

## Original Article

# Surgical treatment of large substernal thyroid goiter: analysis of 12 patients

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**Abstract:** This study was carried out to evaluate the clinical presentation, surgical treatment, complications, and risk of malignancy for large substernal goiter. From March 2010 to December 2012, 12 patients with large substernal thyroid goiter who underwent surgery in our Department were enrolled in the study. Their medical records were retrospectively analyzed. Collar-shaped incision was adequate for resection of the lesions in 10 (83%) patients, while two (17%) patients required combined cervical-thoracic incision. In addition, one case was subjected to postoperative tracheotomy. Transient hypocalcaemia occurred in one case. The incidence of transient hoarseness, tracheomalacia and hypothyroidism was 8.3%. There was no perioperative bleeding, thyroid storm as well as other serious complications. All patients were clinically cured. Therefore, cervical collar incision is nearly always adequate for most cases of larger substernal goiter, and sternotomy can be avoided. Furthermore, the application of intraoperative ultrasonic knife can effectively reduce intraoperative and postoperative complications. Aggressive perioperative management is crucial for the successful removal of large substernal goiter.

**Keywords:** Substernal goiter, operative approach, ultrasonic knife, complications

## Introduction

Substernal nodular goiter usually results from simple goiter. Although bilateral glands are often involved, the large lesions are usually located in unilateral gland. Large substernal nodular goiter often causes compression of surrounding structures, secondary hyperthyroidism and malignant changes. Therefore, surgery will be indicated when the diagnosis is confirmed [1, 2]. However, if it is treated with surgery, the operative bleeding risk was high. Most of the cases are operated upon via a cervical or combined cervical-thoracic approach. Substernal goiter resection performed through cervical approach is minimally invasive with less potential complications. The patients don't require thoracotomy and rehabilitate fast postoperatively [3, 4]. In contrast, combined cervical-thoracic approach pose more risk of intraoperative damages and complications, as well as slower postoperative rehabilitation. Twelve patients of substernal large goiter patients were admitted to our hospital from March 2010 to December 2012. In this article, the medical

records of the 12 cases were retrospectively analyzed, and perioperative management was also analyzed, which is listed as follows.

## Clinical data

### Patient information

Of the 12 patients, 5 were men and 7 were women, with an age range of 28~62 years (median age of 51). The mean duration of the disease among the patients was 3-60 months. Palpable anterior neck mass were noted in all 12 cases, but the lower poles of the masses was not palpable. Lesions located on the left lobe were seen in 4 cases, on the right in 6 cases, and bilateral sides in 2 subjects. The lesions had a maximum size of 15 cm × 6 cm × 5 cm and a minimum size of 8 cm × 5 cm × 4 cm. Eleven cases demonstrated masses descending to the anterior mediastinum, and masses extending into the posterior mediastinum were observed in one case. The maximum length of the mass descending into the chest was 9.5 cm, and the minimum was 4 cm, with

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**Table 1.** Occurrence of clinical symptoms

Clinical symptoms	Total cases	Cases involved	Percentage (%)
Cervical mass	12	10	83.3
Chest distress and tightness	12	10	83.3
Chest pain	12	2	16.7
Hoarseness	12	3	25.0
Jugular vein distension	12	1	8.33
No symptoms	12	2	16.7

an average length of 6.5 cm. Diagnosis of substernal goiter was confirmed by frontal and lateral chest X-ray, color ultrasound and CT scan. Postoperative histopathological examination showed 10 benign nodular goiter and 2 cases of thyroid adenoma. Two cases were accompanied by hypertension and arrhythmia before surgery.

## Clinical manifestations

Of the 12 patients, 10 of them were manifested by cervical mass, 10 cases presented with chest distress and tightness, 2 cases had chest pain, 3 cases suffered from hoarseness, 1 case developed jugular vein distention, and 2 cases didn't complain of any symptoms. Physical examination revealed that all patients had cervical masses. Moreover, the lower edge of the masses could not be reached because it had surpassed the sternoclavicular joint (**Table 1** and **Figure 1**).

## Imaging examination

Conventional frontal and lateral X-ray scan for neck as well as chest, fibrolaryngoscopy, CT scan, thyroid ultrasound, and thyroid function detection were conducted before operation. Frontal and lateral X-ray of cervix and chest displayed varying degrees of tracheal displacement due to compression in 12 cases, of which 10 cases were associated with severe tracheal stenosis (**Figure 2**). Limitation of vocal cord movement was found in three cases by fibrolaryngoscopy. Neck and chest CT scans demonstrated masses located in the anterior right superior mediastinum in 2 cases, in anterior left superior mediastinum in 9 subjects, as well as in posterior mediastinum in 1 case. The lower edges of the masses were found above the level of the aortic arch in 11 patients, and under the level of the aortic arch in one case (**Figure 3**).

