Challenges for huge goiter surgery

Ahmed Abbas[a], Mostafa Sakkary[a], Ahmed Naser[b]

Departments of [a]Surgical Oncology, [b]Radiodiagnosis, National Cancer Institute, Egypt

Correspondence to Ahmed Abbas, MD, MRCS. e-mail: ahmednci@gmail.com

Received 23 December 2018
Accepted 7 January 2019

The Egyptian Journal of Surgery 2019, 38:338–347

Objective
To highlight the technical challenges and perioperative management of huge goiter guided by ultrasound scanning and, in some cases, computed tomography (CT) scan.
Patients and methods
Twenty-seven patients presented with large thyroid masses, whether primary or recurrent, and were studied and investigated retrospectively. Triple assessment was done for all patients in the form of history and physical examination, imaging studies, and fine-needle aspiration cytology. Intraoperative technical challenges and postoperative complications were focused on. Every patient has been scanned primarily by ultrasound examination of the neck followed by CT scan if ultrasound was unable to answer all the questions asked and requested by the treating physicians.
Results
All patients underwent surgical intervention in the form of total or completion total thyroidectomy with or without central lymph node dissection. Transient hypocalcemia was seen in six (22.22%) patients. (Three 11.11 %) patients developed postoperative temporary hoarseness of voice. No major intraoperative or postoperative bleeding was encountered, and no evidence of recurrence was detected during the follow-up period from 6 months to 3 years. Ultrasound was considered enough imaging modality in seven out of the 27 patients, whereas CT scan had to be done in the remaining 20 patients.
Conclusion
Thyroidectomy for huge goiter is a technical challenge but remains the best option for effective and definitive management. Diagnostic radiology is considered an essential part in the preoperative assessment of these patients. Comprehensive perioperative management and team work are crucial for successful outcomes.

Keywords:
huge goiter, imaging, surgery

Egyptian J Surgery 38:338–347

1110-1121

Introduction

Although it is considered a complex process, surgery is the treatment of choice especially for large goiter with compression and in cases of substernal extension. Factors that help successful thyroid surgery include careful preparation, team work, appropriate evaluation of the extent of the disease, airway status, and medical conditions. For a safe management and good outcome of these patients, a proper perioperative management plan, including vigilant surgeon's eyes during surgery, adequately performing a highly meticulous procedure, and respecting anatomic tissue plans, is quite necessary [1].

Surgical outcomes can be optimized when thyroidectomy is done by highly experienced surgeons working in a specialist high-volume center. Both intraoperative and postoperative complications can be serious. Close collaboration of an experienced surgical and anesthesia teams is mandatory in managing intraoperative as well as postoperative complications from massive goiter surgery, such as bleeding, airway distress, recurrent laryngeal nerve (RLN) injury, and transient hypoparathyroidism. Women more than 40 years of age are commonly affected. Patients with large cervical goiters may remain for a long time asymptomatic or become early symptomatic by mediastinal compressing signs. The recommended and the treatment of choice is total thyroidectomy, which is commonly done through cervical approach to avoid unpredictable evolution and the risk of malignancy [2]. Surgery for large goiters carries higher morbidity rates than that for smaller goiters [3].

Patients and methods

Twenty-seven patients presented to the Department of Surgery at National Cancer Institute, Cairo University,

Egypt, with large thyroid masses with or without retrosternal extension from August 2013 till July 2016, and they were retrospectively studied. All patients underwent triple assessment of their goiter, including history and physical examination, imaging studies, and fine-needle aspiration cytology (FNAC) from any suspicious lesions seen on imaging.

Preoperative workup and imaging studies

Ultrasound examinations were done using superficial probe of GE logic ultrasound machine. With lying supine, the thyroid gland was scanned in both transverse and longitudinal planes reaching down till the sternal notch. The carotid arteries and the jugular veins should be included in the scan. Being operator dependent, inability to assess the deep structures of the neck such as the skull base, and limited detection of thoracic extension of huge thyroid are considered limitations of the ultrasound study. Another limitation of ultrasound is its low sensitivity of showing invasion of the adjacent neck organs by the thyroid neoplasm.

Computed tomography (CT) examination of the neck was done with intravenous contrast starting from maxillary sinuses till the beginning of the bronchi. The CT images were evaluated regarding encasement or invasion of the adjacent organs, such as the trachea, esophagus, common carotid artery, internal jugular vein, as well as the RLN.

Invasion of the trachea by the mass was considered if the mass was touching 180° or more of the trachea, loss of the normal tracheal inside, and focal irregularity or protrusion into the mucosa close to the lesion. Infiltration of the esophagus was considered when the mass was touching 180° or more of the esophagus or loss of the normal esophageal circumference. Similar features were used to evaluate affection of the common carotid artery or internal jugular vein by the thyroid mass.

Invasion of the RLN was considered when two out of these findings were present: the fat at the tracheoesophageal groove was completely lost, more than 25% of tumor abutted the capsule at the posterior portions of the gland, and ipsilateral vocal cord palsy.

