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Kyu Eun Lee
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Color Atlas of Thyroid Surgery

Open, Endoscopic and Robotic Procedures

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Preface

In the modern history of thyroid surgery, the development of techniques became more effective and less invasive. There were also many significant scientific developments during this period. Awareness of the thyroid hormone and parathyroid hormone and the development of general anesthesia and hemostats were very important steps to perform thyroid surgery safely and effectively.

As the laparoscopic procedures were developed in early 1980s, Huscher and Gagner performed the first endoscopic thyroid surgery and parathyroid surgery in 1997 and 1996. Growth continued through the late 1990s, and the robotic operation system was introduced in the early 2000s.

There are two main reasons for conducting oncoplastic (AKA minimally invasive) thyroid surgery. First, the incidence of thyroid surgery is increasing. In Korea, the incidence of thyroid carcinoma has been increased by more than 200 % from the year 1995 to 2002. Second, patients desire a good cosmetic outcome. Thyroid cancer is particularly prevalent in young women, which increases the concern about postoperative neck scars; moreover, the prognosis of thyroid cancer is favorable, which places particular emphasis on quality-of-life issues. These issues mean that thyroid cancer management should be based on an oncoplastic concept where both complete surgical resection of the thyroid gland and the cosmetic outcome are pursued simultaneously.

As a surgeon performing both conventional open thyroid surgery and oncoplastic thyroid surgery for many years, I kept on trying to perform safer and more feasible thyroid surgery to help shoulder burden of patients. And I also kept on working to help surgeons to learn safe and effective thyroid surgery. It is a great honor for me to have an opportunity to publish this book, Color Atlas of Thyroid Surgery. I am extremely glad to work with Doctor Lee and Choi who made this publication possible.

I hope that this textbook could help the surgeons from many countries to put steps into the world of thyroid surgery.

Seoul, Korea — Yeo-Kyu Youn, MD, FACS

Acknowledgement

First of all, I would like to thank Dr. Kyu Eun Lee and Dr. June Young Choi gratefully and sincerely for their assistance and guidance in attaining my career as medical doctor and clinical researcher. They inspired me to make new surgical methods for patients and encouraged me to finish this book.

I also thank Bumsuk Academic Research Fund for their support. This book was supported by Bumsuk Academic Research Fund in 2010. Without it, this book would never have been completed on time.

And I extend special thanks to Eun Chai Huh and Dr. Choi for the illustrations and figures of the book. Their contribution to arranging the illustrations and figures on each page with maximum clarity allowed the Atlas a good quality.

In addition, I appreciate Dr. Kyung-Suk Suh, the Chairman of Department of Surgery, Seoul National University College of Medicine, and I would like to thank all the staff for their input, valuable discussions and accessibility. In particular, I would like to thank Dr. Kwi-Won Park, Dr. Seong-Cheol Lee, Dr. Sun-Whe Kim, Dr. Sung-Eun Jung, Dr. Dong-Young Noh, Dr. Han-Kwang Yang, Dr. Jongwon Ha, Dr. Kyu Joo Park, and the rest of the Department for their hard work, expertise and patience.

Without exception, our collaboration with Jagannathan Prakash the Managing Editor and the entire staff at Springer was perfectly pleasant and joyful! Although I might not list all the people who helped me, I still thank you all for your contribution to the work.

Finally, I constantly thank my wife and my children for their support, encouragement, quiet patience and unwavering love. I love you so much.

Yeo-Kyu Youn, MD, FACS

Contents

Surgical Anatomy of the Thyroid Gland

1

1.1 The Thyroid Gland

The thyroid gland is located in front of the neck below the thyroid cartilage. The small, two-or three-in. long gland consists of two lobes connected by isthmus in the middle.

Just beneath the skin of the neck, there is a thin platysma muscle, which covers the whole anterior neck. When the platysma muscle is dissected, the strap muscles are exposed. The strap muscles consist of the sternohyoid muscles and sternothyroid muscles. The midline is shown between right and left strap muscles. Dissection along the midline is needed to approach the thyroid gland. To perform thyroidectomy, the strap muscles should be retracted to lateral position or can be transected for better exposure in case of large goiter.

Beneath the thyroid gland, there is a trachea. The trachea is the most important landmark in performing thyroidectomy. The thyroid gland is firmly attached to the trachea from the second to the fourth tracheal ring. In normal adults, the average weight of the thyroid gland is 15–30 g.

The pyramidal lobe can be seen in 20 % of the patients, which ascends from the isthmus or the adjacent part of either lobe up to the hyoid bone.

The relation between the tubercle of Zuckerkandl and the distal course of the recurrent laryngeal nerve (RLN). Tubercle of Zuckerkandl is the most posterior extent of the thyroid lobe as shown in Fig. 1.2.

The online version of this chapter (doi:10.1007/978-3-642-37262-9_1) contains supplementary material, which is available to authorized users.

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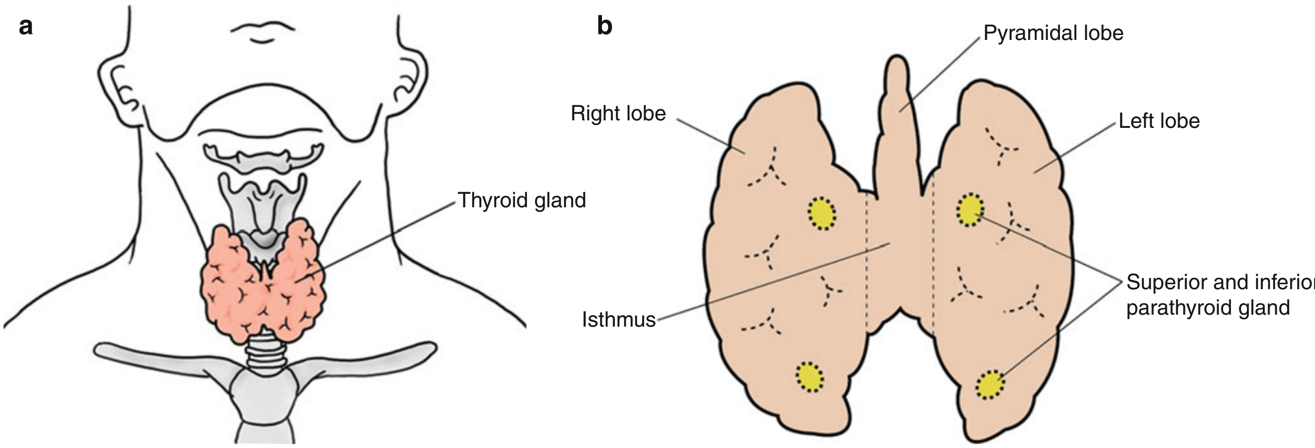

Fig. 1.1 Position and anatomy of the thyroid gland. (**a**) Normal position of the thyroid gland, (**b**) anatomy of the thyroid gland

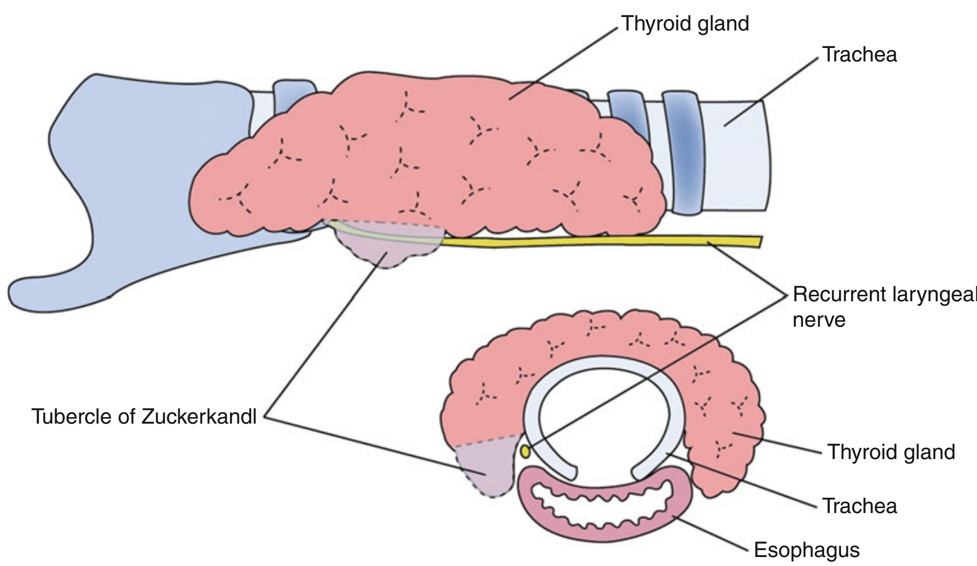

Fig. 1.2 The region of the Tubercle of Zuckerkandl

1.2 Vascular Anatomy of the Thyroid Gland

There are two main arterial blood supplies of the thyroid gland, the superior and inferior thyroid arteries and, to a lesser degree, the thyroid ima artery. The superior thyroid artery is the first branch of the external carotid artery and courses inferiorly to the upper pole of the thyroid gland. It enters the upper pole of the thyroid on its anterosuperior surface. The inferior thyroid artery usually arises from the thyrocervical trunk and passes upward in front of the vertebral artery and Longus colli to the lower pole of the thyroid gland. Before entering the thyroid, the artery usually divides into 2–3 branches. One of the branches supplies the inferior parathyroid.

The thyroid ima artery can be seen in 3–10 % or less of patients. The thyroid ima ascends in front of the trachea to the lower part of the thyroid gland, which it supplies. It varies greatly in size and appears to compensate for deficiency or absence of one of the other thyroid vessels. The thyroid ima artery usually arises from the brachiocephalic trunk (innominate artery). It occasionally arises from the aorta, the right common carotid, the subclavian, or the internal thoracic artery. All of these arteries should be ligated during surgical removal of the thyroid gland.

Venous drainage of the thyroid gland is through a well-developed thyroid venous plexus, which usually drains through the inferior thyroid vein to the left brachiocephalic (innominate) vein. Blood from the thyroid gland also drains to the internal jugular vein via the superior and middle thyroid veins.

The thyroid ima artery is unpaired artery in the anterior surface of the trachea. It can arise not only from the brachiocephalic artery but the right common carotid artery or directly from the aortic arch. Its position anterior to the trachea makes it important in thyroidectomy and tracheostomy.

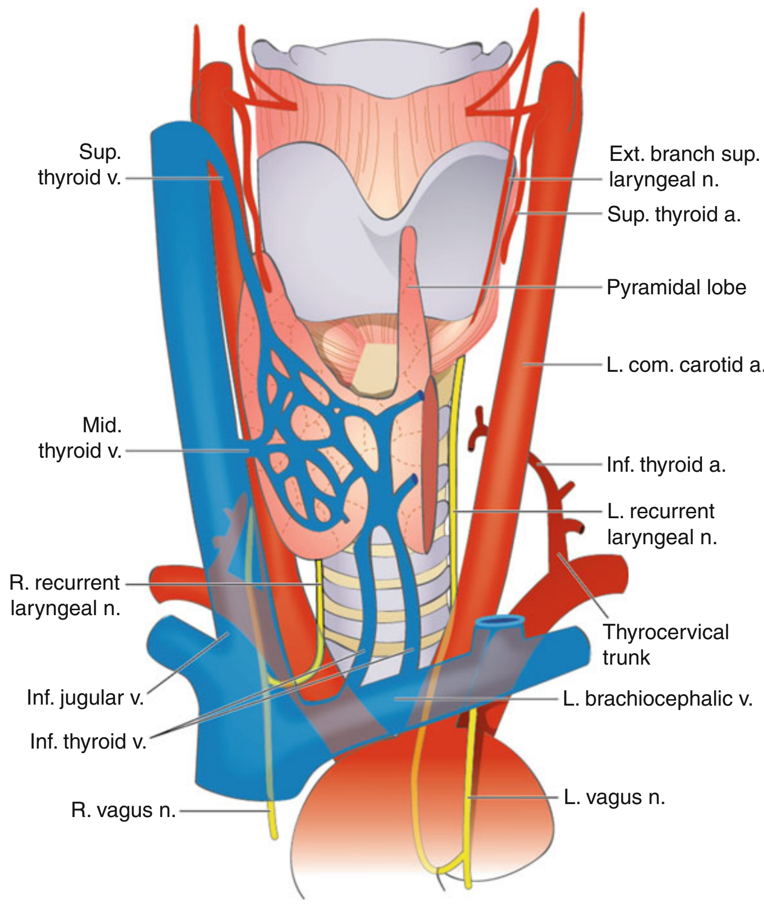

Fig. 1.3 Vascular anatomy of the thyroid gland

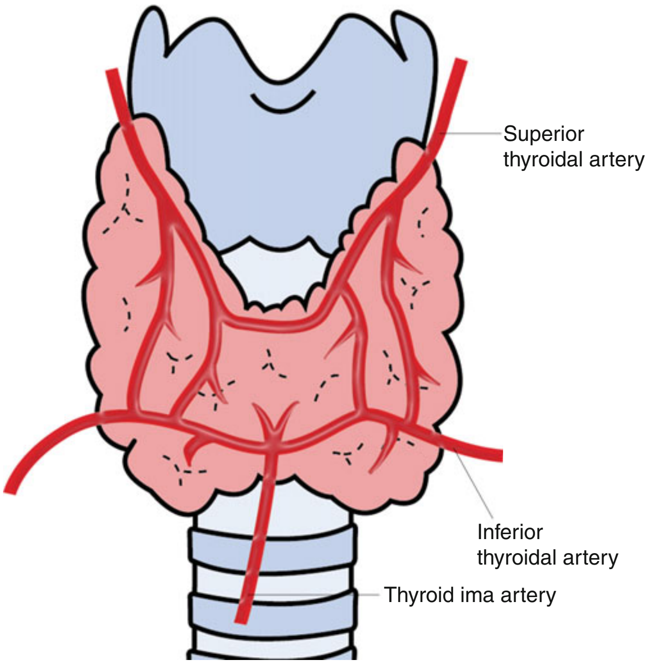

Fig. 1.4 Vascular anatomy of the thyroid gland (thyroid ima artery is shown)

1.3 Nerves

The recurrent laryngeal nerve is a branch of the vagus nerve that supplies motor function and sensation to the larynx. The left recurrent laryngeal nerve branches from the vagus nerve to loop under the arch of the aorta, and the right recurrent laryngeal nerve loops around the right subclavian artery. As they ascend in the neck along the trachea close to the thyroid gland, care must be taken to preserve them during thyroidectomy.

The inferior thyroid artery and its terminal branches are closely associated with the recurrent laryngeal nerve at the insertion of the thyroid gland. Sometimes, the nerve may be mistaken for a branch of the artery. When compared to the artery, the nerve is less regular, rounded, and elastic than the artery. And a small, red, sinuous vessel called vasa nervorum is usually observed on the nerve.

The left recurrent laryngeal nerve ascends along the tracheoesophageal groove with straight course, while the right recurrent laryngeal nerve courses more obliquely and more lateral than left. However, innumerable variations have been described, so care must be taken in all cases.

At the two upper tracheal rings, the recurrent laryngeal nerve is embedded in the posterior portion of suspensory ligament, so called Berry's ligament. This ligament extends

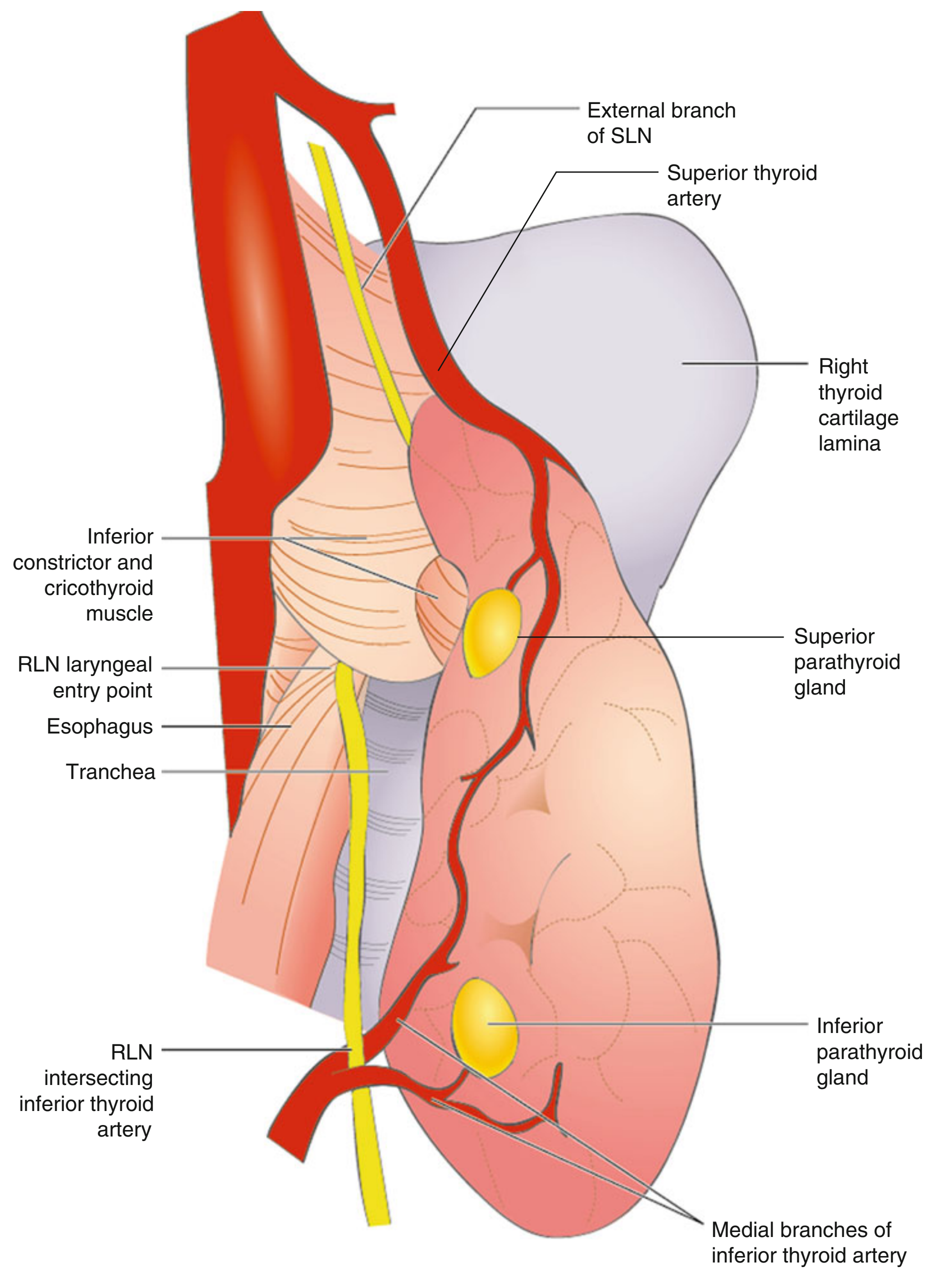

Fig. 1.5 Nerves of the thyroid gland. *SLN* superior laryngeal nerve, *RLN* recurrent laryngeal nerve

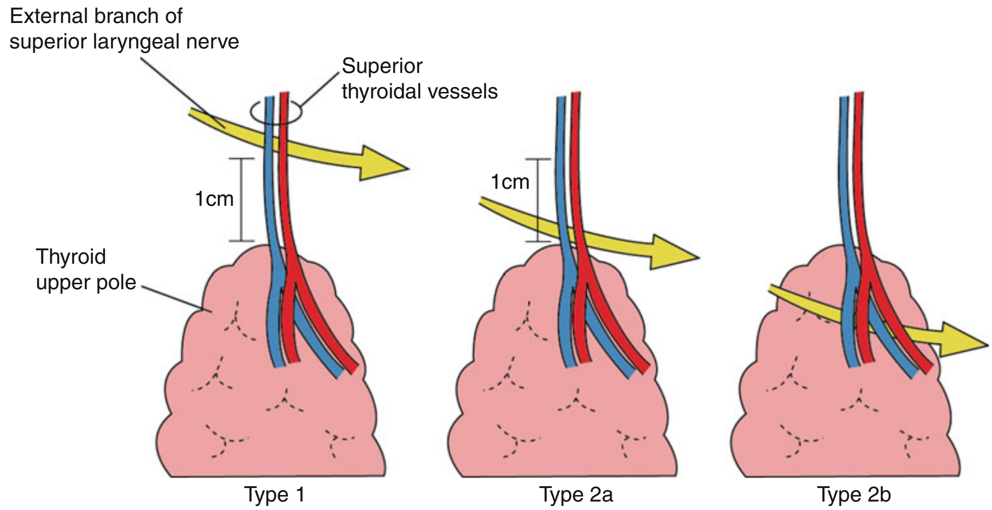

Fig. 1.6 Various relations between external branch of the superior laryngeal nerve and superior thyroidal vessels

posteriorly behind the recurrent nerve and firmly attaches the thyroid to the trachea and esophagus. At this point, there is an artery posterior to the recurrent nerve, which gives off a small branch to the thyroid gland, and this artery is uneasy to be ligated.