## Treatment procedures

### Preoperative preparation

The diagnoses of large substernal goiter were confirmed in twelve patients and following preoperative examinations were performed preoperatively. Prior to surgery, those who combined with secondary hyperthyroidism received oral treatment of compound iodine solution. The patients had symptoms related to the tracheal compression or (with) bronchospasm received dexamethasone 10 mg once per day, as well as oral aminofilina 0.1 g 10 mg bid. Moreover, the patients were also handled with strategies for alleviating coughs and reducing sputum. High blood pressure and cardiac arrhythmias should also be appropriately controlled. Prophylactic antibiotics should be administered prior to incision. Conventional surgical position for standard thyroid surgery was adopted. The patients were placed in a supine position with an occipital pad under the shoulder to allow for neck extension, which affiliated field exposure. Ten patients underwent awoken tracheal intubation under general anesthesia. Two cases were subjected to fiberoptic bronchoscope guided tracheal intubation on awake because of serious compression of tracheal mass.

### Surgical procedures

A 1-1.5 cm low collar-shaped incision was made along the sternum notch. Preoperative management and preparation for thoracotomy should be made. Every layer of the chest wall was incised and anterior cervical muscles were dissected using electric scalpel. The shallow surface and outer surface of the ipsilateral gland were separated with an ultrasonic knife. The upper pole of the lobe was dislocated, where the vessels and medium-sized vein were also dissected. The isthmus was incised by an ultrasonic knife, and half of the dorsal upper isthmus of thyroid gland was separated tightly along the gland. The upper half portion was sutured using a 7-sized silk wire and drawn upwardly. Superficial blood vessels were incised along the capsule. The intrathoracic portion of gland was gently separated by blunt dissection. Supporting sutures were made in the lower pole to facilitate in drawing sutures

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**Figure 1.** Pictures showing anterior neck masses.

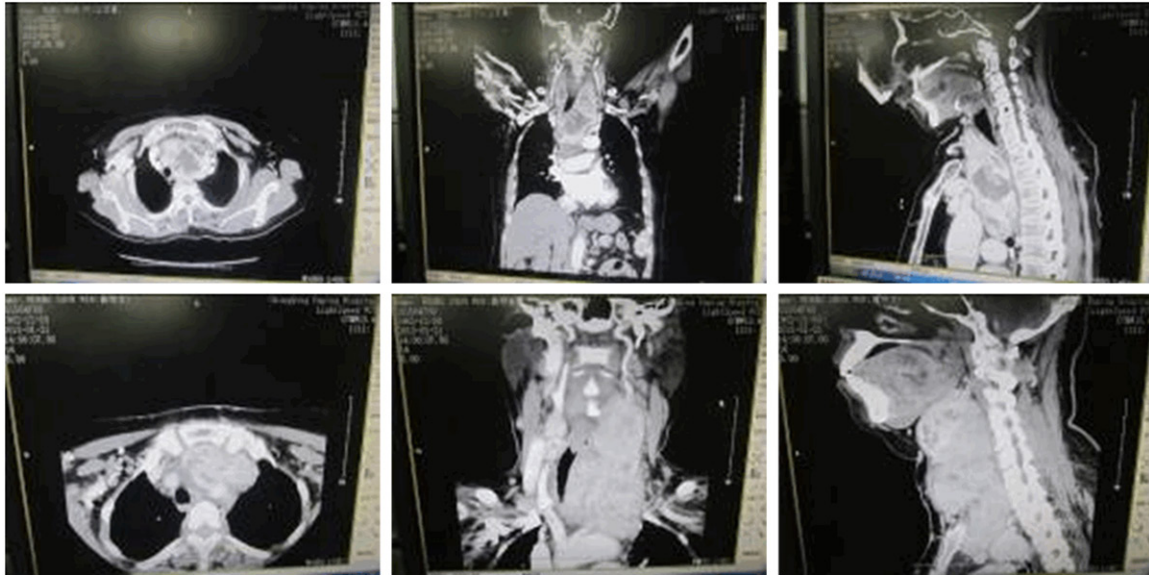


**Figure 2.** Anteroposterior chest X-ray and barium meal test: Chest X-ray revealed widened superior mediastinum tracheal shift to the uninjured side of the chest due to compression. Upper gastrointestinal series unveiled esophageal deviation to unaffected side of the chest due to compression.

