiters. However, a sternotomy was required in 4/42 patients (9.5%), due to extension of substernal goiter below the aortic arch in one patient, and a very large thyroid, reaching the main bronchial bifurcation in the other patients (Figs. 1,2 and 3).

Following preoperative imaging methods, 4 patients had to undergo full median sternotomy (Figs. 1 and 2). One of these 4 patient's goiters was extending below the aortic arch. Two of 4 patients had tracheal deviation and mediastinal mass in their chest X- ray and 1 patient's thyroid was very large and extending towards tracheal bifurcation in neck and chest CT scan and MRI imaging. (Figs. 1 and 2). Both of the patients had significant predictive factors of the need for sternotomy since the patients had significant tracheal deviation and the goiter was extending below the aortic arch. In addition, goiters larger than 10 cm were identified by preoperative imaging methods in these 2 patients, and this finding was also evaluated as a predictive factor of the need for sternotomy. (Figs. 1 and 2).

A mediastinal mass was identified in the chest X-ray of the fourth sternotomy patient. A mediastinal mass of 15 cm was extending towards tracheal bifurcation in neck and chest CT scan and MRI imaging. Fine-needle aspiration biopsy was performed and the mass was identified as thyroid tissue. Following thyroid scintigraphy, CT scan and MRI imaging, it was observed that this mass was not connected to the cervical thyroid, but an ectopic goiter. (Fig. 3). Because of its size and ectopic location, full median sternotomy with cervical incision was performed. Ectopic goiter is another preoperative predictive factor of sternotomy.

CT scan has become the gold standard preoperative radiologic investigation for assessment of substernal extension and its relation to adjacent structures, and also can be used in determining the patients who would likely require thoracic approach. Casella *et al* found that extension of the goiter below the level of the aortic arch appeared to be a significant predictive factor for the need for sternotomy.[16] Conversely, the lack of radiologic extension beyond the aortic arch predicted successful transcervical removal of mediastinal goiters without sternotomy.[16]

Several series have examined the factors that increase the possibility of sternotomy. Flati *et al* stated that sternotomy is inevitable when a goiter is iceberg shaped and more than 70% of it resides within the mediastinum.[6] Some authors have listed revision surgery as a possible indication for sternotomy. De Perrot *et al* felt that sternotomy should only be performed in cases of revision surgery, invasive cancer, or ectopic goiter.[12] Mussi believed that sternotomy should be employed when a goiter could not be extracted from the chest with "gentle maneuvers," as well in cases of all recurrent and aberrant goiters.[22] Sand *et al* employ sternotomy when excessive traction is required during surgery, when the most inferior extent of the nodule cannot be palpated, in cases of revision surgery, in the setting of acute tracheal compression, severe venous obstruction, malignancy, and uncertain preoperative diagnosis.[23] Sancho felt that nodules that extended

inferiorly to the level of the carina placed patients at high risk for sternotomy.[24] Randolph recommended sternotomy for malignant substernal nodules, posterior mediastinal goiter with contralateral extension, mediastinal goiters with mediastinal blood supply, goiters causing superior vena cava syndrome, revision cases, in the setting of difficult delivery from the chest, significant hemorrhage, and when the diameter of the mediastinal nodule significantly exceeds the diameter of the thoracic inlet.[9]

One of the factors that increased the likelihood of sternotomy is malignancy. The incidence of malignancy in retrosternal goiters has been reported between 3–21%.[9,13,17,18] Although fine-needle aspiration biopsy is often impossible in nodules that are located completely within the mediastinum, advanced malignancy can often be suspected on the basis of preoperative MRI or CT scan. Thus, malignancy does not automatically mandate sternotomy, but thoracic access should be considered for malignant nodules that may be adherent to mediastinal structures or blood vessels and larger cancers whose transit through the thoracic inlet might result in tumor spillage. Nevertheless, Rugiu and Piemonte still consider malignant neoplasms as a high risk of sternotomy procedure due to the chance of extra-thyroidal extension of the tumor and/or the need to perform dissection of mediastinal lymph nodes.[11]

The most important predictive factor as to whether a goiter can safely be removed through a cervical approach is the presence of a clear tissue plane around the nodule in the mediastinum on preoperative imaging. If such a clear plane is not present, preparations should be made for sternotomy.[9] Burns *et al* performed a sternotomy in only 3/140 patients with SSG, since, in their opinion, the more significant factors contributing to the need to perform sternotomy are CT evidence of adherence to the surrounding mediastinal tissues and extension of the goiter to, or below, the aortic arch.[25] White *et al*, based on a systematic review of the literature, suggested that sternotomy is more likely to be performed in the presence of a primary substernal goiter or a mass larger than the thoracic inlet.[11] Ahmed *et al* used extension beyond the aortic knuckle on chest X-ray as their landmark for the depth of substernal extension.[26]

Preoperative estimation of thyroid volume, by means of CT scan, can be an effective predictor of which patients are likely to require a thoracic approach.[11] If the nodule is too large to safely traverse the thoracic inlet, sternotomy is indicated. De Perrot *et al* reported that goiters larger than 10 cm required sternotomy. However, as they accrued additional experience, only goiters larger than 15–20 cm needed sternotomy.[12]

Primary intrathoracic or ectopic goiters present as mediastinal tumors. Ectopic goiters sometimes cannot be reached through the neck; their presence can mandate sternotomy. A minority of substernal goiters descend into the posterior mediastinum. These goiters are difficult to extract through a cervical approach alone, and even sternotomy affords suboptimal exposure at times. Posterior mediastinal extension can, therefore, sometimes require thoracic approach in addition to a cervical incision.

The potential need for sternotomy can be predicted on the basis of preoperative CT or MRI scan. Such imaging can identify advanced malignancy with loss of the plane of dissection surrounding the goiter. Significant retrosternal extension can also be identified, along with posterior mediastinal involvement and the presence of ectopic nodule. The presence of such findings on preoperative imaging can help the surgeon prepare for the possibility of sternotomy. Median sternotomy is a standard thoracic procedure, which adds little to the morbidity of substernal goiter surgery.

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