The superior laryngeal nerve is also a branch of the vagus nerve. It descends, by the side of the pharynx, behind the internal carotid artery and divides into two branches: external laryngeal nerve as a motor nerve and internal laryngeal nerve as a sensory nerve. A superior laryngeal nerve takes part in the pitch of the voice.

There is a close relationship between the superior thyroid artery and the external branch of the superior laryngeal nerve. Injuries to this nerve can cause an inability to make high-pitched voice sounds. To avoid injury of external branch of the superior laryngeal nerve, it is recommended to ligate the superior thyroid arteries as low as possible on the thyroid gland.

Classification of the external branch of the superior laryngeal nerve, according to the potential risk of damage.

Type 1: The nerve crosses the superior thyroid vessels more than 1 cm above the border of the thyroid upper pole.

Type 2a: Nerve crosses the vessels less than 1 cm above the border of the thyroid upper pole.

Type 2b: Nerve crossing the vessel below the border of the thyroid upper pole

1.4 Parathyroid Glands

Usually there are four parathyroid glands, which are located on the rear surface of the thyroid gland. The normal size of the parathyroid gland is less than 1 cm and weighs 25–40 mg. They are yellowish brown and may be distinguishable from the thyroid gland. Parathyroid glands control the amount of calcium in the blood and the bones.

There are two higher-positioned parathyroid glands on each side called the superior parathyroid glands, while the lower two are called the inferior parathyroid glands. The superior parathyroid glands are in a more constant location than the inferior glands.

The inferior parathyroid glands are usually located posteriorly to the lower pole of the thyroid but are commonly found within the thymus in the neck or upper mediastinum. The inferior parathyroid glands can be located ectopically at any point on its path of descent.

The superior parathyroid glands are normally located on the dorsal aspect of upper pole of the thyroid gland. Due to the limited pathway of descent of superior parathyroid glands, the ectopic locations are less common than the inferior parathyroid glands.

As shown in Fig. 1.7, the inferior parathyroid gland is anterior and medial to the recurrent laryngeal nerve, while the superior parathyroid gland is located posterior to this plane.

The principal arterial blood supply to both superior and inferior parathyroid glands is described as the inferior thyroid artery; there are also other blood supplies from the superior thyroid artery or anastomotic vessels of superior and inferior thyroid arteries.

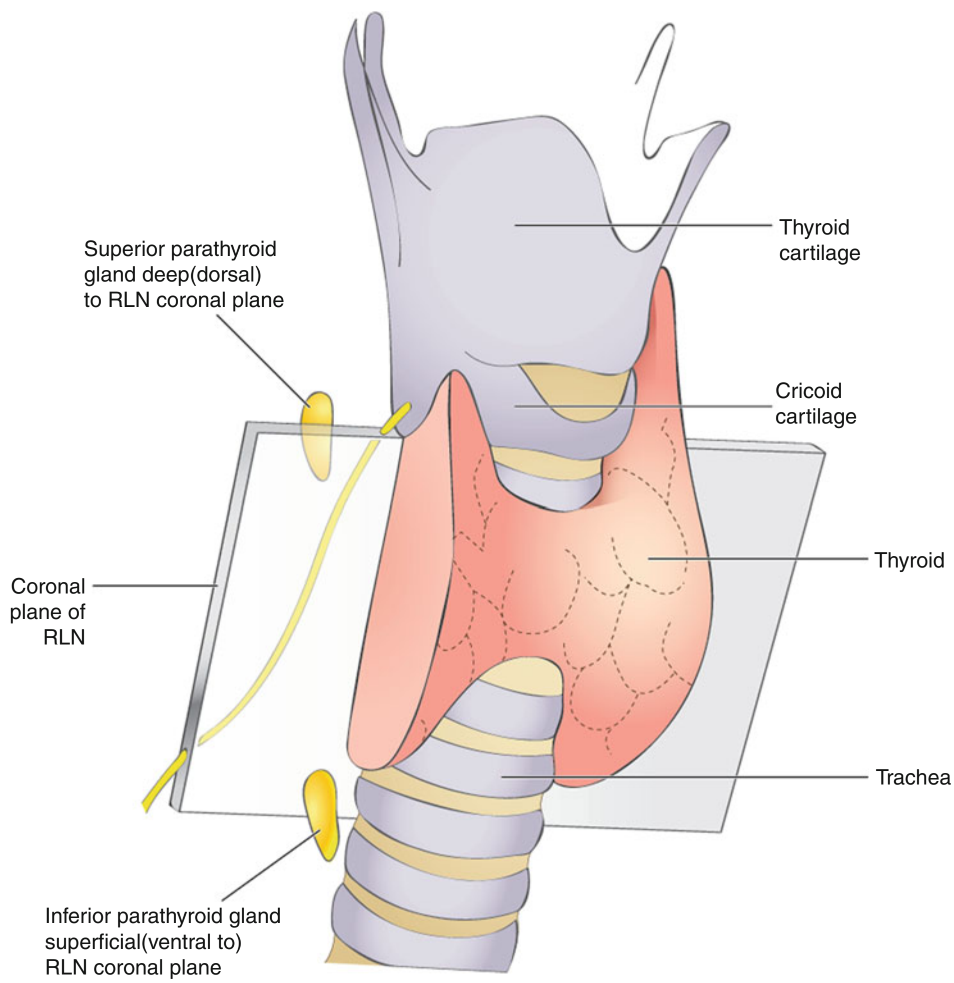

Fig. 1.7 Anatomical position of the superior and inferior parathyroid glands

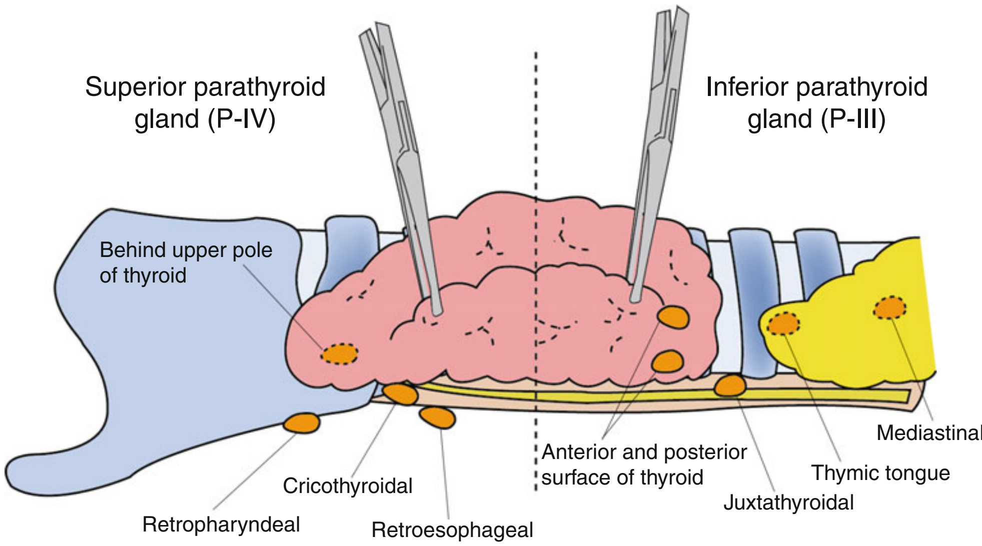

Fig. 1.8 Various locations of the superior and inferior parathyroid glands

1.5 Lymphatic Drainage

Lymphatic drainage of the thyroid gland is multidirectional. Capsular lymph channels, draining the intraglandular capillaries, may cross communicate with the isthmus and opposite lobe. Therefore, it is difficult to predict lymphatic drainage of the thyroid gland.

In the first place, immediate lymphatic drainage is to the periglandular nodes. And it courses to the prelaryngeal (Delphian), pretracheal, and paratracheal lymph nodes. These lymph node groups are called as the central neck compartment. The superior boundary of the central neck compartment is the hyoid bone; the inferior boundary is the suprasternal notch, and the lateral boundaries are the medial border of common carotid artery. These nodes are the most common site of metastasis from thyroid cancer.

The second part of lymphatic drainage is the lateral neck region. Lymphatic drainage of the superior poles of the thyroid gland can flow directly into the lateral neck nodes, while lymphatic drainage of the other parts flows initially to the central neck nodes. Lateral neck compartment can be subdivided and grouped into several levels. As there exist many classifications of grouping neck lymph nodes, the American Academy of Otolaryngology Head and Neck Surgery Dissection Classification describes six different levels in the central (level IA, IB, and VI) and lateral (IIA, IIB, III, IV, VA, VB) neck.

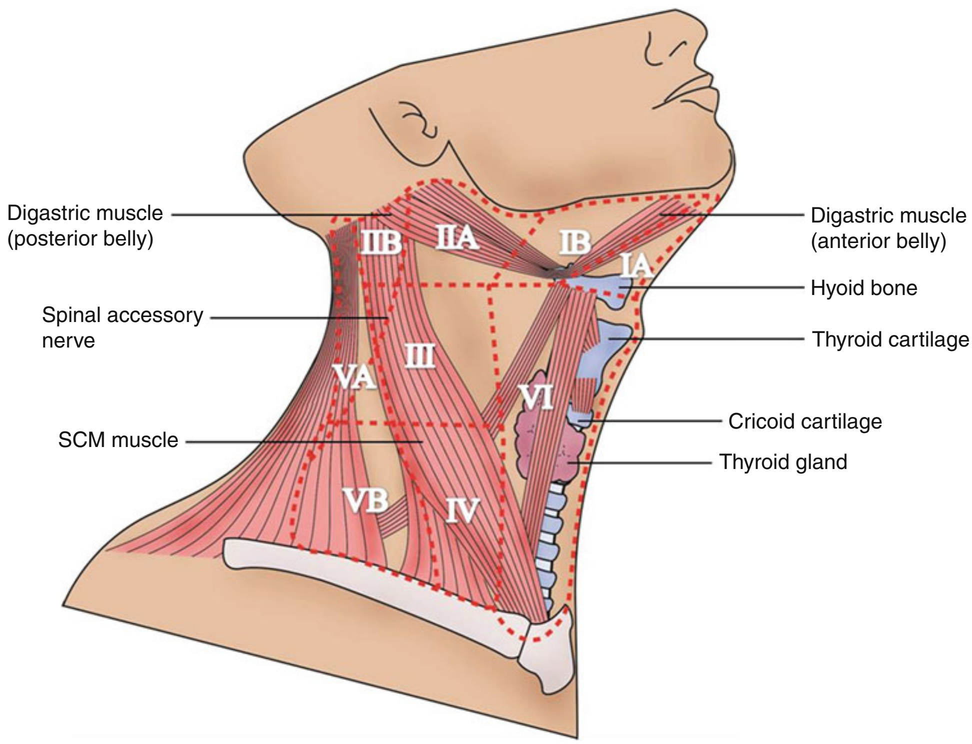

Fig. 1.9 Lymph node regions of the neck

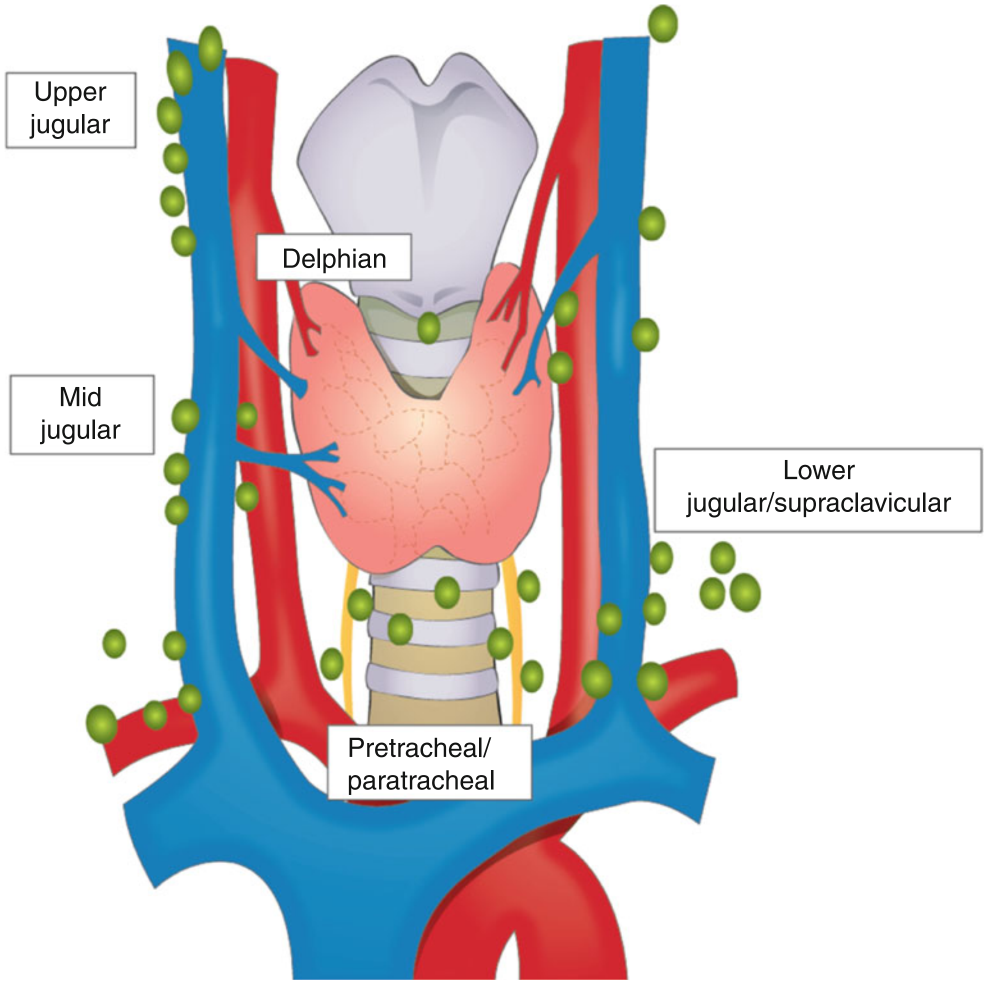

Fig. 1.10 Lymph nodes of importance for operation on thyroid carcinoma

2 Open Thyroidectomy

2.1 Basic Equipment and Instruments of Open Thyroidectomy

2.1.1 The Operating Theater

The operating theater is prepared as a non-sterile atmosphere and all instruments are manipulated to carry out the operations in sterile environments. There are two assistants to assist the operator and a scrub nurse. The operation setting is as below.

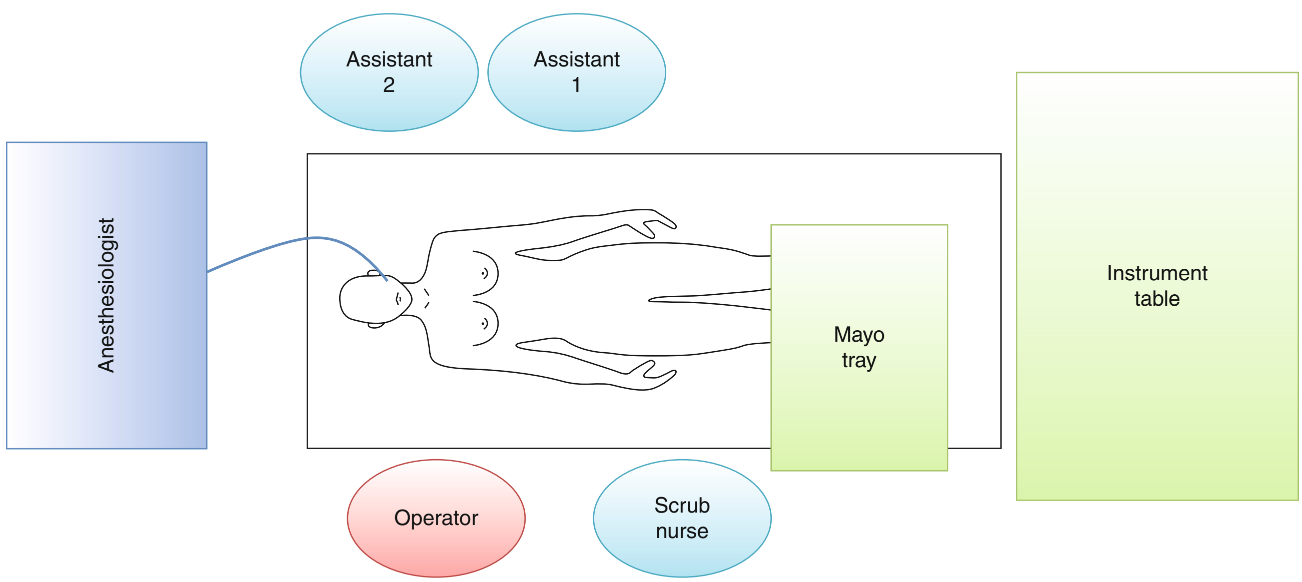

Fig. 2.1 The operating theater of open thyroidectomy

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2.1.2 Thyroid Pillow (Emtas, Seoul, Korea)

Thyroid pillow is made for stable and comfortable positioning of patient.