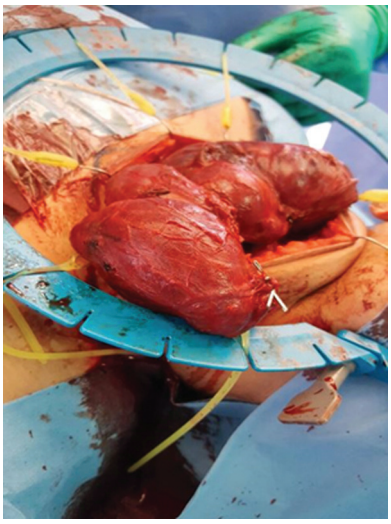
FNAC under ultrasound guidance was done for all patients to obtain preoperative histopathologic diagnosis.

Surgical procedures' details

Skin incision and goiter exposure

The patient was placed supine with neck extension and proper field exposure putting pad under the shoulders.

Figure 1



Intraoperative picture of completely dissected large goiter through cervical approach.

Sternotomy was planned as standby procedure in patients with retrosternal extension to resect the goiter if needed. However, cervical approach alone is adequate most of the time to remove huge goiter even if there is retrosternal extension (Fig. 1). Skin incision was made one to two fingerbreadth above the sternal notch. Raising upper and lower flaps in the usual avascular subplatysmal plane taking care to avoid injury of the dilated engorged anterior jugular veins was done. To give more access to the upper thyroid pedicle, the upper flap was raised up to the level of hyoid bone rather to the thyroid cartilage in some cases.

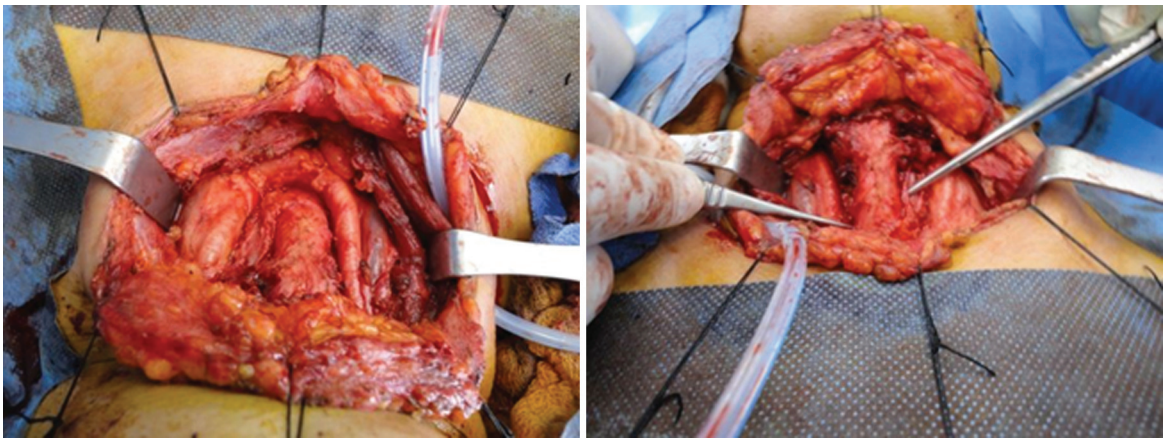
Dissection of the thyroid gland

After opening the middle line in the plan of linea alba cervicalis, the strap muscles are dissected sharply from the gland surface with careful attention to avoid injury of the veins at the gland surface. Muscle cutting incision in the upper third of the strap muscles was done in all cases to give good exposure. In recurrent goiter or suspicious muscle invasion in malignant cases, part of the strap muscles was resected en-block with the gland. Lateral dissection was done using sharp dissection with control of middle thyroid vein at first. Meticulous dissection of the gland from dilated stretched nearby internal jugular vein is crucial. The gland now is pulled anteriorly and medially freeing the loose areolar tissue and exposing the tracheoesophageal groove.

Surgical tricks to expose and preserve the recurrent laryngeal nerve

It is crucial to identify and preserve the RLN which lies normally in the tracheoesophageal groove. However, it

Figure 2



Operative field after total thyroidectomy plus central and selective neck dissection for large malignant goiter with preservation of recurrent laryngeal nerves and parathyroid glands.

can be displaced especially with cases of huge goiter. One of the critical situations where RLN should be identified and preserved is doing completion thyroidectomy in a previously injured contralateral nerve (Fig. 2). Meticulous dissection in a bloodless field with gentle tissue handling and the use of nerve monitor helps avoid nerve injury. By the time of endotracheal extubation, assessment of vocal cord mobility using fibrolaryngoscopy is mandatory to be sure of nerve integrity.

Parathyroid tissue preservation

One of the critical steps during surgery for huge goiter is to identify and preserve any parathyroid tissue to avoid hypocalcemia. Dissection close to the thyroid capsule and use of frozen section examination can prevent removal of parathyroid tissue. Ligation of the branches of the inferior thyroid vessels close to thyroid gland rather than the main pedicle keep intact blood supply to both upper and lower glands and to prevent tissue ischemia. Autotransplantation of parathyroid tissue, which is confirmed by frozen section examination, also can maintain gland function even in late postoperative period. That is why examination of thyroid gland specimen immediately after removal to detect any adherent parathyroid tissue is important.

Retrosternal goiter

Retrosternal goiter (RSG) is vague term that has no uniform definition, to date. The definition depends on the individual surgeon and the clinical and radiologic evaluation. Although more than 10 different definitions of RSG have been described, the most commonly accepted definitions describe a RSG as one that has descended below the plane of the thoracic inlet or has more than 50% of the total bulk of the goiter lying inferior to the thoracic inlet. Careful preoperative planning with CT scan is the gold standard for assessment of RSG and its relation to the adjacent structures [4]. Extension to the level of the arch and beyond was found to greatly influence the need for thoracic approach. This concurs with Haugen *et al.* [5], who classify RSG into three levels related to the aortic arch where RSG reaching this level and below is at a higher risk of requiring thoracic approach.

