Original research

Surgical approach to mediastinal goiter: An update based on a retrospective cohort study

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HIGHLIGHTS

- Mediastinal goiter is often asymptomatic and incidentally diagnosed.
- Gold standard of surgical treatment is total thyroidectomy via a cervicotomic access.
- Sternotomy and thoracotomy may be associated to cervicotomy in selected cases.
- Primary mediastinal goiter has a vascularisation directly from intrathoracic vessels.
- Thyroidectomy for mediastinal goiter is associated to higher rate of complications.

ARTICLE INFO

ABSTRACT

Aim: Surgery for mediastinal goiters (MG) is indicated for compression symptoms and risk of malignancy. Total thyroidectomy by cervicotomy is universally considered the standard surgical approach to MG. In selected cases sternotomy or a thoracotomy are used. Options of the operative technique and practical surgical problems are analysed.

Methods: A retrospective analysis of twenty-eight-years on 1767 cases of MG in a referral centre for endocrine surgery was carried out. All patients underwent standard preoperative study and CT based surgical planning. Surgery was performed by an experienced surgical team with standard technique via cervical approach or in selected case via sternotomy or thoracotomy. Clinical records were examined.

Results: Total thyroidectomy was performed in all cases. A cervical approach was used in almost 99% of patients. Significant shorter surgical time was observed for surgery via the cervical approach vs sternotomy and thoracotomy. Benign struma was observed in 1503 patients and a carcinoma in 264. We observed postoperative bleeding in 0.5% of cases, permanent monolateral recurrent laryngeal nerve palsy occurred in 1.3%, bilateral palsy in 0.6%, transient and permanent hypoparathyroidism in 14% and 4.1% respectively.

Conclusion: MG may be approached by a cervicotomic access only with a clear knowledge of potential risk and complications of the surgical manoeuvres. Sternotomy or of a thoracotomy are indicated only in selected cases but their inapplicability may be really dangerous in those MG not otherwise resectable. MG should be referred only to specialized centre.

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1. Introduction

Mediastinal goiters (MG) are mostly located in the anterior and middle mediastinum, and rarely (10—15% of cases) in the posterior mediastinum [1].

As a matter of fact there are no unique criteria for defining mediastinal, a thyroidal mass grown below the superior thoracic inlet and this is associated to various degree of surgical problems and skills required to allow a safe thyroidectomy by cervicotomy only, without requiring an associated extracervical access.

MG accounts for 5.8% of all mediastinal masses [2] and in patients with unknown goiter, it is often discovered as an incidental finding on a radiographic examination [3]. If no palpable cervical mass are detected at clinical examination nor mediastinal compressive symptoms are evident, most of MG remain asymptomatic for long time allowing a continuous growth into the thorax. Differently the most common symptoms, due to progressive compression on the airway and on the esophagus, are represented respectively by choking, dyspnoea, sleeping apnea and dysphagia. Even vascular and nervous compression, mainly on the superior vena cava and on the sympathetic chain, may become symptomatic and suggest the diagnosis of MG. Indications for surgery in case of MG are the presence of a large mass with compression of adjacent structures and increased risk of malignancy for longstanding occult goiter. Total thyroidectomy by cervicotomy is universally considered the standard surgical approach to the MG but it is always a demanding procedure with increased difficulties according to the effective grade of intrathoracic thyroid growth [4].

Based on an institutional experience we analysed the options of the operative technique and the practical surgical problems faced when dealing with MG.

2. Materials and methods

We retrospectively analysed a population of 13.224, patients admitted for thyroid disease over a period of 28 years, since 1986 to 2014, in the Unit of Endocrine Surgery, S. Maria University Hospital, Terni, University of Perugia. This retrospective cohort study was designed according to the STROBE criteria [5]. We analysed 1767 cases (13,3%) admitted for MG. All MG patients underwent a functional study with dosage of FT3, FT4, TSH, thyroglobulin, parathyroid hormone (PTH) and antibody against thyroperoxidase and thyroglobulin. Neck and Chest computed tomography (CT) for preoperative surgical planning was performed in all cases. The goiter was defined as a MG when at CT it extended at least 3 cm below the thoracic inlet. In selected case endoscopy was used. Preoperative therapy with methimazole or propylthiouracil and beta-blockers was adopted in hyperfunctional goiters. Surgery was performed by an experienced surgical team including skilled endocrine surgeons supported, if required, by thoracic surgeons. Surgical technique is standardized based on the large experience in ordinary thyroidectomy [4,6—9]. In all patients a Jackson Pratt drainage was used and removed according to the clinical course. A serum dosage of calcium and PTH was performed in all operated patients according to the standard protocol in use in our Department as previously reported [4,7]. Follow-up of all patients was carried out in the outpatient service at 6 and 12 months after surgery. The clinical records were analysed for: history of previous thyroid pathology and incomplete surgery with residual intrathoracic goiter, symptoms, presence of tracheal deviation and/or compression, topography of the mediastinal involvement, surgical approach (cervical or cervical combined to sternotomy or thoracotomy), histology and post-operative complications.