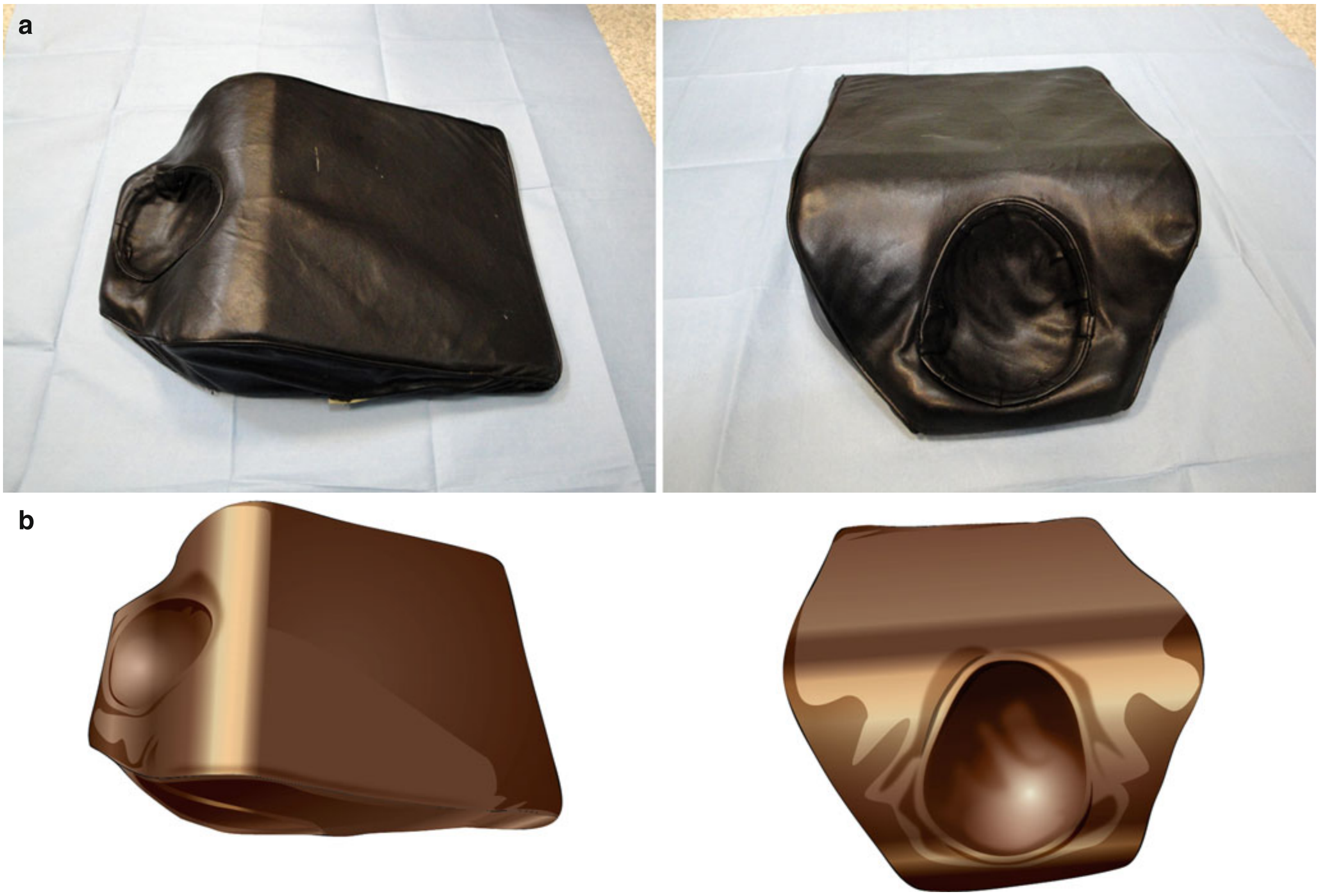


Fig. 2.2 Thyroid pillow. (**a**) photos, (**b**) illustrations

2.1.3 Harmonic® (Ethicon Endo-Surgery)

2.1.4 Basic Instruments

1. Retractors: Army-Navy retractor, Cushing (or Middeldorpf) retractor, and deep Cushing retractor
2. Metzenbaum, Mixter clamps, right-angle clamps, mosquito hemostats, peanut, Allis clamps, Adson tooth forceps, Potts forceps, needle holder, and thyroid clamps
3. Bovie electrocautery
4. Jackson-Pratt drain

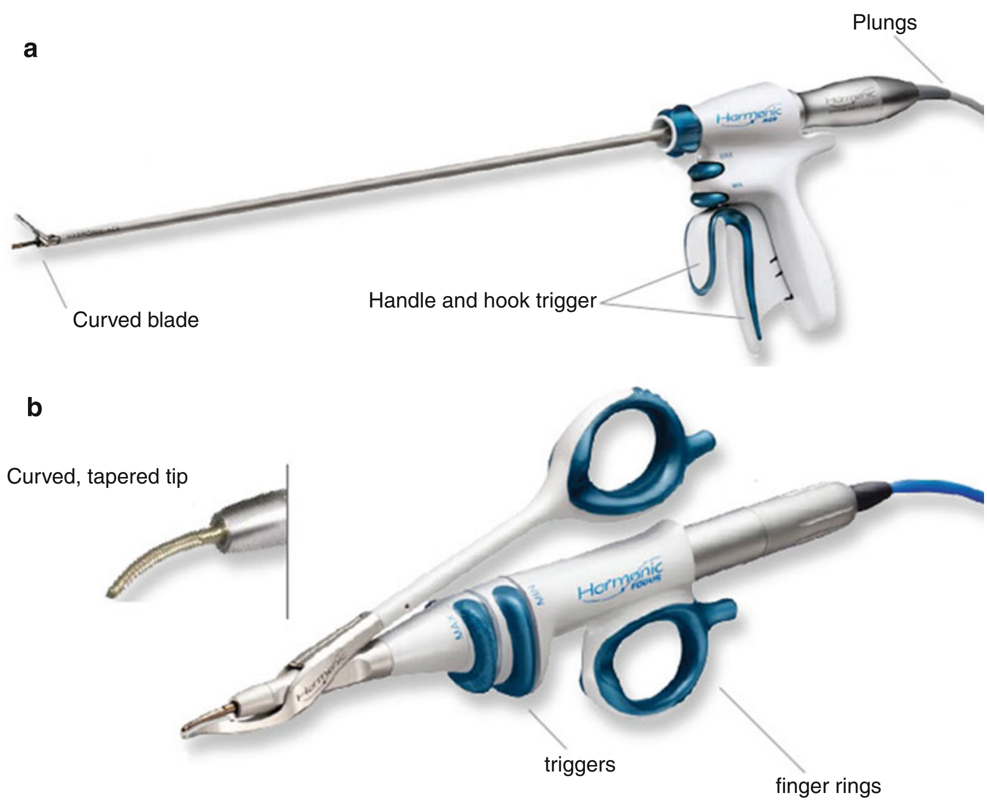


Fig. 2.3 Harmonic®. (**a**) Harmonic Ace, (**b**) Harmonic Focus

2.2 Patient Preparation

2.2.1 General Considerations

Most preoperative evaluations of patient take place on an ambulatory basis. Those preoperative evaluations are required to be checked before admission by the surgeon at the outpatient clinic. Patients with significant comorbidity should be evaluated by referring an anesthesiologist before the operation. Most patients are admitted 1 or 2 days before the operation. After admission, preoperative examinations of patient are reexamined by the surgeon and further examinations such as computed tomography and US-guided marking can be done preoperatively.

2.2.2 Education and Informed Consent

The surgeon should educate and inform patient about the potential risk of a neck scar, recurrent laryngeal nerve injury, hypocalcemia, bleeding, pain, possibility of transfusion, reoperation, and other alternatives available before the operation.

2.2.3 Diet Restriction and Fluid Supplement

NPO past midnight is recommended for all patients before thyroidectomy. This standard order is based upon the belief of reduction of gastric contents and acidity. In general, at least 6 h of cessation of solid food and 2 or 4 h of cessation of fluids are required. Intravenous fluid supplement is given 2–3 h before induction.

2.2.4 Skin Preparation

Preoperative skin preparation of patient is required to prevent surgical site infection (SSI). Skin preparation can be performed with an antiseptic solution according to the routine maneuver of each center.

In male patients, shaving off a beard is required. Hair removal can be accomplished with electric clippers or shaving solutions rather than with a razor to avoid skin injury.

In patients for endoscopic and robotic surgery, shaving of axillary hair is also required before the operation.

2.3 Procedures of Open Thyroidectomy

2.3.1 Patient Positioning

The patient should be placed in the supine position on the operating table with the arms tucked close to the side. A folded sheet or a thyroid pillow is placed vertically under the patient's shoulders to extend the head and neck.

This neck extension should be performed with great caution and with the assistance of the anesthesiologists to ensure that endotracheal tube is secured and the neck is not overextended.

It is helpful to have the operating table placed in a reverse Trendelenburg position to decrease the cervical venous pressure.

The patient's hair may be covered with a mesh cap to avoid contamination of the field. An adhesive tape may be applied to cover up both ears.

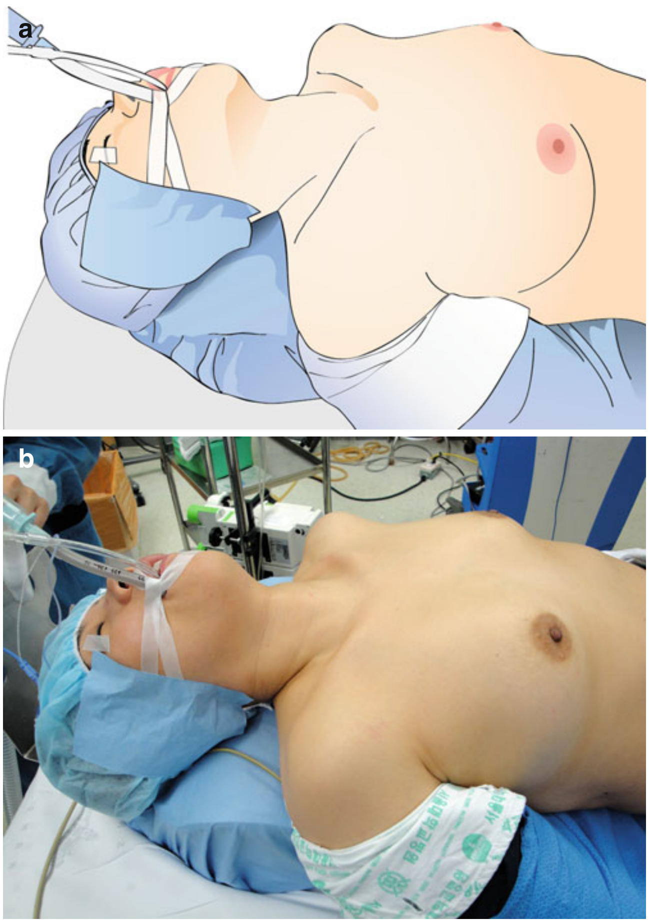


Fig. 2.4 Position of patient. (**a**) illustration, (**b**) photo

Fig. 2.5 An adhesive tape to cover both ears and hairs

2.3.2 Skin Preparation and Draping

The operative field is then prepared with a routine surgical maneuver.

The anterior cervical region is prepared bilaterally from the angles of the mandible, posteriorly to the anterior borders of the trapezius, and inferiorly over the anterior chest wall to the line between the nipples.

When the surgical prep solution is completely dry, the operative field is defined with disposable operative drapes.

We cover the patient's head and face with a transparent plastic sheet that is made adherent to the skin to see through the patient's face and the endotracheal tube.

And a large sterile drape is covered over the patient's shoulder, anterior chest wall, and lower body to complete the draping.

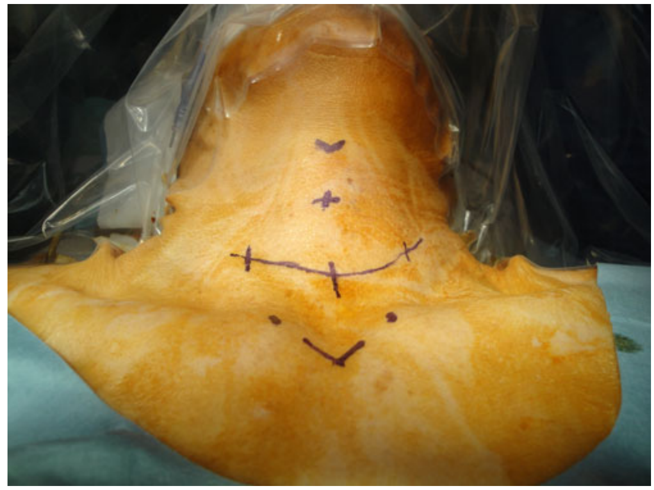


Fig. 2.6 Draping of the operative field

2.3.3 Skin Incision and Dissection

After marking the landmarks as illustrated, a transverse skin incision is made approximately a fingerbreadth above the suprasternal notch. We make 4–6 cm long incision for thyroidectomy. Longer incision should be made in patients with large goiters or nodules.

We apply transparent adhesive film (Tegaderm®) on the incision to protect the skin from excessive strains and electrocautery burns.

Carry the incision down to the platysma muscle. This muscle is easier to identify in the lateral portions of the incision. When the longitudinal fibers of this muscle are seen, transect them with precision because the upper flap will be dissected in a plane along the deep aspect of the platysma. Two or three Allis clamps are placed on the fascia of the platysma to retract the flap vertically while countertraction with the operator's finger exposes a natural bloodless plane. If the plane of dissection is carried down to the cervical fascia, a number of anterior jugular veins are encountered that can produce unnecessary bleeding. Blood staining of tissues may complicate the operation unnecessarily, so care should be taken to leave a thin layer of fat on these veins.

Electrocautery can be used to create flaps in this subplatysmal plane superiorly to the uppermost aspect of the thyroid cartilage in the midline.

Then the lateral portions of the flaps are developed. Adequate exposure can be obtained with wide dissection of these subplatysmal musculocutaneous flaps. A blunt dissection using an operator's finger or a peanut sponge is helpful to avoid unnecessary bleeding.

After the superior flaps are made, the inferior flaps are created to the level of the suprasternal notch and the clavicular heads.

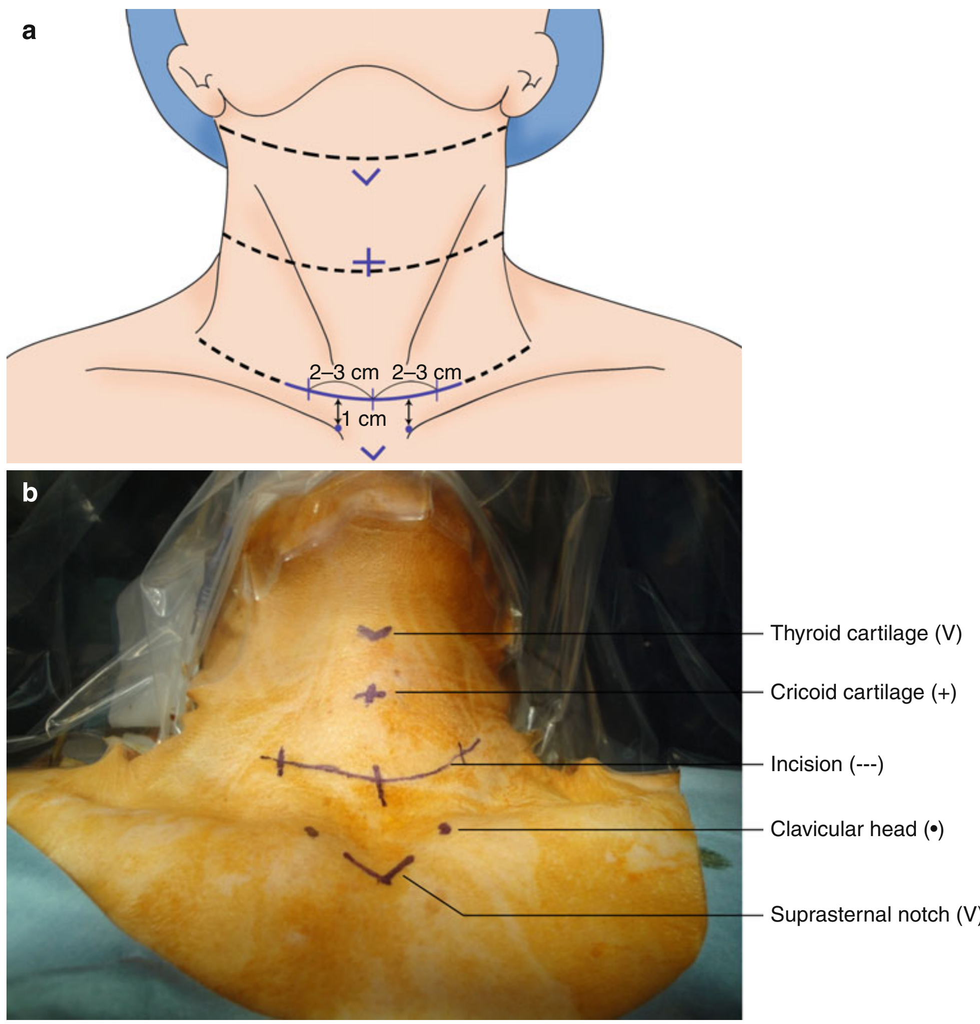


Fig. 2.7 Landmarks and incision. (**a**) illustration, (**b**) photo

Fig. 2.8 Adhesive film to protect skin

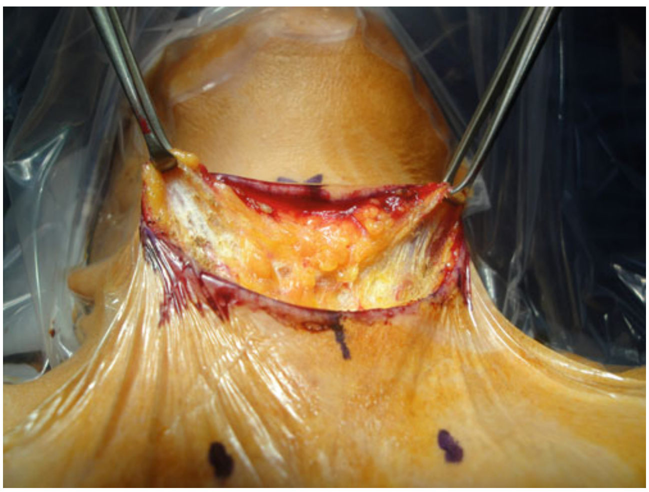
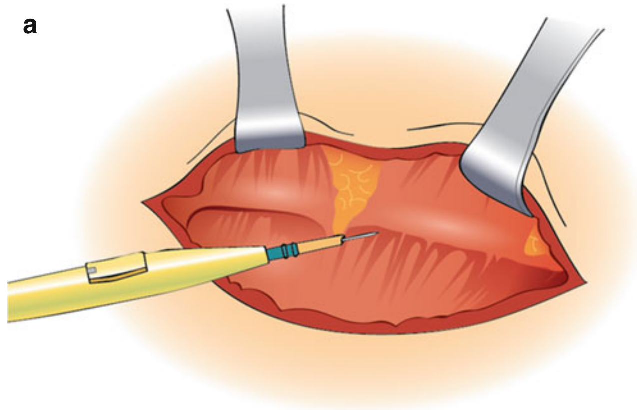