upward and outwards, followed by further separation. The procedure was repeated until the thyroid gland's substernal part was separated upwardly to the cervical incision. The thyroid vein was occluded with an ultrasonic knife. During separation, the knife should always cling to the gland lobe, so as to ensure the integrity of the rear capsule of the gland and avoid damage to laryngeal nerve and parathyroid. Negative pressure drainage was conducted with a silicone tube, and the tube is passed out through the inferior incision. The apocoptic anterior cervical muscles should be first stitched with 4/0 Puri spiritual line for intradermal saturation before the incision was sutured. This surgical approach was adopted in ten patients of this study group (**Figure 4**). **Figure 5** showed negative pressure drainage using a silicon tube.

If significant adhesions existed between the tumor and the mediastinal structures, or there were difficulties in completely removing the tumor from the cervical incision, the middle of the sternum was supposed to be separated to ensure the safety of the surgery. That is, the sternum was separated along from manubrium

to the second intercostals space by a sternal saw via the cervical low collar incision. Homeostasis of cross-section of the sternum could be accomplished using electric coagulation and sealing with bone wax. The edge of sternal incision was stretched and the anterior mediastinum was exposed using rib retractor. The lower pole of gland was bluntly disassociated with figures and pulled upward gently and separated afterwards. The inferior thyroid artery and veins were separated and occluded by ultrasonic knife. The free thyroid was lifted to the cervical incision and was incised with a conventional approach. After obtaining adequate hemostasis, pleura was sutured and chest tubes were then put in place followed by approximating the sternum using surgical steel wires. One case was treated with this surgical approach (**Figure 6**). After the posterior mediastinal mass was removed with thoracotomy, closed thoracic drainage was implemented in one case, which was used in one patient. Tracheomalacia and tracheal collapse during surgery occurred in one case. Tracheotomy was then performed and respirator was utilized to assist breathing and secure airway patency (**Figure 7**).



**Figure 3.** CT scans showing significantly enlarged thyroid, which extends from the lower part of jaw to the level of the aortic arch through the thoracic inlet. Tracheal deviation toward unaffected side of the chest due to compression.

## Postoperative treatment

The patients were placed in a 60° semi-recumbent position after surgery, and ECG monitoring and oxygen saturation monitoring was conducted. Sterile tracheotomy kit was prepared for bedside tracheotomy was prepared. Observe closely the exudate of wound dressings as well as the property and quantity of the drainage. Hemostatic medicines were given if needed. Hormones were used to prevent laryngeal edema if necessary. Appropriate treatments were supposed to be administered according to the damage level of the thyroid gland and the parathyroid glands.

## Results

Substernal thyroidectomy was successfully completed in all 12 patients. Among them, 10 cases underwent cervical low collar-shape incision approach, and 2 cases were subjected to cervical low collar-shape incision accompanied by medial sternotomy (cervix-chest combined incision). There was no perioperative bleeding and thyroid storm. Postoperative histopathological examination confirmed that there were 10 cases of nodular goiter, and 2 cases of thyroid adenoma. Tracheomalacia and tracheal collapse occurred in one case. The patient underwent tracheotomy and the ventilator was used for 2 days and the chest tube was retained