Type and extent of surgery

Total thyroidectomy or completion total thyroidectomy was considered in all cases rather than any form of subtotal or near-total resection, as surgery in a previously visited neck might carry significant morbidities. Central lymph node dissection was done in cases of papillary thyroid cancer (PTC).

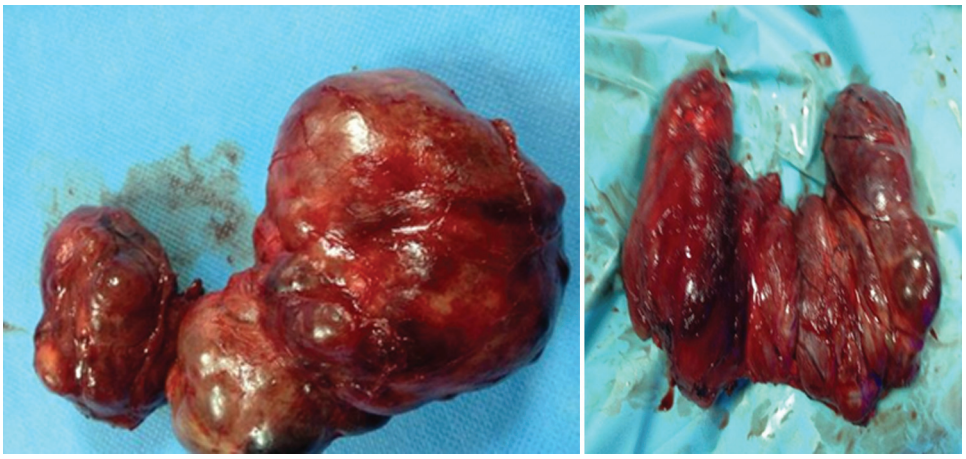
Risk of bleeding

Although wound hematoma occurs in less than 1% of patients doing thyroidectomy, the risk increases in cases of large goiters. The most important element of management of wound hematoma is early recognition. Head up position at 15°, dissection of the upper and lower flaps in avascular plan, proper control of the anterior jugular veins better with transfixion ligation, careful control of the middle thyroid vein early before the lateral dissection, and the use of hemostatic devices can decrease the risk of intraoperative as well as postoperative bleeding.

Risk of injury to other important structures

Although rare, pneumothorax and injury to the esophageal wall, phrenic nerve, or the brachial plexus

Figure 3



Postoperative specimens of large goiter.

have been described. Preoperative image review is crucial to avoid as much as possible such complications. Proper field exposure, meticulous dissection, careful localization of the important structures, and proper tissue handling are golden keys to minimize any iatrogenic injuries. In addition, temporary insertion of nasogastric tube is an effective method to identify the esophagus in case of retroesophageal extension of big goiters. Figure 3 shows postoperative specimens of large goiters.

Tracheomalacia

It is a rare condition but should be considered in cases of large goiter and tracheal compression. Tracheomalacia may be suspected in patients with long-standing large goiter with marked tracheal compression and deviation.

Results

Twenty-seven patients who presented with huge goiter were studied. Of the 27 patients, 18 (66.7%) were females, whereas nine (33.3%) patients were males. The mean age was 51-year old. Six (22.2%) cases presented with neck masses but no compression symptoms, whereas 21 (77.8%) patients presented with neck mass and compression symptoms. One (3.7%) case presented with voice change in addition to the neck mass. The mean duration of the disease was 3–60 months. On physical examination, palpable anterior neck mass was noted in all 27 (100%) cases. Retrosternal extension was appreciated clinically in six (22.2%) patients where the lower poles of the masses were not palpable. The lesions had a maximum size of 15 cm×6 cm×5 cm and a minimum size of 8 cm×5 cm×4 cm. The nodule size ranges from 6 to 15 cm. There were three (11.1%) patients who had previous surgery before in the form of thyroid lobectomy for benign disease, in whom the remaining lobe enlarged and underwent completion total thyroidectomy. Twenty-four (88.8%) patients had no surgery before (five patients had unilateral nodules and 19 patients had bilateral nodules). Thyroid function test results were normal in 23 (85.2%) patients, and concomitant hypothyroidism was noted in four (14.8%) patients. Radiologic evaluation plays a critical role in the preoperative assessment of large goiters. In our study, ultrasound was the first-choice imaging technique to assess thyroid lesions and lymph nodes metastases, as well as the relation of the thyroid mass to the neck vessels. Owing to the nature of our cases, its effectiveness was limited in depiction of tumor extension to adjacent structures. It is not reliable for tumors larger than 4 cm in diameter, those with dense calcifications, and those with substernal extension.