Fig. 2.9 Flap dissection (superior part)



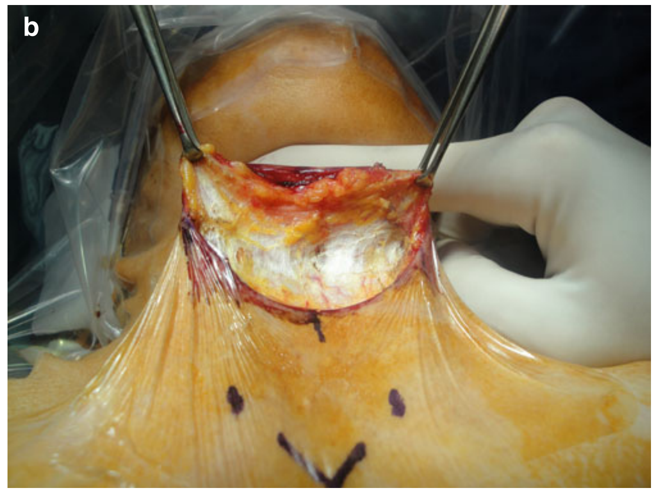


Fig. 2.10 Flap dissection (continued). (**a**) illustration, (**b**) photo

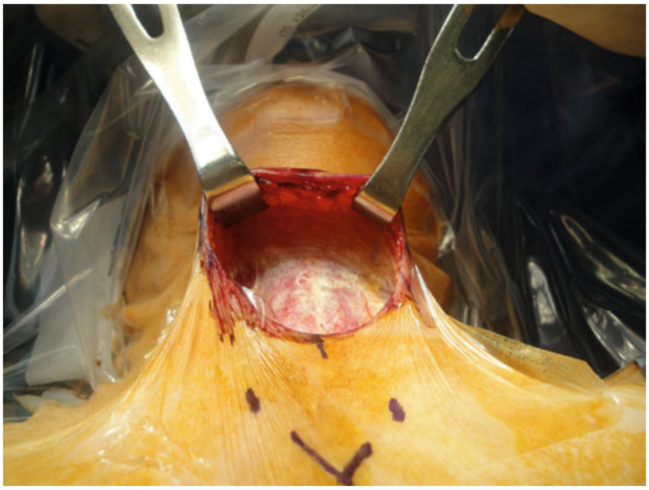


Fig. 2.11 Completed flap dissection

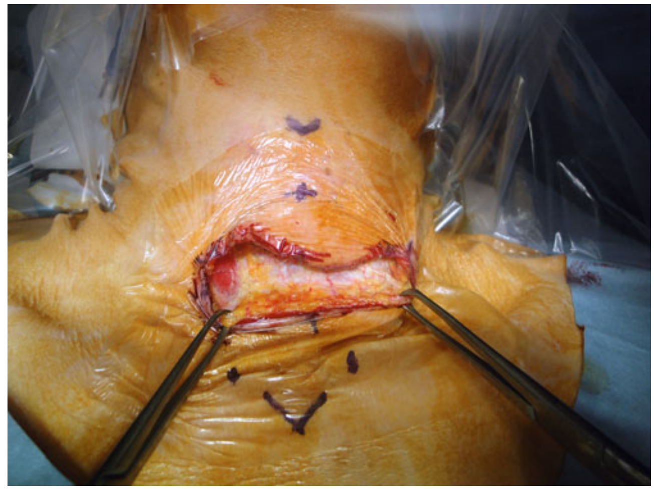


Fig. 2.12 Flap dissection (inferior part)

2.3.4 Midline Incision and Isthmectomy

The midline is best identified by palpating the prominence of the thyroid cartilage and the trachea. The cervical fascia is opened in the midline from the thyroid cartilage to the suprasternal notch to expose the full length of the strap muscles. The sternohyoid muscle and underlying sternothyroid muscle are also separated in the midline from the thyroid cartilage to the suprasternal notch. When the midline incision is made, the isthmus of the thyroid gland will be visible, and as the next step, the fatty tissue inferior to the isthmus is divided to identify the trachea. At this point, great care should be taken not to injure the trachea. The isthmus is then divided in the midline with the electrocautery or the ultrasonic sheers (the Harmonic®). The operator should make sure that there is no lesion in the isthmus before the isthmectomy by preoperative ultrasound or computed tomography. Isthmectomy can give more room in the operative field, and dissection of the posterior surface of the thyroid off the trachea enables better mobilization of the gland to the medial part.

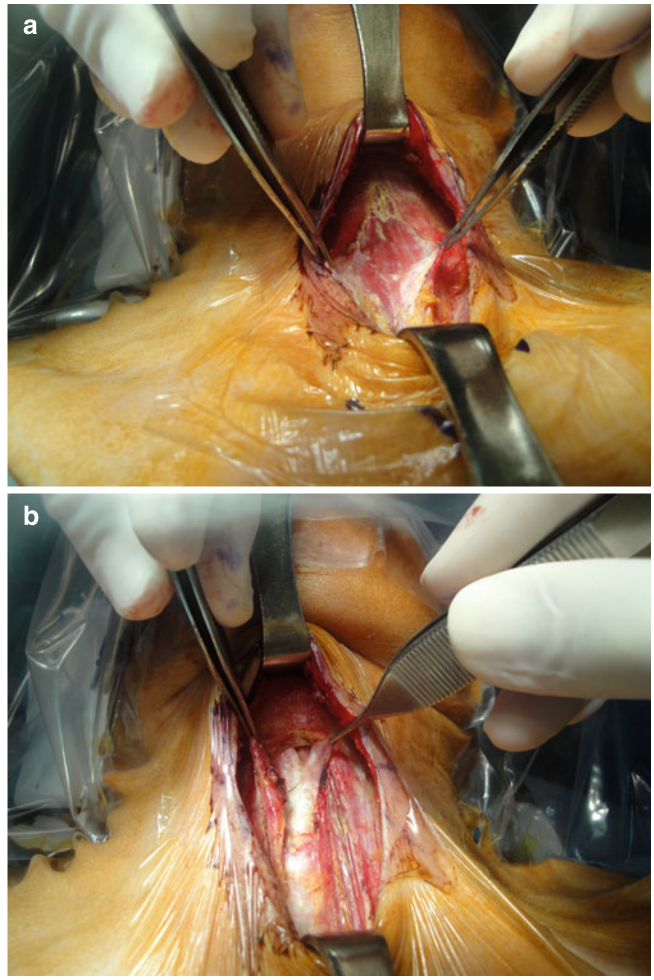


Fig. 2.13 Division in the midline. (**a**) Division between the strap muscles, (**b**) exposure of the trachea after isthmectomy

2.3.5 Dissection of the Pyramidal Lobe

After dividing isthmus, the pyramidal lobe is dissected from surrounding tissues so that it can be removed with the thyroid lobe.

The edge of the divided isthmus is dissected from its attachments to the anterior trachea with electrocautery or ultrasonic sheer.

The pyramidal lobe has a great importance in some occasions, especially in case of papillary thyroid carcinoma. Papillary thyroid cancer can be recurred in the pyramidal lobe due to multifocality or intraglandular metastasis of the disease. And in patients who will undergo radioactive iodine (RAI) ablation postoperatively, the presence of pyramidal lobe can nullify the effect of I-131 and cause repeated RAI ablation. Finally, in patients with Graves' disease, the remnant pyramidal lobe can be a cause of recurrence of the disease. Moreover, hypertrophied pyramidal lobe can cause unfavorable cosmetic results.

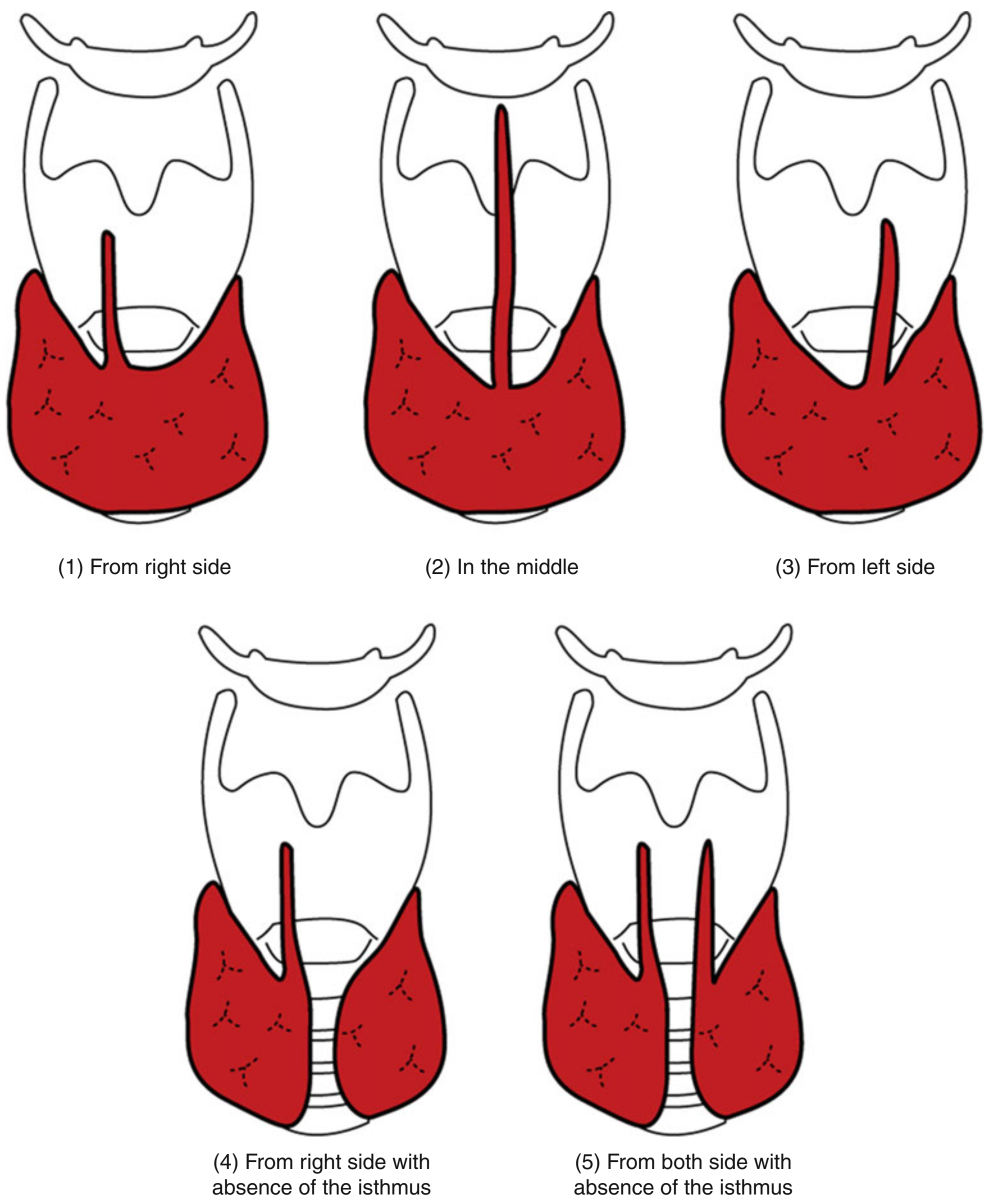


Fig. 2.14 Variations of the pyramidal lobe

2.3.6 Dissection of Lateral Aspect of the Thyroid Gland

The thyroid lobe is retracted medially using an Allis clamp (or a Kelly clamp), and the strap muscle is retracted laterally with a Cushing retractor (or a Middeldorpf retractor).

The sternothyroid muscle is separated more laterally to the underlying thyroid lobe with blunt dissection unless the muscle is directly invaded by the thyroid tumor.

If the thyroid tumor is invading a strap muscle or is adherent to the muscle, a portion of the muscle should be excised to ensure that an adequate margin of tissue is obtained as the tumor is resected.

When the fascia of the sternothyroid muscle is completely incised and reflected, the blood vessels in the capsule of the thyroid gland will be clearly visible.

If the mass of thyroid tissue is large, it may be wiser to divide the strap muscles between clamps. There is no difficulty with healing or regaining of function after a transverse incision of the strap muscles. But this should be done with care in the upper third of the tissue in order to avoid motor nerve injury.

The thyroid lobe is then further moved medially with a blunt "peanut" dissection. This maneuver can be done by grasping the thyroid parenchyma with an Allis clamp.

This dissection permits a medial rotation of the thyroid lobe, but as the middle thyroid vein has not been identified and ligated, the thyroid lobe should not be stretched vigorously.

It may result in unnecessary bleeding and further complicate efforts to find the inferior parathyroid gland and the recurrent laryngeal nerve.

As the lobe is gradually elevated, one or more middle thyroid veins along the anterolateral margin of the thyroid become visible.

These middle thyroid veins are divided between clamps or with the ultrasonic sheers. Now the thyroid lobe can be full rotated medially.

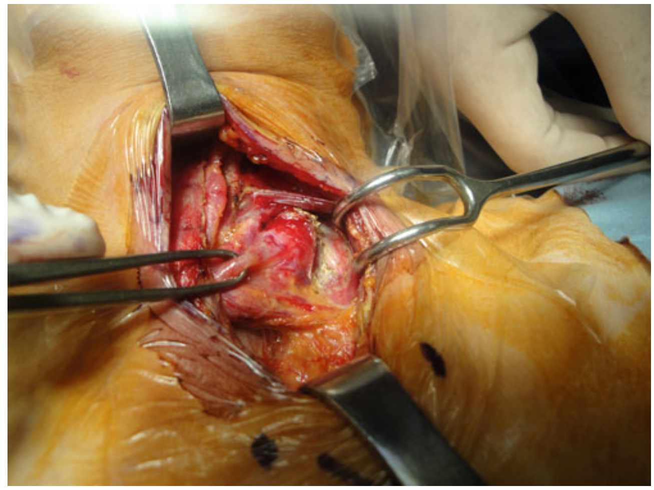


Fig. 2.15 Lateral dissection of the thyroid gland

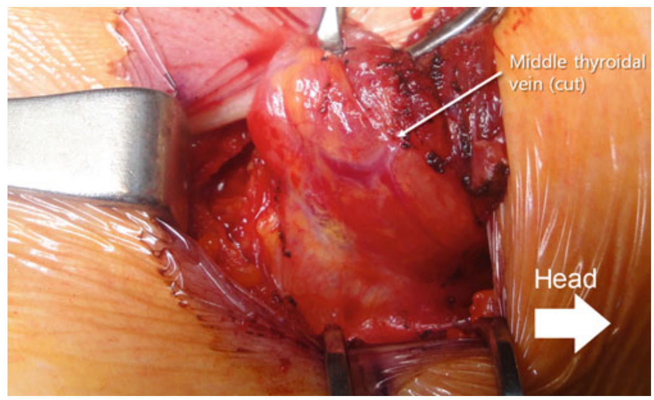


Fig. 2.16 Lateral dissection of the thyroid gland (continued)

2.3.7 Dissection of the Superior Pole

From here on, attention should be given to the superior portion of the thyroid lobe.

One can try to find the inferior parathyroid gland or the recurrent laryngeal nerve before dissecting the upper pole. In endoscopic procedures, the latter is preferable. The upper thyroid pole is mobilized from lateral to medial.

To gain the most exposure, the gland is retracted medially with the surgeon's index finger or another Allis clamp while holding the strap muscles laterally with a deep Cushing retractor. Blunt peanut dissection clears areolar tissue from the lateral aspect of the upper thyroid pole.

Then the upper pole is turned to lateral, and the pole is separated from the cricothyroid muscle medially with the

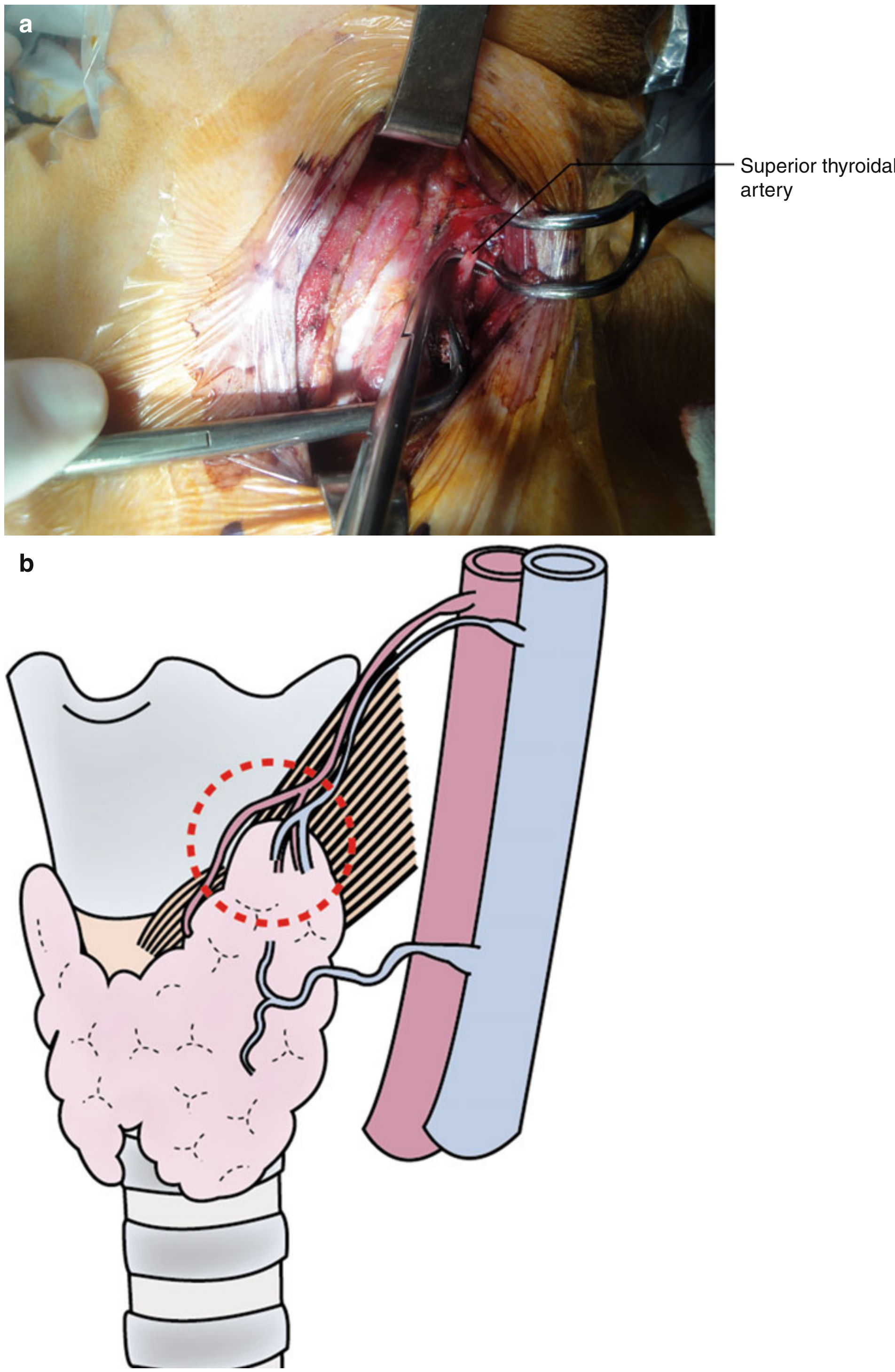


Fig. 2.17 Dissection of the superior pole. (**a**) Ligation of the superior thyroidal artery, (**b**) branches of the superior thyroidal vessels