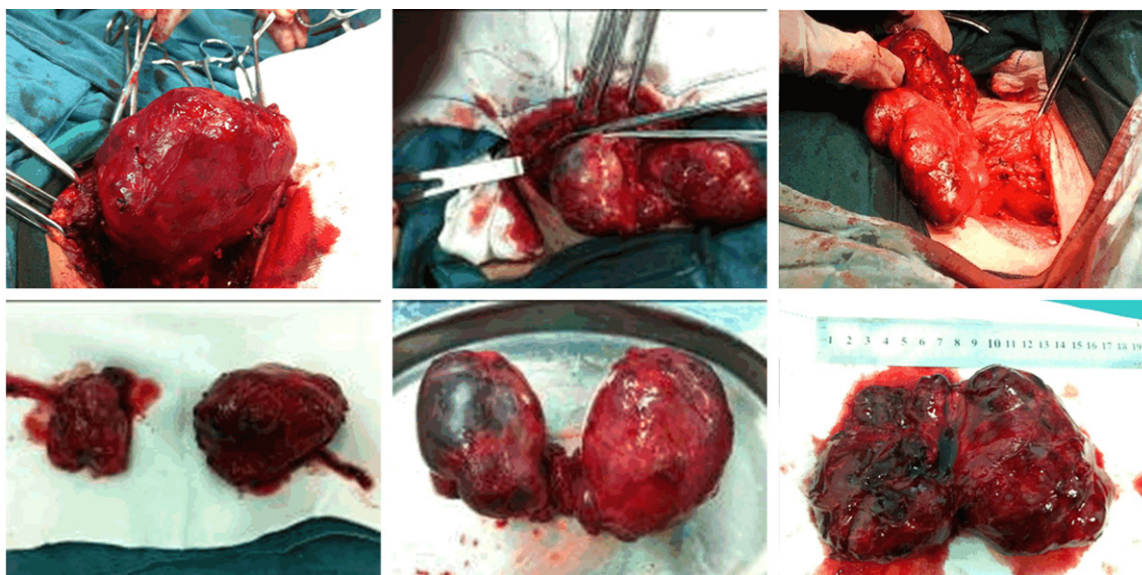
for 5 days. Transient hypocalcemia was seen in 1 case, which relieved after oral and intravenous administration of calcium supplements. In addition, one patient developed transient hoarseness, which was relieved after intravenous infusion of dexamethasone for 3 days. Hypothyroidism was found in 1 case, and was recovered after 6 months of an oral administration of levothyroxine sodium tablets. No recurrent space-occupying lesions were discovered through postoperative follow-up and B-mode ultrasound review of the neck. There were no mediastinal abnormalities. All patients were clinically cured and discharged from hospital, and all preoperative symptoms eventually disappeared. No relapse occurred during a following-up period from 3 months to 3 years (Table 2).

## Discussion

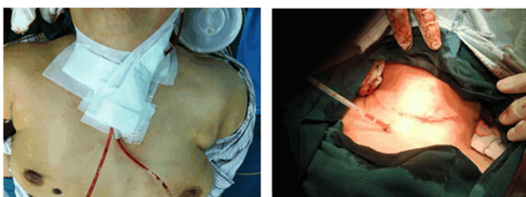
Substernal goiter refers to the thyroid mass grows along dermal sternum from the neck to the substernal portion, descending below the thoracic inlet. The currently accepted definition of an intrathoracic goiter is a thyroid gland with more than 50% of its mass located below the thoracic inlet [5, 6]. It is characterized by slow progression and a longer course of illness. If the substernal goiter compresses the adjacent esophagus, trachea, nerves and blood vessels, then the corresponding symptoms would occur.



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**Figure 4.** Pictures showing cervical surgical approach and the dissected tissues.



**Figure 5.** Postoperative negative pressure drainage.

These symptoms included anhelation and wheezing secondary to tracheal compression, superior vena cava syndrome caused by superior vena cava compression [5], hoarseness caused by recurrent laryngeal nerve compression, and Horner syndrome caused by peripheral adrenergic nerve compression [7]. Some patients may be asymptomatic, and the abnormalities were detected by physical examination.

### *Preoperative examination and assessment*

It is of great importance that carried out preoperative X-ray test, CT scanning, fibrolaryngoscopy, thyroid color Doppler ultrasound test, and thyroid function detection in the neck and thoracic region. Chest X-ray revealed widened superior mediastinum or oval shadow in superior mediastinum. The upper edge was connected with the cervix. The trachea was shifted due to compression [7, 8]. Color Doppler ultrasound test demonstrated that the thyroid mass was

located in dermal part of sternum, with varying sizes of nodules, cystic degeneration and calcification in the bilateral gland. CT examination displayed masses in superior mediastinum, and the size, internal pathological changes and location, the relation with peripheral tissues as well as the displacement. MRI can generate cross-sectional images in any plane, which is used for deciding the definite site and an accurate differential diagnosis of intrathoracic goiter. The vocal cords and their movement can be visualized on fiberoptic laryngoscopy. Thyroid function test could help to detect functional abnormalities in thyroid, based on which aggressive preoperative preparation could be performed to prevent thyroid storm. Thyroid radioisotope scan can determine whether the intrathoracic mass was thyroid tissues.