2.1. Statistical analysis

The chi-square test was used for statistical analysis and $p < 0.05$ was considered statistically significant. All of the data were analysed using *XLS*TAT (Addinsoft, New York, NY, USA).

3. Results

Our series included 1767 patients, 1180 females, 587 males (mean age: 60 years, range: 55—82). Total thyroidectomy was performed in all cases. In 85 patients (4.8%) previous history of thyroid pathology and incomplete surgery was present. Compressive symptoms were present in the 40% of cases. Goiter was located in the anterior mediastinum in 92% of patients. In 170 patients, the MG was incidentally discovered during radiological investigations undertaken for other conditions. Tracheal compression was evident at CT study and symptomatic in 10% of cases. In case of tracheal compression, the insertion of the oro-tracheal tube was guided by a fiberoptic bronchoscope. We observed a secondary tracheomalacia in 37 cases (2.1%). Tracheostomy was never performed for tracheomalacia and instead patients remained intubated post-operatively for few days having the oro-tracheal tube a stenting function. Cervicotomy was performed in 1742 patients (98.5%), a subtotal sternotomy was necessary in 21 patients (1.1%), due to a large thyroid reaching the main bronchial bifurcation and in 4 cases a thoracotomy (3 antero-lateral and 1 postero-lateral) was performed to improve safety in the dissection. The mean surgical time was 110 min (range: 50—240), specifically 101 min (range: 50—205) for surgery via the cervical approach with significant difference (p < 0.05) compared to 165 min (range: 115—240) in cases submitted to sternotomy and thoracotomy. At pathological examination gross specimens presented mean weight of 910 g (range: 490—1730). Histology demonstrated a benign struma in 1503 patients (diffuse in 1436, unilobar in 36, adenoma in 15 and Basedow syndrome in 16) and a carcinoma in 264 (15%). Postoperative bleeding, requiring a reoperation occurred in 0.5% of cases and was controlled via the cervical approach in all patients. We observed the following complications permanent unilateral recurrent laryngeal nerve palsy occurred in 1.3% of patients, bilateral palsy in 0.6%, transient and permanent hypoparathyroidism in 14% and 4.1% respectively. Patients were discharged in 3rd or 4th postoperative day after cervicotomy, with the exception of isolated cases. Symptoms control was successful in all patients over a period of 90 days after surgery. Dysphagia was the hardest disorder to recover. Hyperthyroidism was successfully controlled in all symptomatic patients.

4. Discussion

The simply definition of MG as the presence of thyroid tissue located substernally with any degree of extension into the thoracic inlet, lacks of anatomic precision and can be interpreted unspecifically. Many authors, in presenting their experiences, adopted and proposed different definitions of MG [10,11]. Crile defined as MG those that extend to or are inferior to the aortic arch, whereas Lahey considered goiters located inferiorly to the thoracic inlet on chest X-ray [12]. de Souza and Smith defined mediastinal those goiters with a portion of at least 50% of total volume located in the mediastinum [12].

More precise definitions of substernal goiter have been suggested, namely a goiter lying 2 finger breadths 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 [10—12].

We considered as MG only those presenting at CT scan, performed with hyperextended neck, an extension of at least 3 cm below the cervico-thoracic inlet as previously proposed [12].

Surgical removal of a MG is a challenging procedure even for skilled endocrine surgeons. Safe surgical thyroidectomy in most cases can be performed via a cervical approach, whereas partial or total sternotomy in selected patients, is the first choice approach or might be required intraoperatively especially in case of uncontrolled bleeding via a classical cervicotomy [4].

After a proper definition of MG, a clear knowledge of embryology and of the consequent anatomical classification, based on a CT preoperative study, is mandatory to define the proper surgical access for thyroidectomy. Primary sternotomy is not mandatory for extrication of just a large MG, as in the experience from De Perrot who reported as initial indication for sternotomy a goiter size of 10 cm which was moved to 15—20 cm with increased additional experience [13].

In fact sternotomy of principle must be proscribed because it is not founded on anatomical and technical reasons [1]. Most retrosternal goiters are situated in the anterior mediastinal compartment and can be easily removed by a transcervical approach. According to the literature only 10—15% are located in the posterior mediastinum and may require additional extracervical incisions with sternotomy used in up to 29% of cases in the different experiences [14]. In our series we observed only 8% of posterior MG with very limited recourse to sternotomy.