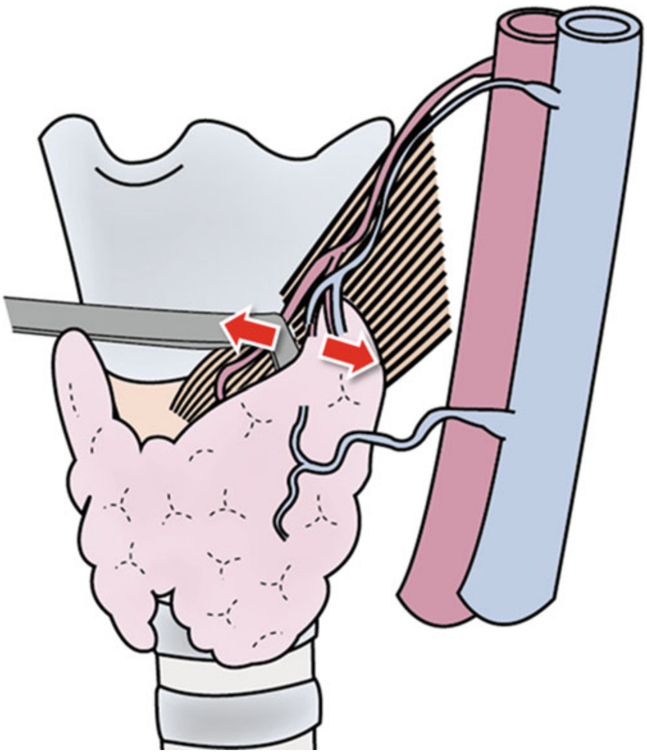


Fig. 2.18 Dissection of the superior pole (continued). The thyroid cartilage is retracted to the medial side with the retractor and the thyroid gland is retracted to the lateral side with the clamps. (*arrow*)

Mixter clamps or right-angle clamps. Extreme care is taken to keep all medial dissection close to the thyroid pole lest the external branch of the superior laryngeal nerve should place at risk. This nerve can lie on the lateral surface of the cricothyroid muscle, in close proximity to the superior thyroid vessels, and it is not always possible to visualize this nerve.

After dissecting both lateral and medial aspect, the upper thyroid pole can be retracted anteriorly and inferiorly using the right-angle clamps.

At the anterior aspect of the pole, the superior thyroid artery and vein can be seen.

Under direct visualization, Mixter clamps are directed anterolaterally to these superior thyroid vessels to isolate and elevate them.

Another set of Mixter clamps are then placed across the pedicle, and they clamp these vessels superior and inferior to the dissecting Mixter clamps.

At this point, the inferior clamp should be placed close to the thyroid and the superior clamps placed as low as possible so as not to injure the external branch of the superior laryngeal nerve.

The superior pole pedicle is then divided between the clamps and ligated firmly. One can divide the superior thyroid vessels with the ultrasonic sheers without ligating vessels. In more than 4,000 cases, we have not had a bleeding case at these vessels using the ultrasonic sheers. This is repeated until the entire superior pole becomes free. And as the pole becomes mobilized, one should take great care not to injure the underlying superior parathyroid gland.

2.3.8 Saving the Superior Parathyroid Gland

With the superior thyroid vessels ligated and divided, the upper pole of the thyroid is completely liberated and can be lifted anteromedially out of the operative wound.

This anteromedial retraction is best achieved when two or three Allis clamps held in the first assistant's hand apply a small pressure to create slight tension.

In this position, both the recurrent laryngeal nerve and the parathyroid glands can be identified, and the remainder of the procedures is held as well – I don't understand what this sentence means).

The location of the superior parathyroid gland is very much consistent and is in the place of upper third of the thyroid gland (near the tubercle of Zuckerkandl at the level of the cricoid cartilage) and has direct contact with the thyroid capsule posteriorly.

After a careful dissection is made to create a plane between the thyroid capsule and superior parathyroid gland, blunt peanut dissection can push the parathyroid back on a broad pedicle, safely away from the thyroid gland.

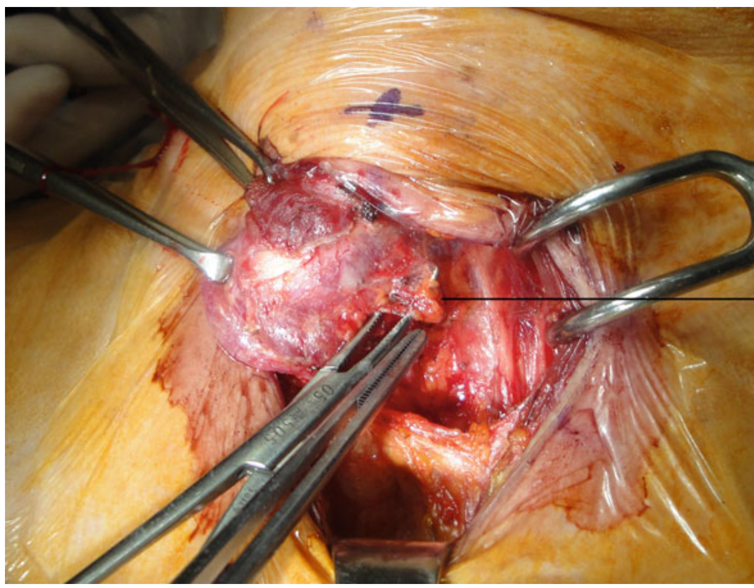


Fig. 2.19 Preservation of the superior parathyroid gland

2.3.9 Saving the Inferior Parathyroid Gland

Approximately 85 % of the inferior parathyroid glands are found within 1 cm of where the recurrent laryngeal nerve crosses the inferior thyroid artery, so one can use any of them as a guide to others.

The inferior thyroidal artery and vein are divided individually as close to the thyroid gland as possible.

Note that the inferior pole vessels are the blood supply to the inferior parathyroid gland and some to the superior parathyroid gland, so only the terminal branches that are directly entering the thyroid gland should be divided.

Division of the inferior thyroid vessels can also be performed with the ultrasonic sheers. Once the vessels are divided, further dissection of this area should be done with care, and this dissection is best performed with the peanut sponge and the Mixter clamp.

If preservation of the parathyroid is not feasible, reimplantation should be considered. The contralateral sternocleidomastoid (SCM) muscle is suggested for reimplanting parathyroid gland in an open thyroidectomy.

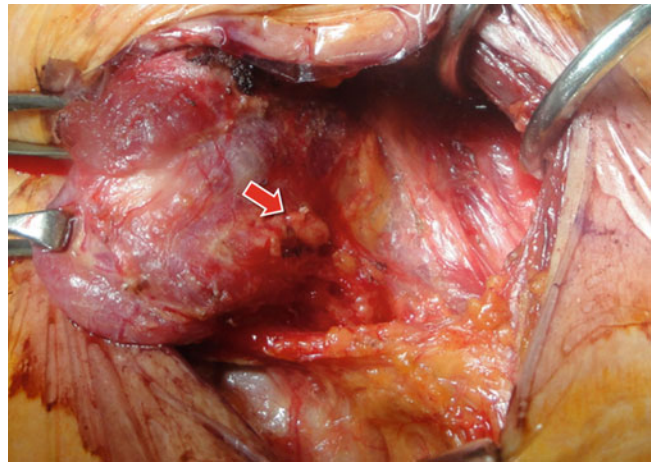


Fig. 2.20 Preservation of the inferior parathyroid gland (marked by *arrow*)

2.3.10 Preserving the Recurrent Laryngeal Nerve

At this point, the recurrent laryngeal nerve should be identified.

The right nerve travels laterally in the lower neck and then travels obliquely towards the midline at an angle approximately 30° to the tracheoesophageal groove.

During this course, it can pass behind, between, or anterior to the main branches of the inferior thyroid artery. The left nerve, on the other hand, travels in the tracheoesophageal groove for its entire cervical course.

The courses of both nerves are quite different, but the most consistent position is where they enter the larynx on the posterolateral aspect of the cricothyroid muscle.

The nerves may be identified at the level of the cricoid cartilage.

If the nerve is not seen immediately, only tissue that is transparent and definitively identified to be vascular or lymphatic structures should be divided with care. This may be achieved with the Mixter clamps or sharp mosquito hemostats.

Once the nerve is identified, use a fine dissector such as the Mixter clamps or sharp mosquito hemostats to delineate the plane just superficial to the nerve.

Continue this plane of dissection in cephalad direction to the site where the nerve enters the larynx posterolaterally.

Be aware that the nerve may divide into two or more branches along its course from the level of the inferior thyroid artery to the larynx.

Use of electrocautery adjacent to the nerve is not recommended because its electricity can cause an injury to the nerve.

As mentioned above, the recurrent laryngeal nerve can easily be found near the entrance of the inferior thyroid artery to the thyroid gland (marked as (2)). The tubercle of Zuckerkandl can also be used as a guide to the recurrent laryngeal nerve (marked as (1)).

Also the recurrent laryngeal nerve is at greatest risk for injury at the thoracic inlet (marked as (3)), so great care must be taken while performing central compartment dissection.

The normal anatomic locations of the right and left recurrent laryngeal nerves are shown in the posterior and anterior views in Fig. 2.24. Also, shown in the cross-sectional view is the relationship of the superior parathyroid gland and the left recurrent laryngeal nerve to the left thyroid lobe, the carotid sheath, the inferior thyroid vessels, the esophagus, and the trachea.

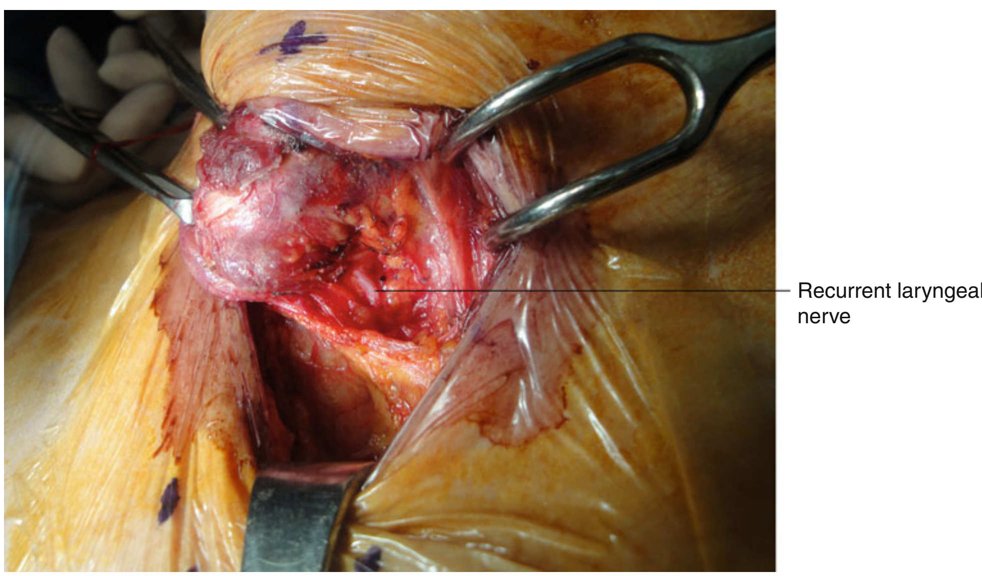
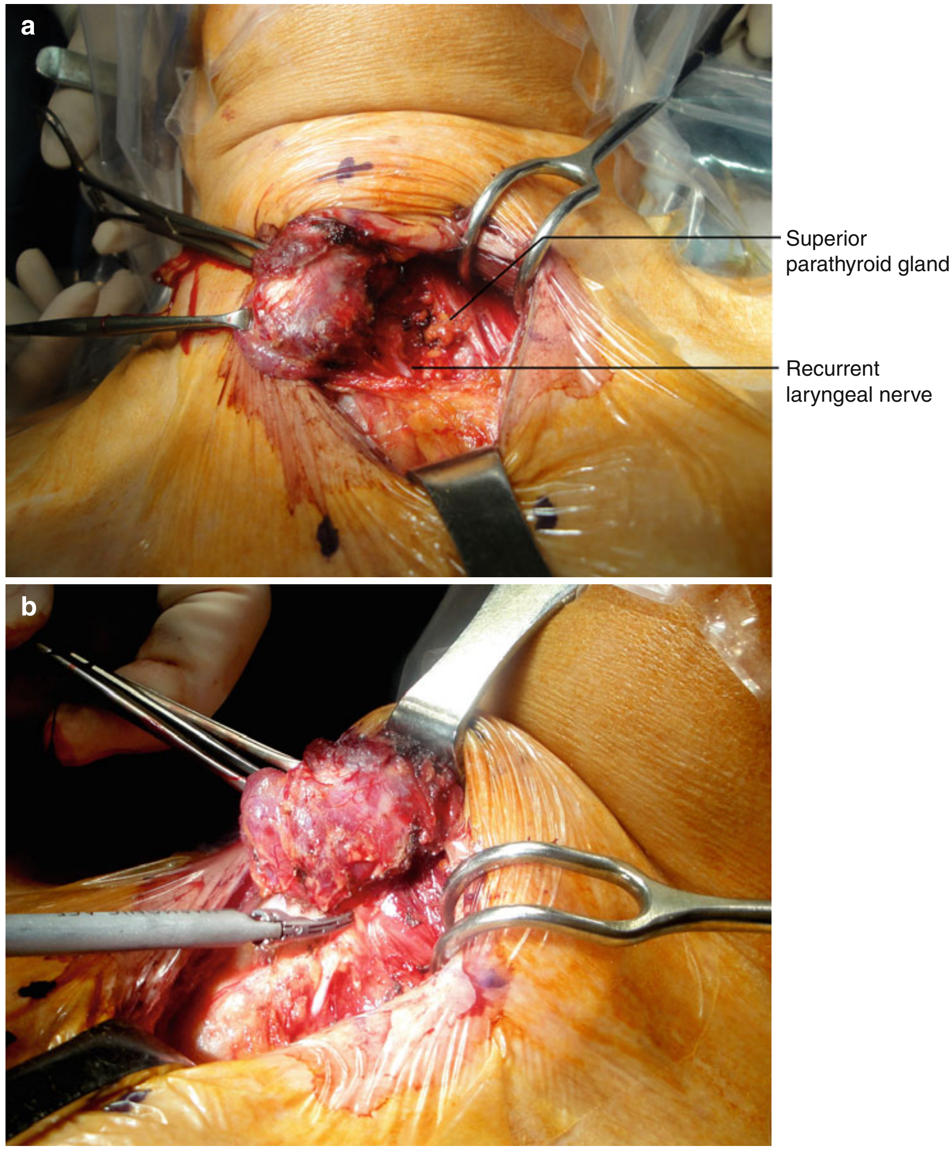


Fig. 2.21 Preservation of the recurrent laryngeal nerve

Fig. 2.22 (**a**) Preservation of the recurrent laryngeal nerve, (**b**) Resection of the Ligament of Berry



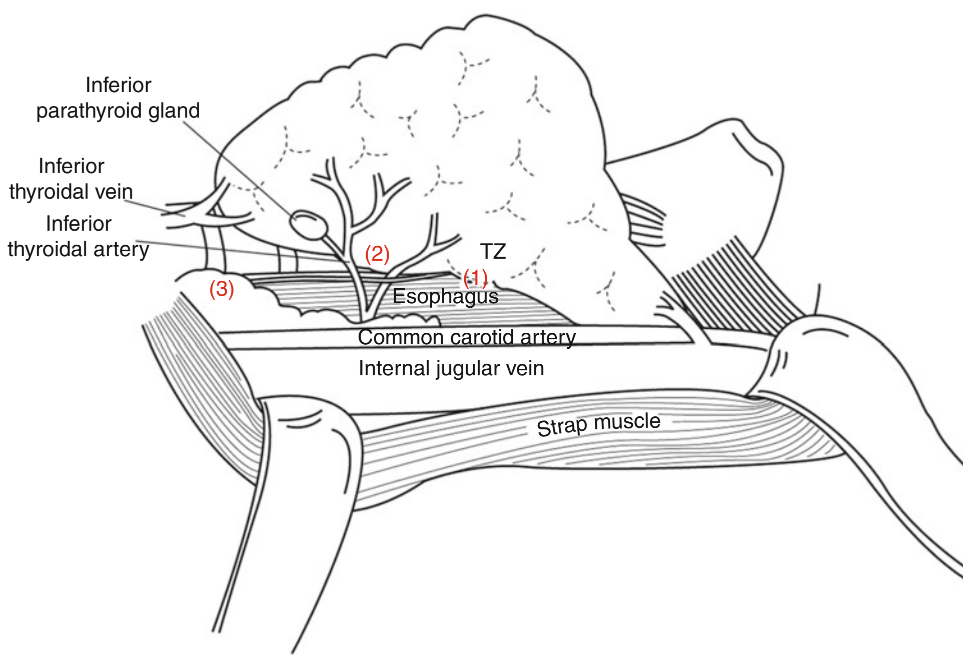


Fig. 2.23 The points where the recurrent laryngeal nerve is at great risk for injury: (*1*) at the ligament of Berry, (*2*) at the branches of the inferior thyroid artery, and (*3*) at the thoracic inlet during performing central neck dissection. *TZ* tubercle of Zuckerkandl

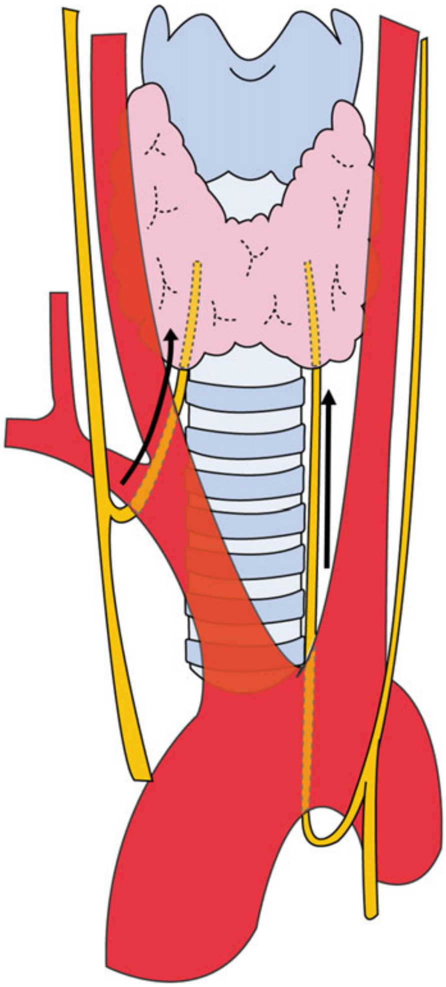


Fig. 2.24 The right recurrent laryngeal nerve does not get into the tracheoesophageal groove until it approaches near to the cricothyroid joint. (See both *arrows*)

2.3.11 Dissection of the Anterolateral Aspect of the Trachea

Unroofing of the recurrent laryngeal nerve at the point of the ligament of Berry and the final attachment between the thyroid gland and anterolateral aspect of the trachea should be performed carefully due to the high risk of nerve injury.