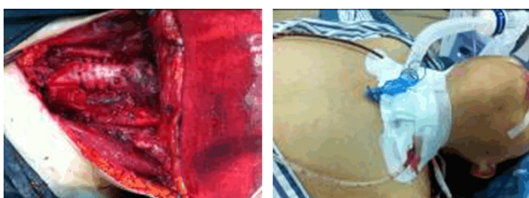
### *Intraoperative procedures*

General anesthesia with endotracheal intubation was implemented. General anesthesia induced with fiberoptic bronchoscope guided tracheal intubation on awake should be initiated when bronchial stenosis developed. A cervical low collar-shaped incision was applied in ten patients of the study group, which was conducted under direct bronchoscopic guidance. When the mass was small in size, the lower pole of gland was bluntly disassociated with figures and pulled upward gently and separated from sternum afterwards. When the tumor was

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**Figure 6.** Combined cervical-thoracic approach.



**Figure 7.** The left picture showing tracheomalacia following the tumor removal. The right picture demonstrating ventilator-assisted breathing after tracheotomy.

large and difficult to pull out, the upper, inner and outer edge of the gland should be completely separated. The mass was pulled upwardly followed by a blunt dissection along the thyroid capsule. Lower vessels were freed under direct bronchoscopic guidance. When the tumor mass was cystic, the tumor puncture and needle aspiration of the cyst should be executed first to shrink tumor size so as it could be easily taken out from through the cervical incision. The lower pole of intrathoracic goiter was dislocated clinging tightly to the capsule gently with alternative operation of sharp and blunt dissection. The exposures of lower blood vessels were difficult because of dislocation following great compression. In this condition, grudging dissection and ligation was not recommended, especially when the lower pole of the tumor was adhered to the superior pleura and intrathoracic large blood vessels, the dissection and ligation should be performed more gently to avoid hemorrhage and pneumothorax. The recurrent laryngeal nerve should not be exposed using routine measures, but only dislocated clinging tightly to the outer surface and the posterior capsule was preserved. If the lower pole of the mass located posterior to the sternum and difficult to exposed, it was sutured using a 7# silk and then pull upward gently to facilitate the blunt separation of the lower pole.

The suture could be repeated several times if necessary until the intrathoracic tumor was removed completely.

For huge tumor that had been growing for a long time, with sternal tumor of unclear boundary or existence of adhesion to the mediastinal vessels showing by preoperative enhanced CT or MRI examination, there were increased risks of blood vessels damage during operation. Thus, sternotomy was performed to offer full exposure and the tumor was dissected under direct vision [8-10]. During the surgery, 2 cases in the group were subjected to sternotomy combined with cervical approach to ensure the safety of the operation.

### *Application of intraoperative ultrasonic knife*

Because the substernal goiter was huge with extremely rich blood supply and the vessels on surface of tumors were usually distorted and thickened, indicating a tendency of intraoperative hemorrhage. The cervical approach was considered not adequate and routine hemostasis by ligation is usually very difficult to be carried out due to the limited operation space. In such condition, once the bleeding point retracted into the thorax, it would be difficult to be tracked. A sternal splitting approach was ultimately be initiated in this scenario. The application of ultrasonic knife would solve this problem very well. The ultrasonic knife provides advanced sealing and cutting with superior hemostasis, which can directly cut a vessel with the diameter below 0.3 cm or 0.5 cm diameter blood vessel even without ligation. The ultrasonic knife can deliver effective separation, resection and hemostasis within small surgical space, substantially affiliating the resection of substernal goiter via cervical incision approach. Decreased bleeding and a clear operation field were obtained while dealing with

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**Table 2.** Occurrence of postoperative complications

Postoperative complications	Total cases	Cases involved	Percentage (%)
Hoarseness	12	1	8.3
Transient hypocalcaemia	12	1	8.3
Tracheomalacia	12	1	8.3
hypothyroidism	12	1	8.3
Thyroid storm	12	0	0
Postoperative bleeding	12	0	0

vascular network at the surface thyroid, affiliating better exposure and protection of the recurrent laryngeal nerve. This surgical procedure was used in ten cases in the study group. Less postoperative bleeding occurred and no blood transfusion was required. Postoperative complications were rare and no postoperative bleeding and thyroidstorm was observed. Transient hoarseness was seen in 1 case and transient tetany in 1 case. As a result, in substernal goiter resection surgery conducted by sternotomy through a cervical incision approach, the application of intraoperative ultrasonic knife could reduces surgical injuries and complications occurrences under the premise of same therapeutic effect conducted [11].