In fact the majority of MG are secondary to the growth of the struma from the lower part of one or both lobes of cervical thyroid or isthmus through the thoracic inlet. Swallowing, gravity and thoracic negative pressure help the growth of the goiter from the anterior superior mediastinum between trachea and sternum direct into the chest cavity. Left and right brachiocephalic veins, superior vena cava, aortic arch and its three branches arrest the progression of this growth in the mediastinum. Differently the primary MG, which accounts only for 0.2—1% of all the MG [9], is defined as all or part of the thyroid blastoma that during the embryonic developmental period is pulled into the thoracic cavity by the descendent heart and great vessels and then continues to develop in the mediastinum.

The blood supply in secondary MG comes from the inferior thyroid artery and its branches while primary posterior mediastinal goiter maintains little or no connection with the cervical thyroid gland and has a vascularisation derived from aortic arch, innominate and thoracic vessels [15]. These anatomical bases suggest that at least in the secondary MG located in the anterior mediastinum a complete control of the arterial supply (inferior thyroid arteries) is possible and safe via a cervical approach whereas in a thyroidectomy for primary MG, vascular control is possible only directly in the mediastinum. Considering the above classification when approaching a secondary MG, presenting large volume or a strict connection with the left and right brachiocephalic veins or the superior vena cava or the aortic arch and its three branches, other surgical access than cervicotomy alone must either be taken into account.

When the descending portion of the goiter develops from the right lobe a safer control of the closer vascular structures particularly the brachiocephalic vein and the azygos vein may be achieved by an antero-lateral thoracotomy. These veins can in fact be damaged during the digital manoeuvres performed in order to achieve the deliverance of the goiter by a finger pulling beneath the lower pole. Blind dissection, although carefully carried out on an avascular plane, may determine traction on the surrounding structures inducing a severe bleeding which is very difficult to control from the cervical incision. Therefore if not primarily associated to cervicotomy, an urgent thoracotomy is required

intraoperatively and the surgeon must be familiar with the skills and the instrumental facilities, to perform at the right time what needed. This scenario is not present in all the "general surgery" theatres and sounds correct to refer such a MG patients only to specialised institutions in which the endocrine surgeon alone or supported by the thoracic specialist, may face safely all the surgical problems that might present during the procedure. MG is associated even to anesthesiological problems. Airway distress associated to chronic tracheal compression can be life-threatening, particularly if suddenly precipitated by spontaneous or traumatic intra-parenchymal bleeding of the goiter or by tracheal infection and may require intubation or semi-emergent surgery [16]. Patients with MG can either present difficult intubation and a flexible bronchoscopy for a fiberoptic bronchoscope guided tracheal intubation must be available if required and tracheal endoscopy must be part of the preoperative study, to evaluate the grade of tracheal compression, the risk of tracheomalacia and to exclude an invasion of the tracheal wall by a suspicious neoplasm.

Intraoperatively changes in the patient position may determine, for the goiter dislocation, a mediastinal syndrome with compression of heart and great vessels determining cardiac output decreases and blood pressure drop. This requires professionals and instrumentations such as the cardiopulmonary bypass (CPB) to keep ready before induction of anesthesia [4,17].

We didn't experienced the use of CPB mostly depending on the limited recourse to extra-cervical approach with accurate selection of patients.

On the other side, as above described for primary intathoracic goiters, secondary MG characterized by large size and posterior location, especially when developing from the left lobe, might be approached by a sternal split or a sub-total or total sternotomy in association to cervicotomy. In these patients the principle issue is to give the correct indication to a sternotomy which is always a demanding procedure and is frequently associated to potential post-surgical complications [18,19].

Some of these complications are just related to the surgical access (pneumothorax, post-operative pain, mediastinitis, sternal suture dehiscence) and it is furthermore much less tolerated by patients than simple cervicotomy [20—22].

Considering all these aspects, sternotomy must be carried out only if strictly required. In our series we confirmed, on a large group of patients, that total thyroidectomy for MG via a cervical approach is feasible and safe and that it might represent the gold standard of treatment. The most adopted criteria for selecting patients requiring sternotomy or thoracotomy based on CT features, are the volume of the thyroid gland and the extent of the goiter to or below the tracheal bifurcation, vascular connections, specific risk of bleeding and associated lymphadenopathy in case of suspicious malignancy [23—25]. In our experience the radiological volume of the goiter and the specimen weight were not statistically associated to a prevalent extracervical approach. Nevertheless large volume might be even considered as an option for additional access.