The ligament of Berry, a dense fibrous band that covers the nerve, is divided between the knots.

Often, there is a small artery passing close to the recurrent laryngeal nerve in this ligament which can hardly be controlled because of its proximity to the nerve.

After the ligament of Berry has been dissected, the remainder between the gland and the trachea can be easily performed with the electrocautery or the Metzenbaum scissors. On the anterior aspect of the trachea, there is an avascular plane.

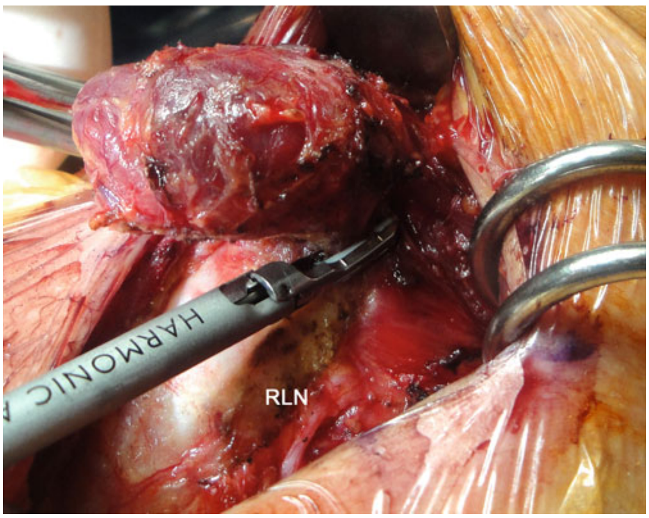


Fig. 2.25 Dissection of the ligament of Berry. *RLN* recurrent laryngeal nerve

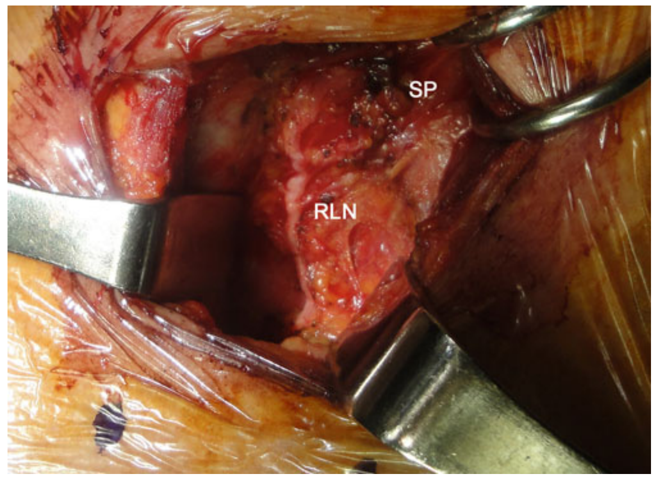


Fig. 2.26 After thyroid lobectomy was performed. *SP* superior parathyroid, *RLN* recurrent laryngeal nerve

2.3.12 Histological Confirmation and Decision of Total Thyroidectomy

Once the specimen is excised, it is reexamined in order to ensure that no parathyroid tissue has been inadvertently removed.

If a normal parathyroid gland is identified on the excised thyroid specimen, it should be autotransplanted at the end of the operation.

At this point, the surgeon must decide whether to perform a subtotal or total thyroidectomy.

If the frozen section is proved to be malignant, total thyroid lobectomy is strongly indicated.

If the frozen section shows a benign tumor, contralateral lobectomy is not needed.

However, cancer can be found in the final (permanent) diagnosis; therefore, possibility of a delayed completion thyroidectomy should be informed to the patient.

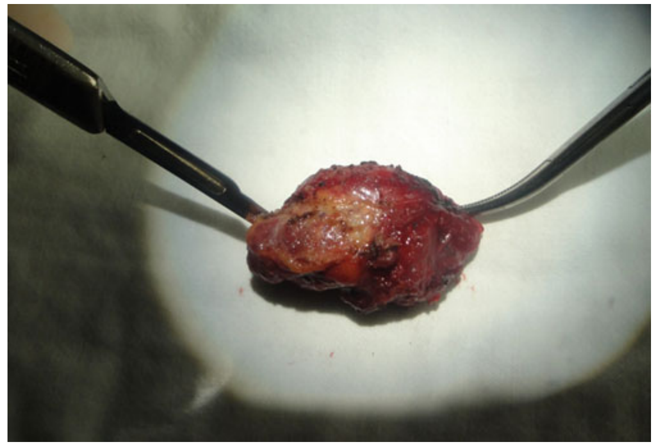


Fig. 2.27 Histological confirmation of the thyroid nodule

2.3.13 Central Neck Dissection

In patients with papillary thyroid carcinoma or medullary carcinoma, metastases to the lymph nodes are commonly seen, especially when the primary tumor is larger than 2 cm.

In these conditions, the most prevalent area of lymph node metastases is the ipsilateral central lymph node group, and the prevalence ranges from 20 to 90 %, with an average of 60 % in patients with PTC.

Therefore, in regard to the treatment of the frozen-proven PTC/MTC patient, an elective central neck dissection (CND) for the clinically node-negative central neck is considered to be optimal for an initial treatment.

As illustrated, level VI is bounded superiorly by the hyoid bone, inferiorly by the suprasternal notch, laterally by the carotid arteries, anteriorly by the superficial layer of the deep cervical fascia, and posteriorly by the deep layer of the deep cervical fascia.

The fatty tissues, with the central lymph nodes embedded, are dissected from the carotid artery laterally from the inferior part of the thyroid gland to the suprasternal notch with electrocautery or ultrasonic sheers. Then the fatty tissues are dissected from the trachea along the tracheoesophageal groove. The dissection should be done after identifying the full course of the recurrent laryngeal nerve.

It is not too much to say that the central lymph node dissection is used in identifying the way of the recurrent laryngeal nerve and keeping it safe. After carefully dissecting the central lymph nodes, the surgeon should examine the specimen for the presence of the parathyroid glands that were also removed inadvertently. Should there be any parathyroid glands detected, they should be reimplanted as described subsequently. Even if all parathyroid glands appear to have been spared, the specimen of central nodes should be examined thoroughly.

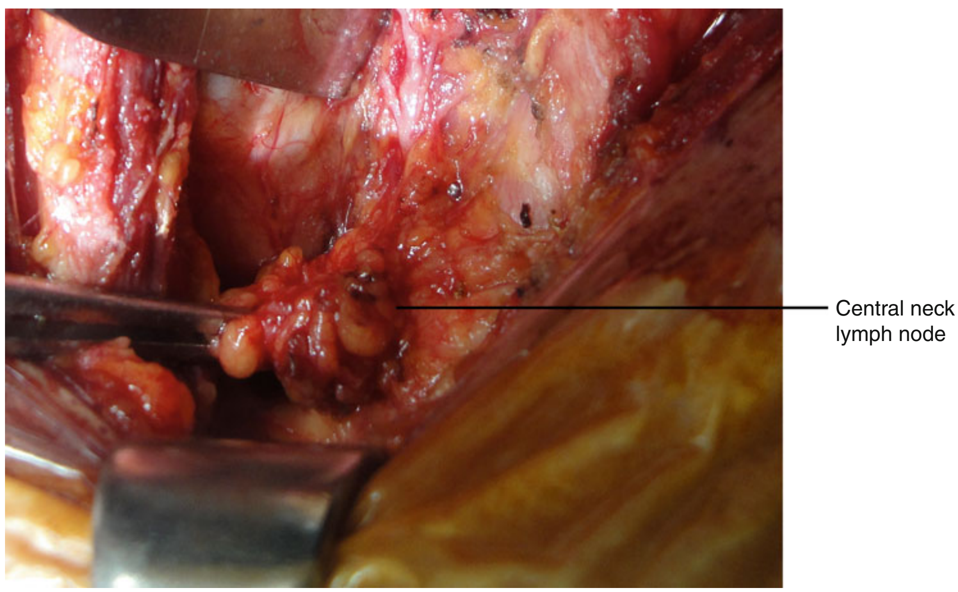


Fig. 2.28 Central neck dissection

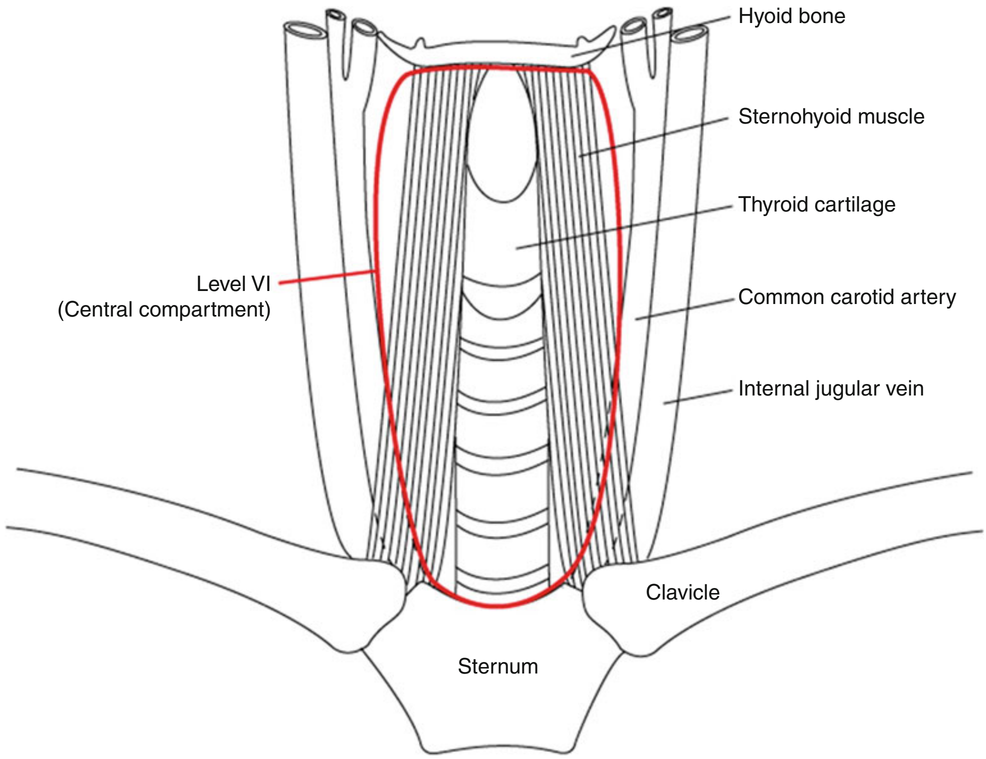


Fig. 2.29 Boundaries of central compartment

2.3.14 Contralateral Lobectomy of the Thyroid Gland

Contralateral lobectomy of the thyroid gland is also performed in a manner that is similar to the ipsilateral lobectomy.

During the course of total thyroidectomy, as many of the parathyroid glands should be preserved as possible, and if the blood supply of some of them looks to be impaired, they should be reimplanted properly.

The procedure of autotransplantation of the parathyroid gland will be described subsequently.

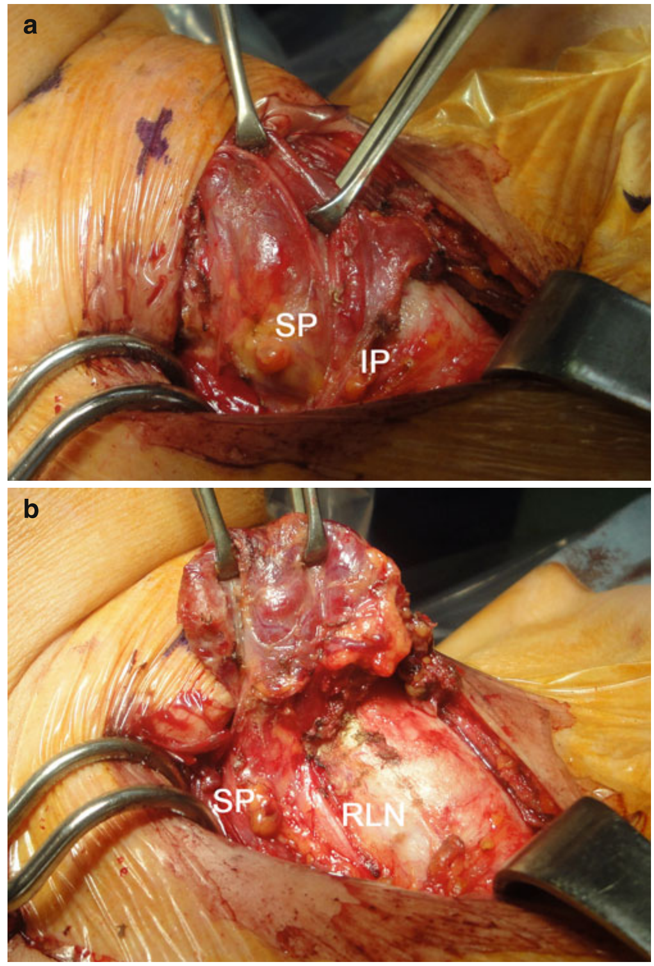


Fig. 2.30 Contralateral lobectomy of the thyroid gland. (**a**) Lateral dissection saving superior and inferior parathyroid glands, (**b**) saving recurrent laryngeal nerve. *SP* superior parathyroid, *IP* inferior parathyroid, *RLN* recurrent laryngeal nerve

2.3.15 Autotransplantation of the Parathyroid Gland

If there is some doubt regarding the viability of a parathyroid gland during surgery, or a parathyroid gland has been resected inadvertently, frozen section should be requested to confirm the presence of the parathyroid tissue.

In the meantime, the remainder of the suspected parathyroid glands should be kept in saline-moistened gauze and placed in a bucket of ice.

When frozen section is confirmed as the parathyroid tissue, the residual gland should be minced in pieces smaller than 1 mm^3 with the iris scissors and transplanted to striated muscle tissue, as the sternocleidomastoid (SCM) muscle or brachioradial muscle of the forearm.

The pocket containing the minced gland is secured with a figure-of-eight suture.

It is preferred to use contralateral SCM muscle, since it can supply plenty of blood to the parathyroid gland, and there is no need to make another incision.

The site is then marked with a metal clip to avoid confusion with true recurrent thyroid carcinoma. This is the third reason why we prefer the contralateral SCM muscle for reimplantation of the parathyroid gland.

In patient, who underwent the total thyroidectomy, the serum calcium and phosphate should be monitored in the initial postoperative period and a low calcium level should be corrected properly.

Fig. 2.31 Autotransplantation of the parathyroid gland (other case)

2.3.16 Closure and Dressing

When the thyroid lobectomy is all done, the operative field is irrigated with warm saline and obtained complete hemostasis by ligatures and electrocautery.

Meticulous hemostasis should be achieved before the operation is over.

After achieving hemostasis, the fibrin glue (Tissucol®) is spread all around the operative bed and two closed suction drains (Hemovac® or Jackson-Pratt®) are placed to the operative bed through the incision.

Drains are firmly anchored by 3-0 nylon sutures.

The right and left strap muscles are re-approximated together with absorbable sutures continuously.

The skin is closed with knot-buried stitches with 4-0 Vicryl sutures.

Sterile adhesive wound strips (Steri-strip®) are applied on the wound, and the wound is covered with a semiocclusive dressing.

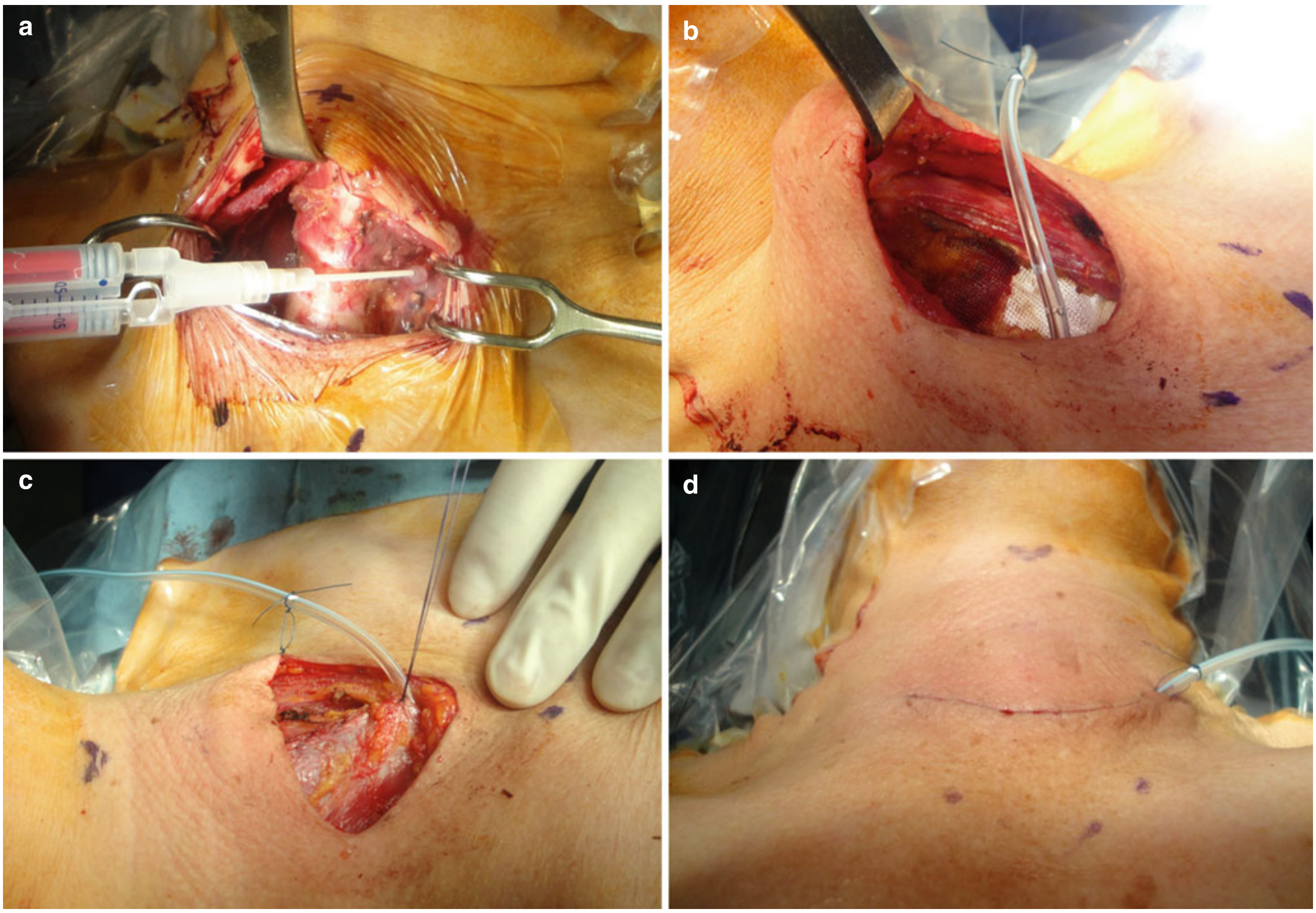


Fig. 2.32 Closure of wound. (**a**) Hemostasis with fibrin glue, (**b**) drain insertion, (**c**) midline closure between strap muscles, (**d**) skin closure

Fig. 2.33 Closure of wound (continued)

2.4 Postoperative Care

2.4.1 Recovery Room

After surgery, patients are sent to the recovery room for 1–2 h where nurses monitor patient status. Since postoperative bleeding can occur, nurses check for signs of drainage from the wound and swelling of the neck.