CT scan was by far the most accurate diagnostic tool where RSG was detected in 100% of our six cases with RSG. Vertical extension at or below the level of aortic arch and loss of tissue planes were considered the most important CT findings, raising the possibility of thoracic approach for RSG. In our series, although the intraoperative findings of RSG were concordant with preoperative CT results, CT scan detected vertical extension of RSG below aortic arch in two of six (33.3%) patients, but during surgery, only one (33.3%) patient had extension of RSG below the arch that necessitated partial sternotomy. Two patients of 27 (7.4%) demonstrated discrepancy between preoperative imaging and intraoperative findings. In one (3.7%) patient with huge malignant goiter, preoperative CT scan detected tracheal and questionable esophageal invasion based on the deformity of their lumens with focal mucosal

irregularity and thickening. However, during surgery, there was no actual invasion. In another patient (3.7%) with recurrent huge colloid goiter, CT scan described complicated anatomic extension of the goiter to the posterior mediastinum. So, the preoperative decision was to incorporate partial sternotomy or mini-thoracotomy in addition to the cervical approach for adequate exposure. Interestingly, the recurrent goiter was totally dissected and retrieved through the cervical approach without the need for any thoracic approach. Preoperative imaging, including ultrasound and CT scan, showed marked displacement and encasement of the great vessels of the neck in some cases without actual tumor invasion, and these findings were concordant with our operative findings.

Mediastinal extension was noted in six (22.2%) patients. Five (18.5%) cases demonstrated masses descending to the anterior mediastinum, and one (3.7%) case showed extension into the posterior mediastinum. Only one patient needed partial sternotomy in addition to the neck incision where the thyroid reached the aortic arch, whereas other cases with mediastinal extension the thyroid were delivered into the neck by blunt dissection and gentle traction.

All patients underwent surgical intervention. The type of surgical procedure done is shown in Table 1. Total thyroidectomy was done in 21 (77.7%) cases for benign goiter. Completion total thyroidectomy for recurrent benign goiter was done in three (11.1%) cases. Total thyroidectomy plus central lymph node dissection was done in three (11.1%) patients with papillary thyroid carcinoma.

Postoperative pathological examination (Table 2) revealed benign nodular goiter in 22 (81.4%) patients, benign nodular goiter with incidental finding of concomitant PTC in two (7.4%) patients, and PTC in three (11.1%) patients.

Postoperative follow-up ranged from 9 months to 3 years. All patients received thyroxin therapy aiming to maintain the upper limit of normal of T3 and T4. Thyroid-stimulating hormone was maintained at 0.1–0.5 IU/ml to prevent or reduce recurrence. Local or distant recurrence was not observed in any of the patients during the follow-up period.

In our series, postoperative complications were encountered in nine (33.3%) patients (Table 3). None of the patients experienced major intraoperative or immediate postoperative complications (i.e., bleeding or airway obstruction). Six (22.2%) patients had transient hypocalcemia and three (11.11%) patients developed hoarseness of voice (HOV). In correlation to the type of surgery performed, postoperative hypocalcemia developed more in those patients who underwent total thyroidectomy and central lymph node dissection (66.6%). On the contrary, patients who underwent total thyroidectomy and completion thyroidectomy had less incidence of postoperative hypocalcemia (14.2 and 33.3%, respectively) (Table 4). The occurrence of postoperative hypocalcemia is correlated not only to the type of surgery performed but also to the final histopathologic results. Hypocalcemia was encountered in two out of three (66.6%) patients with PTC in comparison with three of 22 (13.6%) patients with benign goiter (Table 4). Patients with hypocalcemia were treated with calcium supplement and vitamin D, and they improved gradually within 12 months postoperatively. Three (11.1%) patients experienced HOV. The highest incidence of HOV was found in

Table 1 Types of surgical procedures

Surgical procedures	Number of patients	Total number of patients	Percentage
Total thyroidectomy	21	27	77.78
Completion total thyroidectomy	3	27	11.11
Total thyroidectomy+central lymph node neck dissection	3	27	11.11

Table 2 Postoperative pathological findings

Pathology	Number of patients	Total number of patients	Percentage
Benign colloid goiter	22	27	81.48
Benign colloid with incidental PTC	2	27	7.41
PTC	3	27	11.11

PTC, papillary thyroid cancer.

Table 3 Postoperative complications

Postoperative complications	Number of patients	Total number of patients	Percentage
Bleeding	0	27	0
Dyspnea	0	27	0
Hoarseness	3	27	11.11
Hypocalcemia	6	27	

Table 4 Incidence of postoperative hypocalcemia in relation to the type of surgery and final pathology results

Variables	Number of patients	Number of patients with hypocalcemia	Percentage
Type of surgery			
Total thyroidectomy	21	3	14.2
Completion thyroidectomy	3	1	33.3
Total thyroidectomy+CND	3	2	66.6
Pathology of goiter			
Benign colloid	22	3	13.6
Benign colloid+incidental PTC	2	0	0
PTC	3	2	66.6

PTC, papillary thyroid cancer.

Table 5 Incidence of hoarseness of voice in relation to the type of surgery

Type of surgery	Number of patients	Number of patients with HOV	Percentage
Total thyroidectomy	21	1	4.7
Completion thyroidectomy	3	0	0
Total thyroidectomy +CND	3	2	66.6

HOV, hoarseness of voice.

patients with huge malignant goiter, where total thyroidectomy and central lymph node dissection were done (66.6%). One (4.7%) patient developed HOV following total thyroidectomy without CND (Table 5). Patients recovered within few weeks postoperatively with the help of speech therapy.

Discussion

William Halstead has stated that 'the extirpation of the thyroid gland for goiter typifies better than any operation the supreme triumph of the surgeon's art' [6].