Another aspect to consider is the potential malignant risk of a longstanding MG. In our experience thyroid carcinoma accounted for 15% of goiters. In these cases a real total thyroidectomy must be offered to patients and this is relevant when considering the correct approach in order to gain an "en bloc" thyroidectomy. By using CT criteria [17] and thyroglobulin dosage suspicion of malignancy must be evaluated preoperatively and additional intrathoracic approaches, to gain adequate exposure and to allow delivery of the intact gland, must be considered. The clinical practice of the piecemeal resection with morcellation is sometimes adopted in not experienced hands to face complex dissection [2]. This approach must be proscribed in MG because it determines high risk of goiter recurrence for persistence of vascularised thyroid tissue, possible

neoplastic spilling in case of cancer and always bleeding [26].

Many authors reported several combinations of surgical approach ranging from videothoracoscopy to mediastinoscopy and robotic procedures to increase safety in the dissection of mediastinal structures, limiting comorbidity of classical thoracotomy and sternotomy [27–29].

The "forgotten goiter", defined as a thyroid mass found after surgery, is a rare condition whose incidence might increase after surgery for MG, if the procedure is not performed according to the criteria of total thyroidectomy, with glandular residual in the mediastinum. In fact the "forgotten goiter" is usually the consequence of the incomplete removal of a plunging goiter, and moreover, sometimes it may be attributed to a concomitant, unrecognized mediastinal goiter which is not connected to the thyroid [30–32]. A properative study of the CT scan and digital esploration of the mediastinum is recommended in order to avoid this condition which may require reoperative thyroid surgery which is associated to higher risk of complications, including temporary or permanent recurrent laryngeal nerve palsy and hypoparathyroidism [29].

Postoperative complication rate following surgery for MG, as we already showed is slightly higher than the average rate for cervical goitre thyroidectomy, especially concerning hypoparathyroidism and post-operative bleeding [4,18]. This evidence support that the cervical access, if not contraindicated, contains morbidity following thyroidectomy for MG.

The volume and mediastinal position of the goiter may displace, from their usual location, recurrent nerves and parathyroids, whose identification can be quite difficult, especially for the lower glands located under the goitre or in a very low position in the cervicothoracic junction. This condition increase the risk of inducing a damage during the surgical manoeuvres.

The use of electrophysiologic recurrent laryngeal nerve monitoring (Nerve Integrity Monitor, NIM™) during thyroidectomy has been considered as a routine complement to the visual nerve identification. In the treatment of MG, it may be particularly useful to the control of the nervous traction which is very common during dissection [33,34].

Other specific complications observed in MG may be related to tracheomalacia associated to chronic compression of a MG on the trachea. Methods for the treatment of severe tracheomalacia in adults such as surgical treatments, stent implantation, tracheostomy, tube insertion and external tracheal stabilization are limited and there is no uniform standard [4].

In our experience it can be treated conservatively by maintenance of the oro-tracheal tube with positive pressure ventilation for few days after surgery. This approach induces self sclerosing healing of the peritracheal tissue, coming after thyroidectomy, which stabilizes the tracheal structures. In MG surgery even lesions of the cervical thoracic duct can be observed both on the left and on the right side and it is related to dissection and blind traction at the level of the cervico-thoracic junction [35–40]. It can be treated conservatively or by surgical approach as we previously reported [41].

We experienced on a large series of MG, although the limits of a retrospective analysis, that total thyroidectomy via a cervical approach for MG, is the treatment of choice, requiring an association to extracervical access only in selected case. With this approach, in experienced hands, the complication rate, which although higher than in thyroidectomy for ordinary cervical goiter, might be considered acceptable for the extreme complexity of the disease. Crucial point of the preoperative setting and of the surgical treatment were analysed to clarify that thyroidectomy for MG is a demanding procedure in which is important to recognize those goiter really considerable as mediastinal and among them those requiring a prudential approach with all the skills available to face potential severe intraoperative complications.

5. Conclusion

MG of large size may be approached by a unique cervicotomic access only in experienced hand with a clear knowledge of the potential risk and of the complications of the surgical manoeuvres. Adoption of a partial or complete median sternotomy or of a thoracotomy, primarily indicated only in selected cases, are not available in all the surgical unit and their inapplicability may be really dangerous in those MG not otherwise resectable, which should be referred only to specialized centres.

Ethical approval

Not required.

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Author contribution

Andrea Polistena: Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data; also the drafted and editing of the manuscript.

Alessandro Sanguinetti: Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Roberta Lucchini: Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

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Roberto Cirocchi: Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data.

Nicola Avenia: Participated substantially in conception, design, and execution of the study and in the analysis and interpretation of data; also partecipated substantially in the drafting and editing of the manuscript.

Conflicts of interest

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