2.4.2 Diet Restriction

There are no restrictions on diet, and most patients take in water and solid food a few hours after surgery. Hospital staff monitor patients to ensure water and food do not enter the trachea.

2.4.3 Ambulation

Patients are encouraged to move about to avoid deep vein thrombosis.

2.4.4 Analgesics

Acetaminophen or a nonsteroidal anti-inflammatory drug (NSAID) is administered to patients with pain as needed. Narcotic painkillers are rarely administered. Postoperative headache from prolonged overextension of the neck is controlled with acetaminophen or an NSAID.

2.4.5 Thyroid Hormone Replacement

Patients who underwent total thyroidectomy or near-total thyroidectomy require thyroid hormone replacement, while patients who underwent lobectomy do not.

2.4.6 Voice Care

After surgery, patients can have a hoarse voice due to edema of the subglottis caused by irritation of the endotracheal tube or injury to the recurrent laryngeal nerve. Temporary recurrent nerve injury occurs in 10 % or less of cases, and permanent nerve injury (i.e., nerve dysfunction for more than 6 months) occurs in less than 1 % of cases. Recurrent laryngeal nerve injury and vocal cord fixation are assessed by indirect laryngoscopy (rigid or flexible) at bedside. If vocal cord fixation persists for more than 6 months, consultation with a voice specialist is recommended.

2.4.7 Wound Care

Wound care using aseptic techniques is performed 1–2 days after surgery. Before discharge, the wound is drained and dressing is changed. Patients can shower 2–4 days after discharge.

3 Endoscopic Thyroidectomy: Bilateral Axillo-Breast Approach (BABA)

3.1 Basic Equipment and Instruments of Endoscopic Thyroidectomy

3.1.1 The Operating Theater

The operating theater for endoscopic thyroidectomy is similar to that of open thyroidectomy. The room is a clean and sterile space to perform the operation in aseptic manners.

3.1.2 Instruments

3.1.2.1 Endoscope

5-mm 30° endoscope (Karl Storz Endoscopy Inc., California, USA)

Fig. 3.1 5-mm 30° endoscope

The online version of this chapter (doi:10.1007/978-3-642-37262-9_3) contains supplementary material, which is available to authorized users.

Y.-K. Youn et al., *Color Atlas of Thyroid Surgery*,
DOI 10.1007/978-3-642-37262-9_3, © Springer-Verlag Berlin Heidelberg 2014

3.1.2.2 Thyroid Pillow (Emtas, Korea)

Fig. 3.2 Thyroid pillow

3.1.2.3 Harmonic® (Ethicon Endo-Surgery, Cincinnati, Ohio, USA)

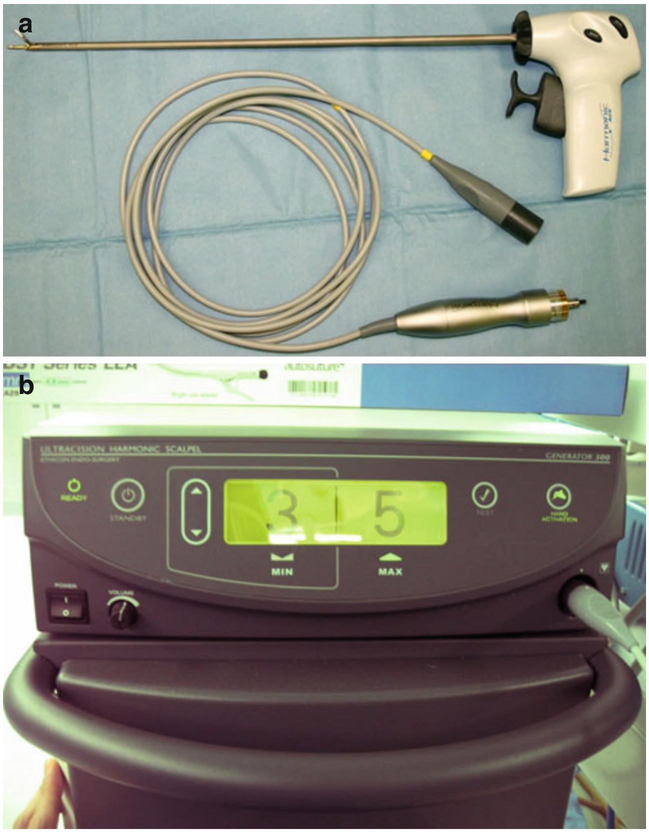


Fig. 3.3 Harmonic® (**a**) handpiece, (**b**) generator

3.1.2.4 Vascular Tunneler (Gore-Tex)

Fig. 3.4 Vascular tunneler

3.1.2.5 Suction-Irrigator

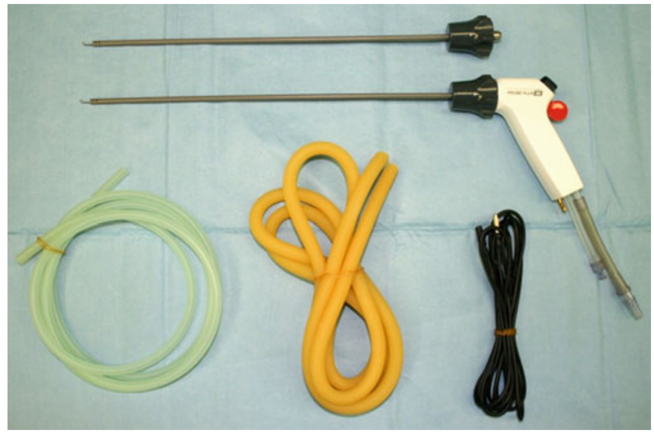


Fig. 3.5 Suction-irrigator

3.1.2.6 Trocar (Ethicon Endo-Surgery, XCEL: B12XT, B5XT)

1 trocar, Φ12 mm, 15 cm long
3 trocars, Φ5 mm, 15 cm long

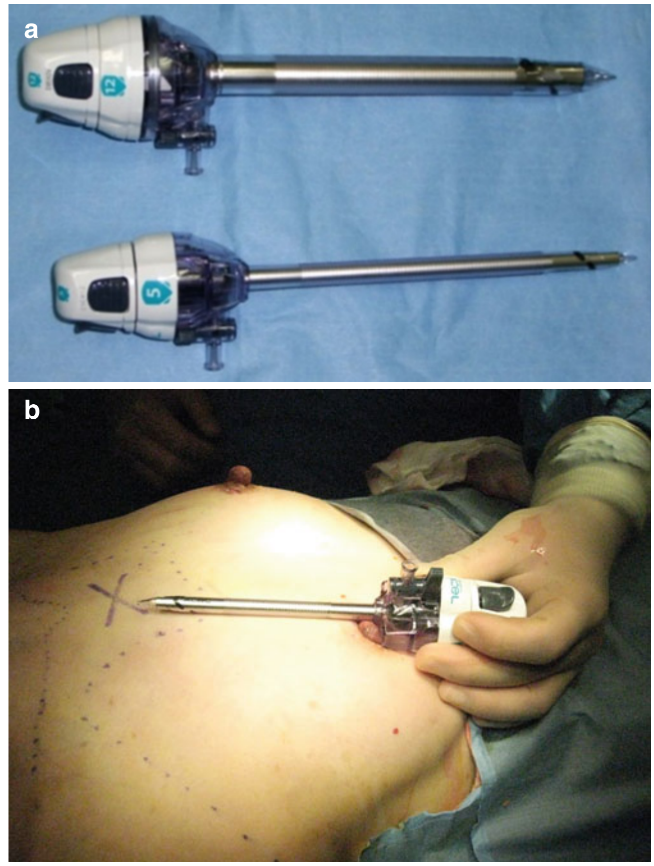


Fig. 3.6 Trocars. (**a**) Φ12-mm trocar (*upper*), Φ5-mm trocar (*lower*), and (**b**) 15-cm long trocar are needed to reach the operative field

3.1.2.7 Snake Retractor, Φ5 mm

Right and left snake retractors

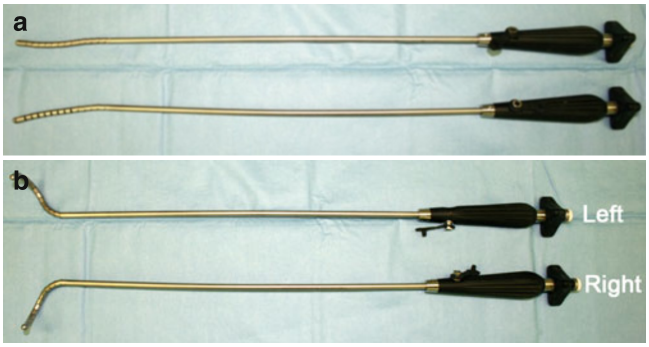


Fig. 3.7 Snake retractor. (**a**) open, (**b**) closed

3.1.2.8 Endobag, Φ10 mm

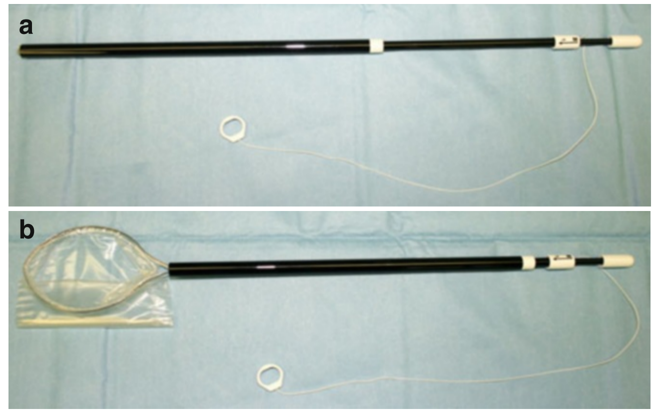


Fig. 3.8 Endobag. (**a**) closed, (**b**) open

3.1.2.9 Endo-suture and Endo-needle Holder, Φ5 mm

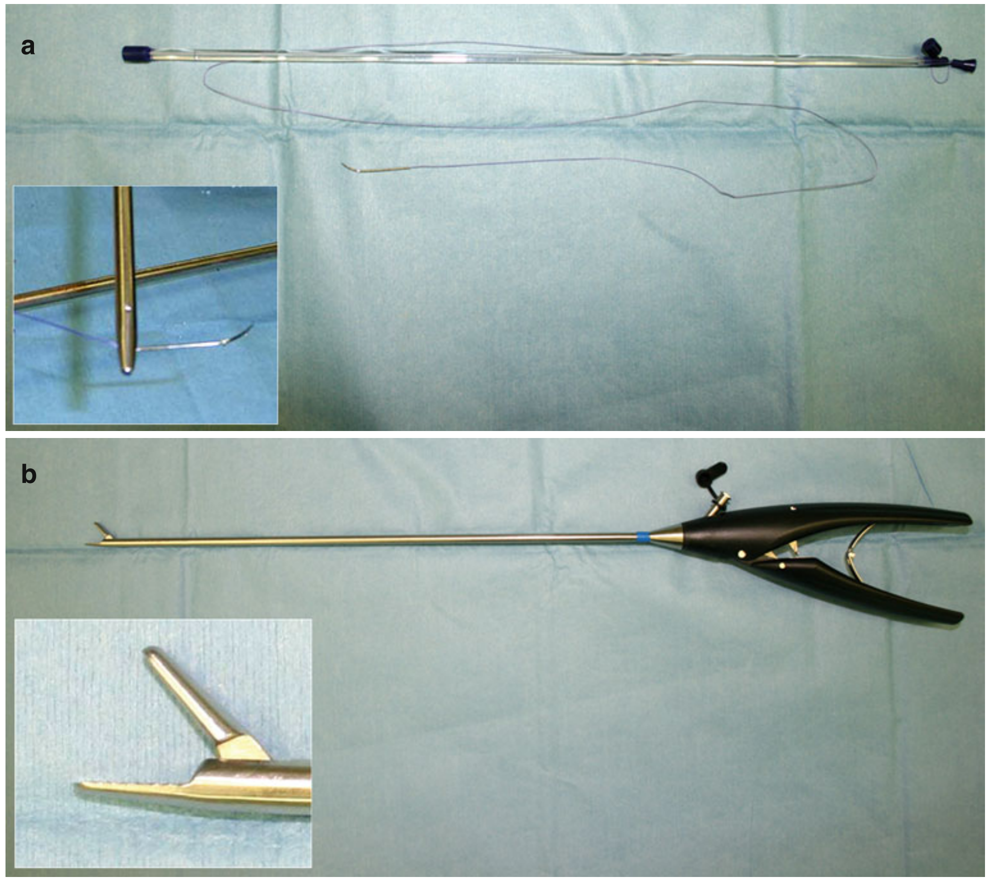


Fig. 3.9 (**a**) Endo-suture, (**b**) endo-needle holder

3.1.2.10 Basic Instruments

1 Endo-clinch, Φ5 mm
1 Endo-Maryland forceps, Φ5 mm
1 Endo-right-angled forceps, Φ5 mm

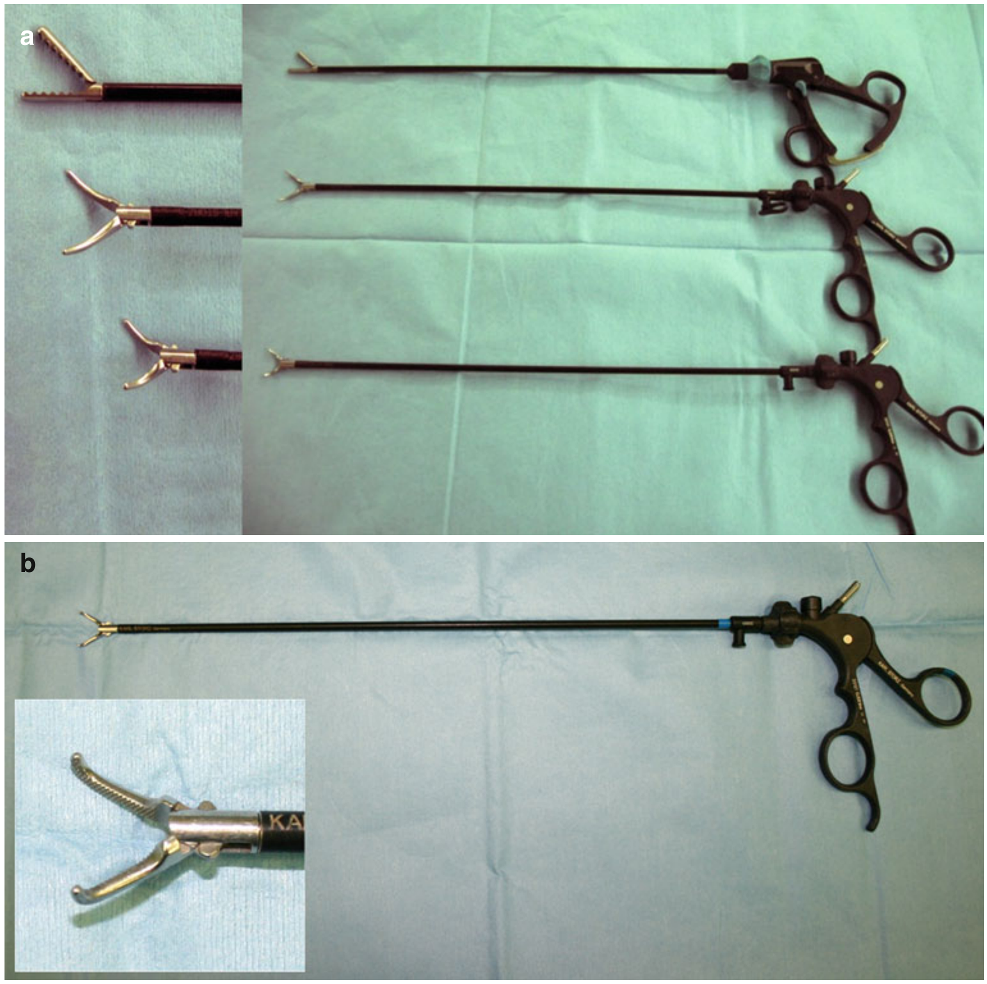


Fig. 3.10 Endoscopic instruments. (**a**) Endo-clinch and endo-Maryland forceps, (**b**) endo-right-angled forceps

3.1.2.11 Two 10-mL Syringes with 22-G Spinal Needle

200 mL of normal saline with 1 mL of 1 % epinephrine (1:200,000)

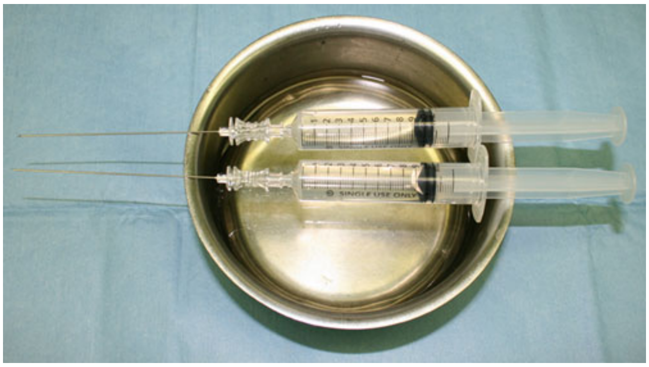


Fig. 3.11 200 mL of epinephrine-saline

3.2 Patient Selection: Indications and Contraindications

Indications for endoscopic thyroidectomy are as follows: (1) benign thyroid nodules that are needed to be excised (the size of nodule is not considered to be important, but for beginners, the nodule less than 3–4 cm in diameter is preferable), (2) for diagnosis for the nodules of suspicious for follicular neoplasm or Hurthle cell neoplasm, and (3) completion thyroidectomy of the patient diagnosed with follicular carcinoma or Hurthle cell carcinoma of previous diagnostic lobectomy.