### *Preventive strategies for intraoperative complications*

Recurrent laryngeal nerve injury is one of the most common lethal complications of thyroid surgery [12-15]. Furthermore, there is a higher rate of the recurrent laryngeal nerve injury during substernal goiter operation. The exposure of recurrent laryngeal nerve during operation maintains controversial. The author believed that the deliberate dissection of the recurrent laryngeal nerve injury is unnecessary in the first attempt, preservation of capsule of the posterior thyroid can avoid damage to the recurrent laryngeal nerve. Besides, some researchers have proposed that the detection of IONM in recurrent laryngeal nerve surgery can effectively prevent the nerve injury. However, visual recognition of recurrent laryngeal nerve and the precise operation technology is still the most important factors for the success of surgical operation [16].

Parathyroid injury or blood supply impairment often leads to postoperative hypocalcemia. Some researchers noted that the incidence of parathyroid injury during substernal goiter sur-

gery is 0-6% [17]. Hands numbness and convulsion was observed in one patient, which were eventually relieved after treatment of oral calcium and intravenous calcium gluconate. The author noted that the integrity of capsule of the posterior thyroid is the key to protection of parathyroid. The inferior thyroid artery should not be ligated, the integrity of capsule of posterior thyroid should be maintained, and loose connective tissues in lower pole of thyroid gland should be preserved. Hence the resected tissue samples should be detected seriously. Once parathyroid is found in the resected samples, it should be cut into small pieces with size of about 1 mm × 1 mm and was transplanted back into the sternocleidomastoid [18].

The trachea would lose its structural support after the tumor resection due to long-term compression of substernal goiter, resulting in postoperative softening and collapse of trachea wall. In some serious cases, suffocation may occur. Therefore, tracheomalacia should be intensively considered postoperatively. If it is the case, then endotracheal suspension or tracheotomy may be necessary. There was no consensus on whether conventional tracheotomy was reasonable after the substernal goiter resection. Conventional tracheotomy was not recommended except for the following cases: (1) long-term compression of the trachea by huge goiter, and destruction of more than 2 tracheal rings showed by CT scanning. (2) Obvious tracheal compression with narrow of the lumen, and there is difficulties in tracheal intubation and induction of anesthesia. (3) Occurrence of trachea collapse after the tumor resection, and the endotracheal tube cannot be pulled out. Under these circumstances, a preventive tracheotomy should be actively initiated, and breath is assisted with ventilator, which better ensure patient safety [19, 20]. One case of tracheomalacia developed after tumor resection. Tracheotomy was carried out during operation and ventilator-assisted breathing was implemented in the following 2 days. The endotracheal tube was removed, the patient was eventually cured and discharged from hospital 5 days after operation.



## Postoperative treatment

The patients were placed in a semi-recumbent position after surgery to improve pulmonary gas exchange and drainage of wound surface. The patients encouraged to perform coughing and deep breathing exercises after having surgery in order to help clear mucus. For those individuals who had viscous sputum, aerosol inhalation was suggested. The lung should be intensively monitored for physical signs and symptoms in order to determine whether there was a pneumothorax. Steroids (such as hydrocortisone) can be used for 1 to 2 days to prevent laryngeal edema, and to reduce the transient hoarseness caused by the inflammatory edema. Chest negative drainage should be performed consistently to prevent pleural effusion, protecting the surgery space. The volume and property of the drainage was intensively observed in order to determine the time for extubation. Generally, the drainage tube is retained for 48-72 hours after operation. Those individuals suffered from tracheostenosis should stay in ICU for 1-2 days with retained drainage tube. If necessary, tracheotomy should be carried out prophylactically in patients with tracheostenosis. Generally, the tracheal tube can be removed 5-7 days after the tracheotomy. The timely intraoperative hemostasis is crucial for prevention of incision bleeding. Once bleeding occurred, it can not be ceased by compression and a second surgery needs to be performed for hemostasis. Postoperative hypoparathyroidism is usually ignited by the temporary parathyroid ischemia, which can be relieved by supplement of calcium gluconate. This can also gain more time for the transplant of compensatory parathyroid. Suppression of recurrence can be achieved routinely by the medication of thyroxine tablets postoperatively. Their thyroid function should be reviewed periodically for guidance of therapeutic modalities. Individuals presented with postoperative hyperthyroidism should be further treated with iodine in a gradually reduced dose pattern to avoid thyroid storm.

## Disclosure of conflict of interest

None.

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