The size and location of goiter determine the symptoms and signs. Trachea or esophagus compression by the goiter can cause worsening dysphagia to solids, positional dyspnea, and dysphonia specially if there is substernal extension. Shin *et al.* [7] reported positive correlations between thyroid size and presence of shortness of breath and globus sensation.

The presence of symptoms related to compression of the trachea or esophagus (dyspnea and/or dysphagia), suspicion of malignancy, and prevention of complications from progressive enlargement or mediastinal extension are the main indications for surgical intervention [8].

The perioperative management of large goiters is a challenging complex process as it carries significant anesthetic and surgical risks. Preoperative anesthetic assessment of large goiter is very important concerning mainly the airway, which may be compromised owing to tracheal deviation or compression. Team work and close collaboration between highly experienced surgical and an anesthesia team is crucial for proper induction and reversal of anesthesia. In addition, these teams should be aware and must be cognizant of complications from massive goiter surgery such as bleeding, airway distress, and RLN injury.

Profound knowledge of anatomy and adoption of meticulous surgical technique during thyroidectomy can help avoid most of postoperative complications. The presence of highly specialized thyroid centers with good volume operations contributes to a safe surgical procedure and good outcome [4].

Complication rates appear to be affected by the surgeon's experience. A study in Maryland comprising 5860 patients reported the lowest complication rate in patients operated on by surgeons who performed more than 100 neck explorations annually, and other studies confirmed these results [5,9].

Complications following large goiter surgery include bleeding, airway compromise, hypocalcemia, and RLN injury. Although the incidence of these complications is rare, they still exist. On the contrary, surgery for recurrent goiter and redosurgery carry even more complications, especially nerve injury and damage to the parathyroid tissue. In some reports, the incidence of complications was approximately 8% after surgery owing to recurrence of nodular goiter. Among these complications, the incidence of damage to the RLN was 0–14.0% and that of hypocalcemia was 1.2–10.6% [10,11]. The incidence of symptomatic postoperative hemorrhage requiring reintervention amounts to 1.2% [12].

Postoperative bleeding commonly occurs few hours after surgery and can lead to progressive neck swelling, respiratory distress, pain, and increased blood drainage. One of the most serious complications

associated with significant neck hematoma is respiratory compromise owing to tracheal compression and laryngeal edema. Immediate decompression by opening the wound under aseptic conditions may be lifesaving till the patient has been returned back to the operating room as early as possible for evacuating the hematoma and dealing with any bleeding points.

The standard surgical treatment for nodular goiter is subtotal thyroidectomy. However; controversy still exists between total and subtotal thyroidectomy [13].

In terms of postoperative complications, total or near-total thyroidectomy versus subtotal thyroidectomy had no significant difference and were comparable in the subsequent treatment [14].

The risk factors of recurrence after subtotal thyroidectomy are age less than 40 years and multiple nodules, and based on that evidence, total thyroidectomy rather than subtotal thyroidectomy is recommended for patients with bilateral multinodular goiter aiming to avoid a second surgery for recurrence [14]. In all our patients, as the goiters weather primary or recurrent are quite big, total or completion total thyroidectomy was done for both benign and malignant cases to avoid the need for any further surgeries with more technical difficulties and significant morbidities.

LN dysfunction is not uncommon following surgery for giant goiter owing to limited operative space and anatomical variation of RLN. Paralysis of the RLN could be transient or seldom permanent [15,16]. It is the most common complication after thyroidectomy, especially for large goiters, for cancer, or in redo cases. Injury to the RLN can result from sharp trauma (transection), clamping, ligation, compression, traction, thermal injury, or ischemia [17]. Intraoperative nerve identification and exposure are the most effective measures to prevent its injury. The use of intraoperative neuromonitoring technique is an important component in the field of modern surgery that helps decrease nerve injury. In our series, direct anatomic identification and protection of the RLN was the gold standard to minimize nerve dysfunction. The goiter was approached from lateral to medial, and the RLN was properly localized and exposed from below upward with the help of intraoperative neuromonitoring.

Three patients developed temporary HOV postoperatively probably owing to traction injury to the nerve, which gradually improved by time with the help of speech therapy.

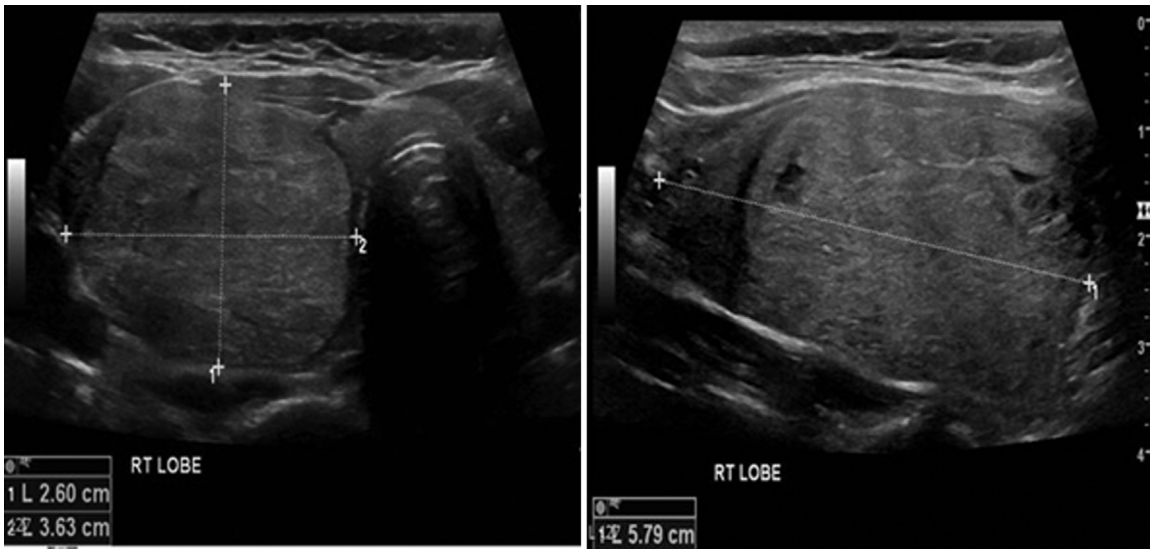
Transient or permanent hypoparathyroidism is common after surgery for giant goiter, which is usually attributed to the misdissection or damage to the parathyroid glands, inadvertent removal, and/or the impairment of their blood supply [18]. Postoperative hypocalcemia resolves in 80% of cases in ~12 months. Every effort is made to evaluate the parathyroid tissue intraoperatively [19]. Preservation of the capsule at the back of thyroid gland helps protection of superior parathyroid gland, whereas preservation of the loose tissues at the lower part of the thyroid helps protection of inferior parathyroid gland. Selective ligation of the terminal branches of the inferior thyroid artery is required to preserve the blood supply of both upper and lower glands. Careful attention must be paid to the calcium levels postoperatively. Obtaining parathyroid hormone in the postoperative period can help determine the need for postoperative calcium supplementation with or without postoperative calcitriol and the safety of discharge [20,21]. In the current study, all efforts were made to preserve parathyroid glands.

As all patients had large size of goiters whether primary or recurrent in addition to the variable locations of the glands, six out of the 27 patients developed transient hypocalcemia. We tried to preserve the upper glands initially by working very close to the capsule of the thyroid gland with ligation of the small terminal branches of the inferior thyroid vessels. The operative specimen was checked immediately after retrieval for any adherent parathyroid tissue. For glands that appear to be devascularized, the use of immediate parathyroid autotransplantation of 1-mm fragments of saline chilled tissue into pockets made in the sternocleidomastoid muscle is extremely effective in avoiding permanent hypocalcemia.

Proper surgical exposure and bloodless field are crucial for meticulous dissection and successful outcome with minimal or no complications. To facilitate goiter dissection, section of prethyroid muscles and ligation of the middle thyroid veins early in the procedure are recommended. To facilitate goiter removal, careful dissection and externalization of the retrosternal part of the gland are important operative tricks [22].

Sonography is considered the initial diagnostic modality worldwide for the diagnosis of thyroid lesions (Fig. 4). However, its value can be of low sensitivity in the detection of extrathyroidal extension (Fig. 5). CT is more accurate than sonography in the detection of mediastinal and

Figure 4



Ultrasound examination of the thyroid gland shows large solid mass in the right thyroid lobe. The whole lesion could be determined by the ultrasound with no need for further imaging modalities.

Figure 5

Ultrasound examination of the thyroid gland (not shown) shows large left lobe mass with indistinct lower border. CT scan was done with axial image (left), showing large left lobe mass with retrosternal extension into the upper mediastinum, which is well seen in the coronal image (right). The coronal image also shows indentation of the thoracic trachea (white arrow) with no definite CT evidence of tracheal invasion. CT, computed tomography.

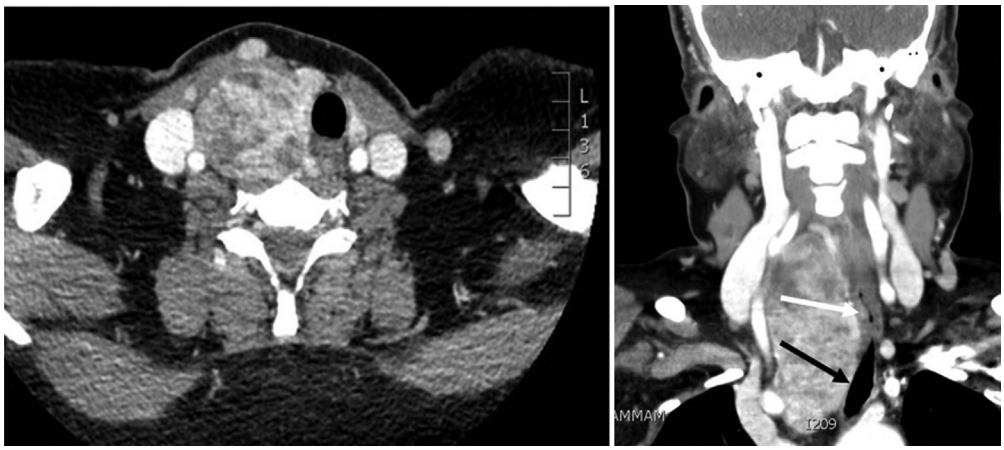
retropharyngeal lymph nodes metastases as well as tumor invasion of the adjacent structures [23].

The preoperative detection of invasion of the neck muscles, trachea, larynx, esophagus, pharynx, and RLN or major blood vessels in the neck is very important for the best surgical outcome and to decrease the recurrence rate [23]. CT scan is an alternative imaging modality if ultrasound cannot accurately assess the extra-thyroid extension of the mass [24,25], as sonography is operator dependent and is not accurate for lesions bigger than 4 cm in diameter, masses with dense calcifications, and masses with downward extension into the mediastinum [26,27]. However; sonography can accurately detect the relation of the mass to the nearby neck vessels without extensions outside the neck [26].

Ultrasound is usually used for detection of lymph nodes metastases; especially, it can be combined with ultrasound-guided FNAC of the thyroid mass and the lymph nodes at the same time [28]. Stulak *et al.* [29] have shown that ultrasound sensitivity is 83% and specificity is 98% for detection of lymph nodes metastases.

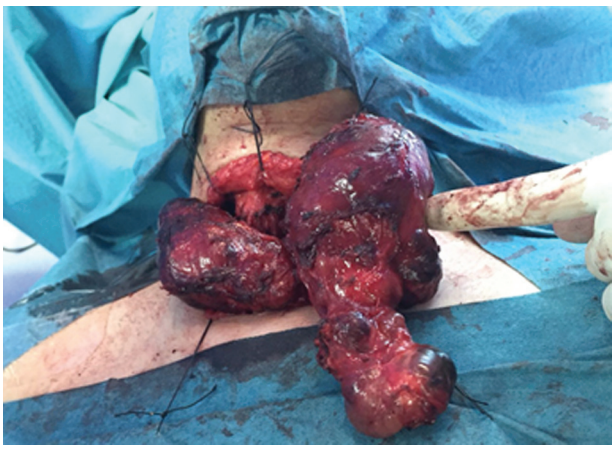
Tracheal and esophageal invasion on CT examination can be expected if the mass is contacting 180 or more of

Figure 6



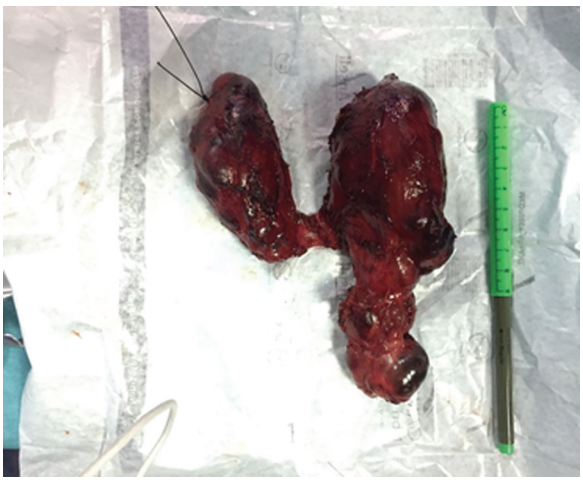
CT scan of the neck shows large heterogeneous mass in the thyroid gland in the axial image (left) with large retrosternal extension into the upper mediastinum in the coronal image (right). The mass is markedly compressing the trachea (black arrow in the coronal image) and the esophagus (white arrow in the coronal image) with high possibility of their invasion manifested by tracheal deformity and loss of normal esophageal structure at the level of the thyroid mass. CT, computed tomography.

Figure 7



Operative picture showing huge goiter with big substernal extension after complete removal via cervical approach.

Figure 8



Operative specimen of the previous case after removal marker pen refer to the big size of the goiter with marked retrosternal extension to the left side.

the circumference of these structures. Deformity of the tracheal lumen, focal mucosal irregularity, and intraluminal mass are other signs of tracheal involvement [30] (Fig. 6).

Loss of the normal esophageal wall and lumen on CT study should raise the possibility of esophageal infiltration by the thyroid mass, although it is more difficult to evaluate than tracheal involvement as the esophagus is usually not distended with air [31].

Conclusion

Thyroidectomy for large thyroid masses is a challenging surgical technique owing to high incidence and possibility of complications. However, it remains the best treatment option for effective and definitive cure. Comprehensive perioperative management and team work are crucial for successful outcomes. Complete exposure of the operative field and meticulous technique are the golden keys for successful surgical intervention. Ultrasound and CT scans are essential in preoperative evaluation of the thyroid masses and detection of extrathyroidal extension (Figs 7 and 8).

Conflicts of interest

There are no conflicts of interest.

References

1 Stavrakis AI, Ituarte PH, Ko CY, Yeh MW. Surgeon volume as a predictor of outcomes in inpatient and outpatient endocrine surgery. Surgery 2007; 142:887–899.

2 Rugiu MG, Piemonte M. Surgical approach to retrosternal goiter. Do we still need sternotomy? Acta Otorhinolaryngol Ital 2009; 29:331–338.

3 Abboud B, Sleilaty G, *et al.* Morbidity and mortality of thyroidectomy for substernal goiter. Head Neck 2010; 32:744–749.

4 Richard DB, Paul GG, Leigh DD. Surgeon's approach to the thyroid gland: surgical anatomy and the importance of technique. World J Surg 2000; 24:891–897.

5 Haugen BR, Alexender EK, Bible KC, *et al.* American Thyroid Association management guidelines for patients with thyroid nodules and differentiated thyroid cancer. Thyroid (Epub ahead of print. 2015).

6 Ling YC, Christine O, James S, Stan SL, Mark S. Sutureless total thyroidectomy: a safe and cost-effective alternative. ANZ J Surg 2011; 81:510–514.

7 Shin JJ, Grillo HC, Mathisen D, Katlic MR, Zurakowski D, Kamani D, Randolph GW. The surgical management of goiter. Laryngoscope 2011; 121:60–67.

8 Chen AY, Bernet VJ, Carty SE, Davis TF, Ganky I, Inabnet WB III, Shaha AR. American thyroid association statement on optimal surgical management of goiter. Thyroid 2014; 24:181–189.

9 Sosa JA, Bowman HM, Tielsch JM, *et al.* The importance of surgeon experience for clinical and economic outcomes from thyroidectomy. Ann Surg 1998; 228:320–330.

10 Mishra A, Agarwal A, Agarwal G, *et al.* Total thyroidectomy for benign thyroid disorders in an endemic region. World J Surg 2001; 25: 307–310.

11 Gibelin H, Sierra M, Mothes D, *et al.* Risk factors for recurrent nodular goiter after thyroidectomy for benign disease: case-control study of 244 patients. World J Surg 2004; 28:1079–1082.

12 Rosato L, Avenia N, Bernante P, De Palma M, *et al.* Complications of thyroid surgery: analysis of a metacentric study on 14,934 patients operated on in Italy over 5 years. World J Surg 2004; 28:271–276.

13 Unalp HR, Erbil Y, Akguner T, *et al.* Does near total thyroidectomy offer advantage over total thyroidectomy in terms of postoperative hypocalcemia? Int J Surg 2009; 7:120–125.

14 Vaiman M, Nagibin A, Hagag P, *et al.* Subtotal and near total versus total thyroidectomy for the management of multinodular goiter. World J Surg 2008; 32:1546–1551.

15 Ruth SR, Pamela JE, Stanley BS, Mark SS, Leigh D. Post-operative partial hypoparathyroidism: an under-recognized disorder. ANZ J Surg 2011; 81:524–527.

16 Reeve T, Thompson NW. Complications of thyroid surgery: how to avoid them, how to manage them, and observation on their possible effect on the whole patient. World J Surg 2000; 24:971–975.

17 Myssiorek D. Recurrent laryngeal nerve paralysis: anatomy and etiology. Otolaryngol Clin North Am 2004; 37:25–44.

18 Rios ZA, Rodriguez JM, Galindo PJ, *et al.* Clinical recurrence of multinodular goiter after surgery. A multivariate study on the risk factors. Rev Clin Esp 2005; 205:9.

19 Mazzaferri EL, Kloos RT. Clinical review 128: current approaches to primary therapy for papillary and follicular thyroid cancer. J Clin Endocrinal Metab 2001; 86:1447–1463.

20 Noordzij JP, Lee SL, Bernet VJ, Payne RJ, Cohen SM, McLeod IK, *et al.* Early prediction of hypocalcemia after thyroidectomy using parathyroid hormone: an analysis of pooled individual patient data from nine observational studies. J Am Coll Surg 2007; 205:748–754.

21 Wiseman JE, Mossanen M, Ituarte PH, Bath JM, Yeh MW. An algorithm informed by the parathyroid hormone level reduces hypocalcemic complications of thyroidectomy. World J Surg 2010; 34:532–537.

22 Randolph GW, Dralle H, *et al.* Electrophysiologic recurrent laryngeal nerve monitoring during thyroid and parathyroid surgery: international standards guideline statement. Laryngoscope 2011; 121: S1–S16.

23 Jenny KH, Barton FB, Andreia RG, Wai KL, Christine MG. Imaging of thyroid carcinoma with CT and MRI: approaches to common scenarios. Cancer Imaging 2013; 13:128–139.

24 Ann DK. Imaging for staging and management of thyroid cancer. Cancer Imaging 2008; 25:57–69.

25 Passler C, Scheuba C, Asari R, Kaczirek K, Kaserer K, Niederle B. Importance of tumor size in papillary and follicular thyroid cancer. Br J Surg 2005; 92:184–189.

26 Chammas MC, Gerhard R, De Oliveira IR, *et al.* Thyroid nodules: evaluation with power Doppler and duplex Doppler ultrasound. Otolarybgol Head Neck Surg 2005; 132:874–882.

27 Loevner LA, Kaplan SL, Cunnane ME, Moonis G. Cross-sectional imaging of the thyroid gland. Neuroimaging Clin N Am 2008; 18:445–461.

28 Rosario PW, De Faria S, Bicalho L, *et al.* Ultrasonographic differentiation between metastatic and benign lymph nodes in patients with papillary thyroid carcinoma. J Ultrasound Med 2005; 24:138–159.

29 Stulak JM, Grant CS, Farley DR, *et al.* Value of preoperative ultrasonography in the surgical management of initial and preoperative papillary thyroid cancer. Arch Surg 2006; 141:489–496.

30 Seo YL, Yoon DY, Lim KJ, *et al.* Locally advanced thyroid cancer: can CT help in prediction of extrathyroidal invasion to adjacent structures? Am J Roentgenol 2010; 195:W240–W244.

31 Wang JC, Takashima S, Takayama F, *et al.* Tracheal invasion by thyroid carcinoma: prediction using MR imaging. Am J Roentgenol 2001; 177:929–936.