Absolute contraindications for endoscopic thyroidectomy are the patient with previous open neck surgery, thyroid malignancy which expected to recur easily (i.e., medullary thyroid cancer, advanced papillary thyroid cancer, and poorly differentiated thyroid cancer), and overt breast malignancy.

Relatively not recommended patients for endoscopic thyroidectomy are with large size thyroid nodules over 5 cm in diameter, male patient (due to the prominent clavicle and no breast mound which allows movability of the instruments), with Graves' disease, and with well-differentiated thyroid carcinoma over 1 cm in diameter.

3.3 Procedures of Bilateral Axillo-Breast Approach (BABA) Endoscopic Thyroidectomy

3.3.1 Patient Positioning

The patient is placed in supine position on the operating table with the Q-pillow underneath his/her shoulders. Extend the patient's neck to expose the operative field (i.e., anterior neck).

Arms should be fixed in the abducted position in order to expose the axillae.

The blood pressure cuff is placed on the patient's ankle.

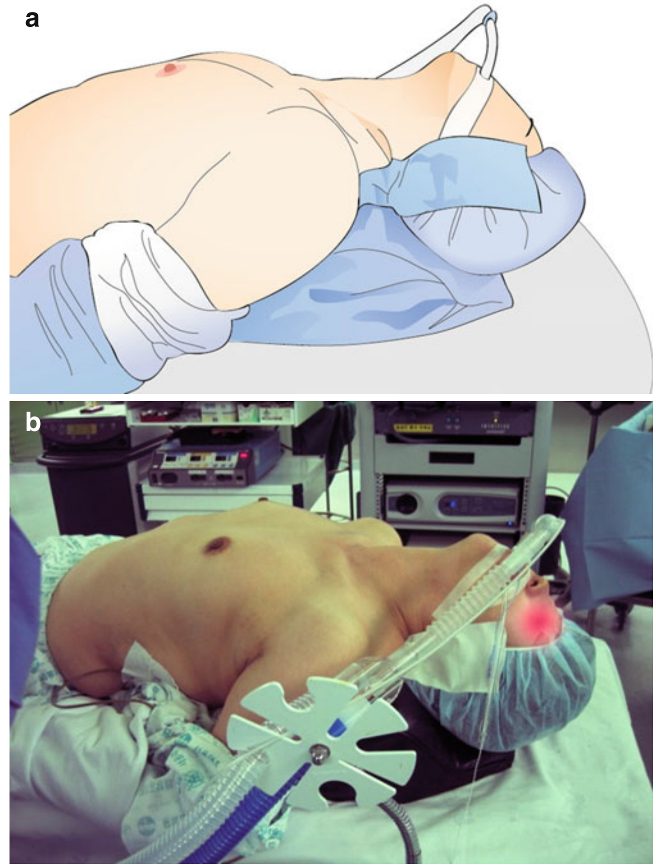


Fig. 3.12 Position of patient. (**a**) illustration, (**b**) photo

3.3.2 Skin Preparation

Antiseptic solution is applied to the patient's skin from the patient's chin to the xiphoid process. Axillae and proximal regions of arms are also prepared with antiseptic solution.

Fig. 3.13 Skin preparation

3.3.3 Draping

Cover the patient with sterile universal drapes, except the anterior neck and both axillae and breasts.

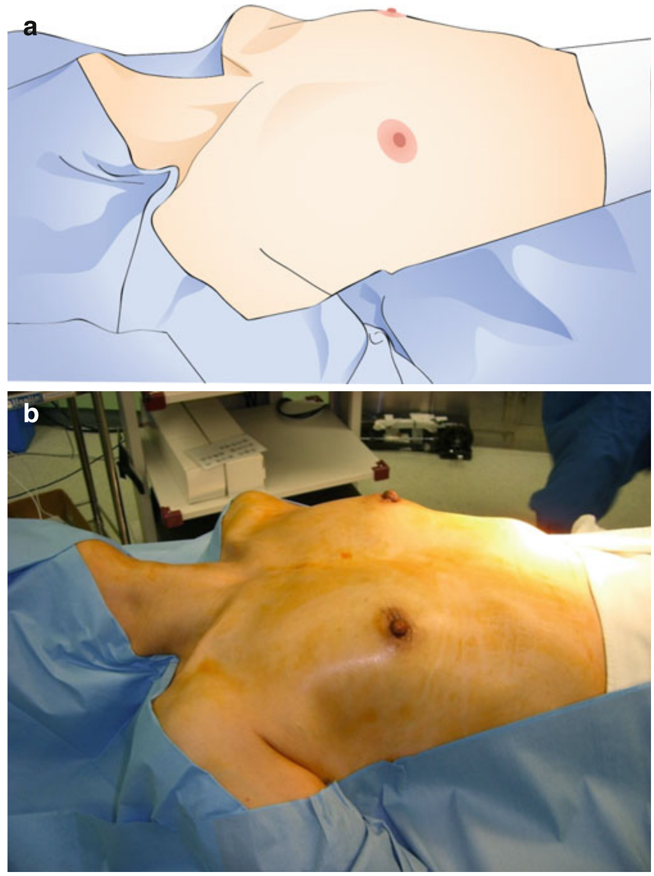


Fig. 3.14 Draping of the operative field. (**a**) illustration, (**b**) photo

3.3.4 Field Setup

Sterilized devices and lines should be installed on the operative field:

- Harmonic® and endo-electrocautery
- Camera line
- CO_2, suction, and irrigation lines
- Air vent
- Bovie pedal

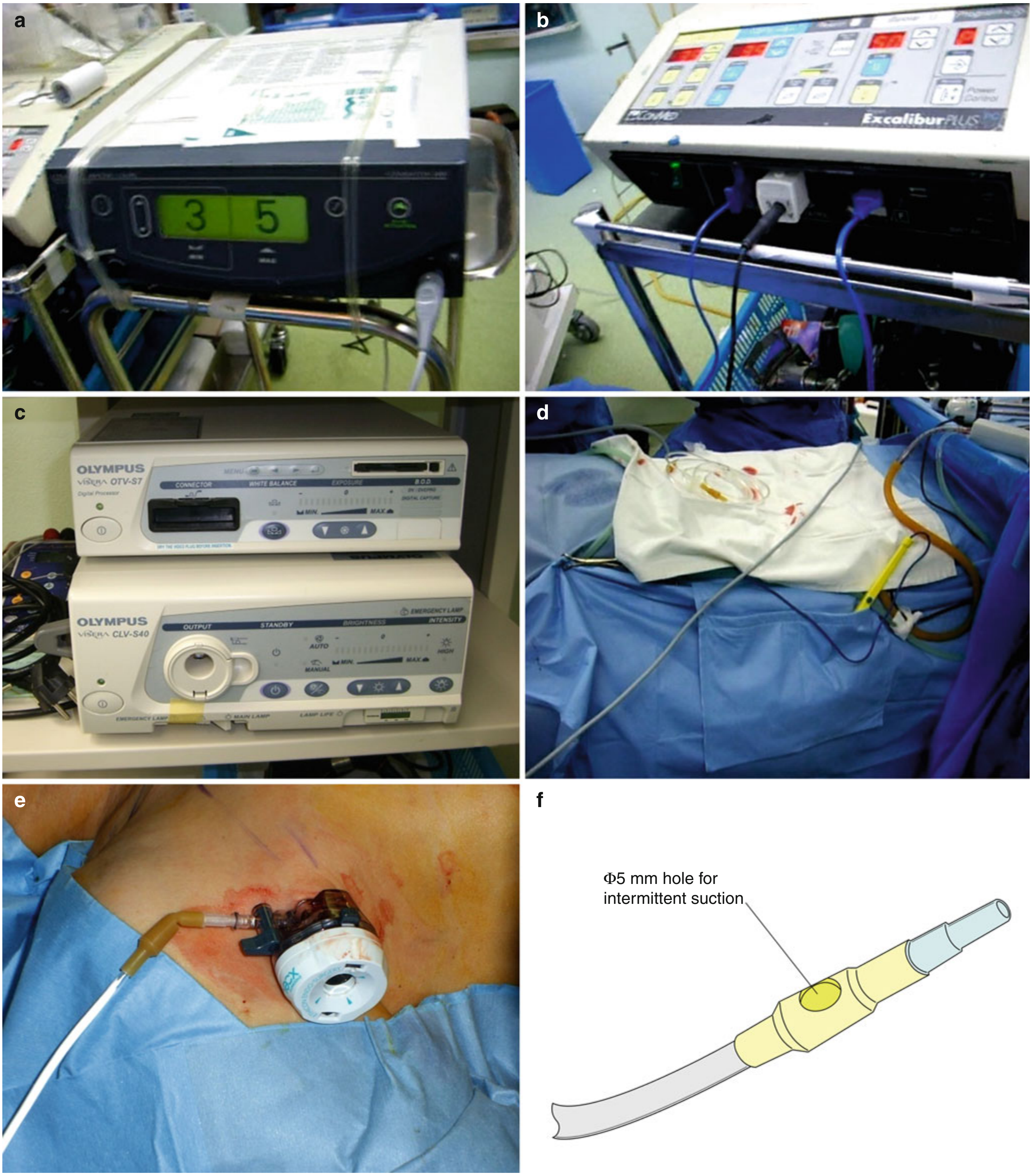


Fig. 3.15 Field setup. (**a**) Harmonic®, (**b**) electrocautery, (**c**) camera and light source, (**d**) operative field setup, (**e**) air vent, and (**f**) making air vent with IV extension

3.3.5 Operating Room Setup

Here is the schematic depiction of the aerial view of the operating room setting for endoscopic thyroidectomy. For right lobectomy, the operator stands on the left side of the patient and vice versa for left lobectomy.

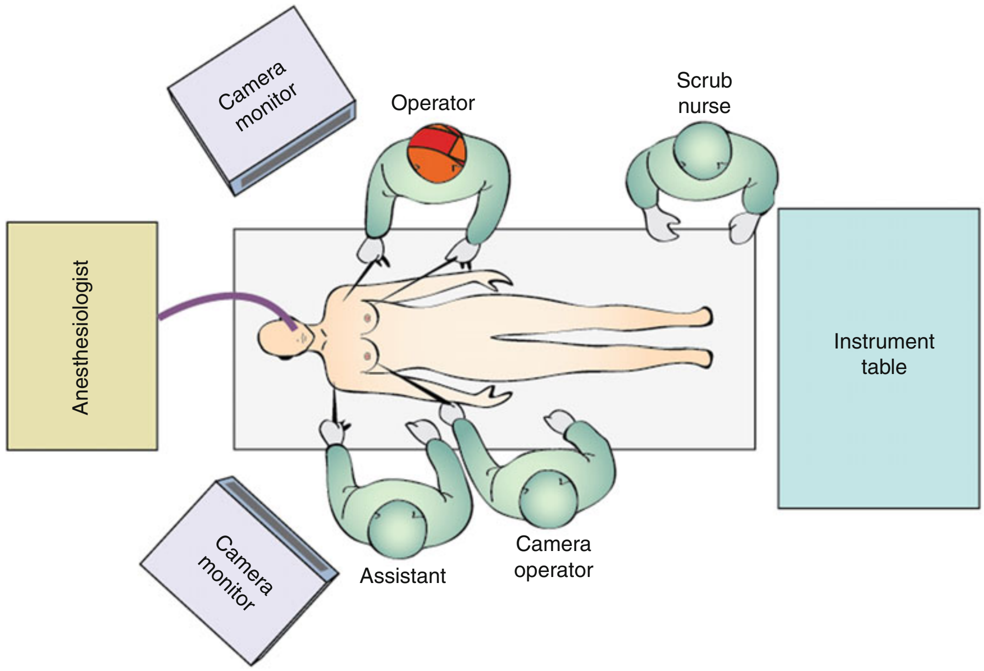


Fig. 3.16 Operating room setup (for right lobectomy)

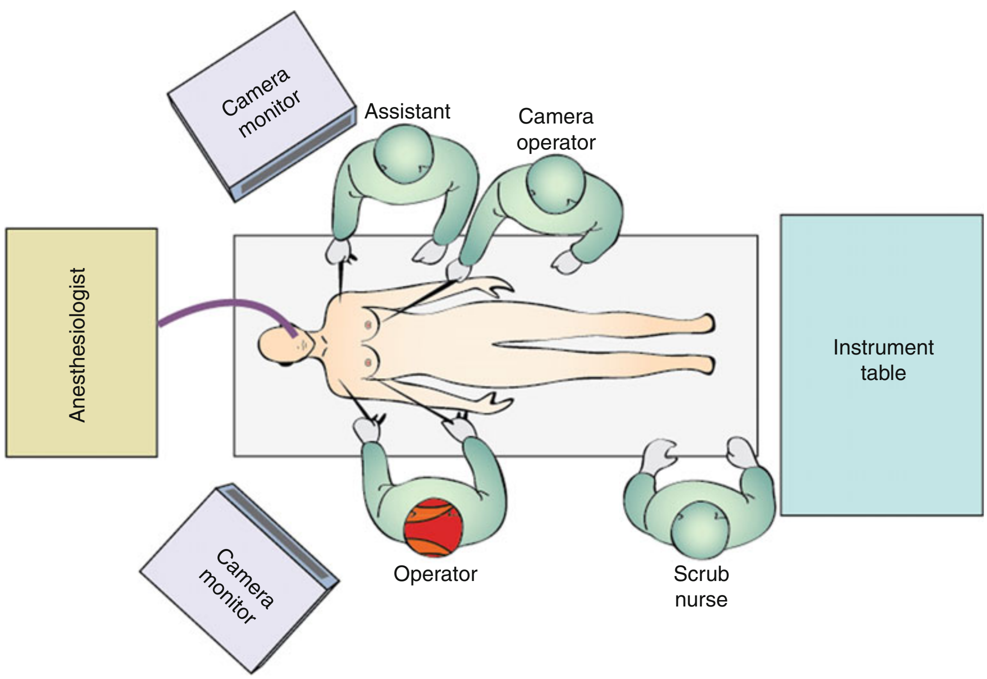


Fig. 3.17 Operating room setup (for left lobectomy)

3.3.6 Drawing Guidelines on the Body

Draw marking lines along the landmarks of the chest and the neck – midline, thyroid cartilage (V), cricoids cartilage (+), anterior border of the SCM muscle, superior border of the clavicles, suprasternal notch (U), incisions, trajectory lines from the port site to the thyroid gland, and the working spaces as well.

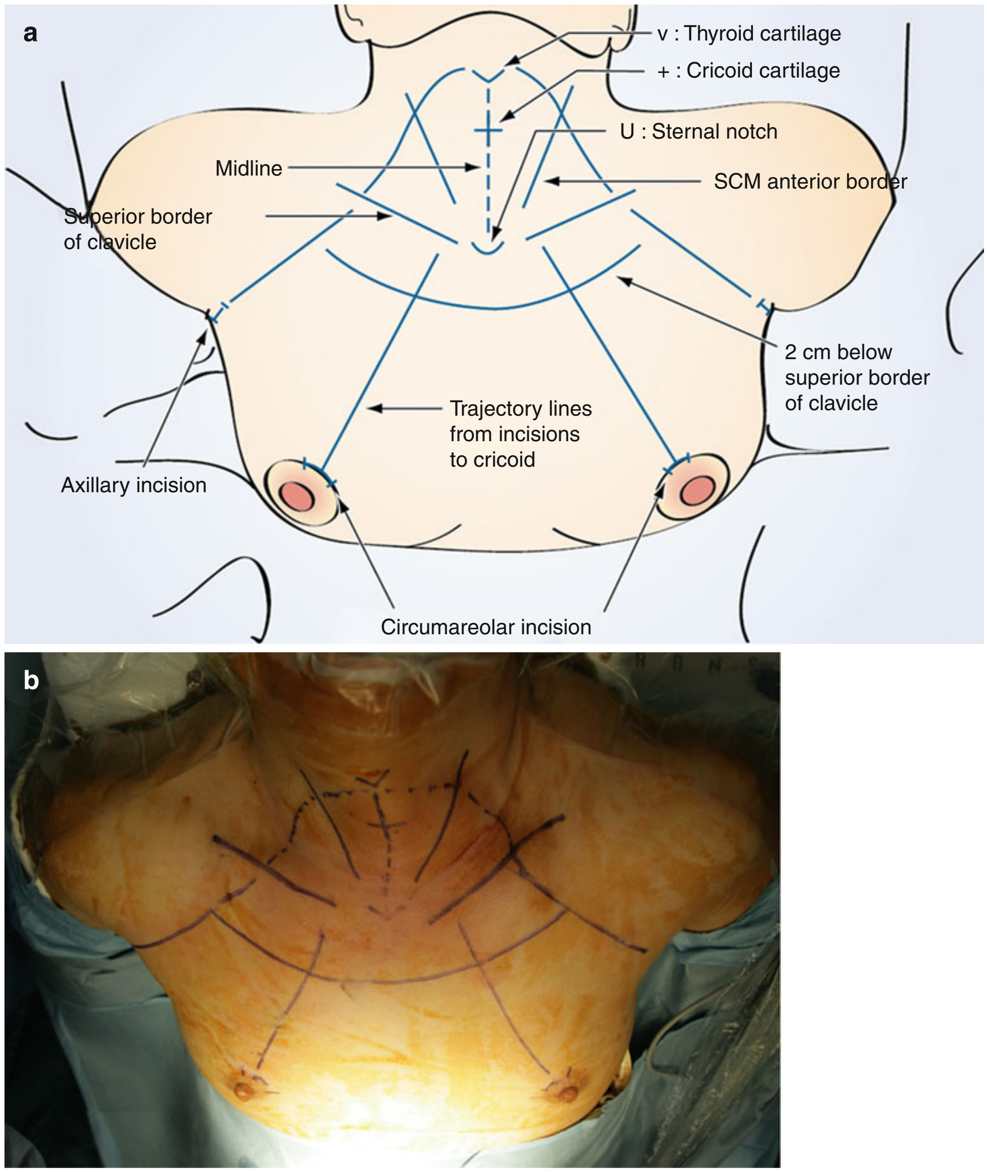


Fig. 3.18 Guidelines of BABA endoscopic thyroidectomy. (**a**) illustration, (**b**) photo

3.3.7 Saline Injection

Diluted epinephrine solution (1:200,000) is injected in the working area under the platysma in the neck and subcutaneously in the anterior chest. In the neck area, a "pinch and raise" maneuver of the skin facilitates the injection of saline into the subplatysmal area. This "hydrodissection" technique results in the formation of a saline pocket in the subplatysmal layer, which decreases the bleeding in the flap area and makes the subsequent dissection easier (Fig. 3.20).

Note: Drawing the plunger backward before making the injection will prevent intravenous injection of the solution which may cause high blood pressure and tachycardia.

Pinch and raise technique is a useful method to avoid the needle injury to the trachea and the major vessels.

Injecting saline in the supraclavicular area should be avoided because of the risk of pneumothorax.

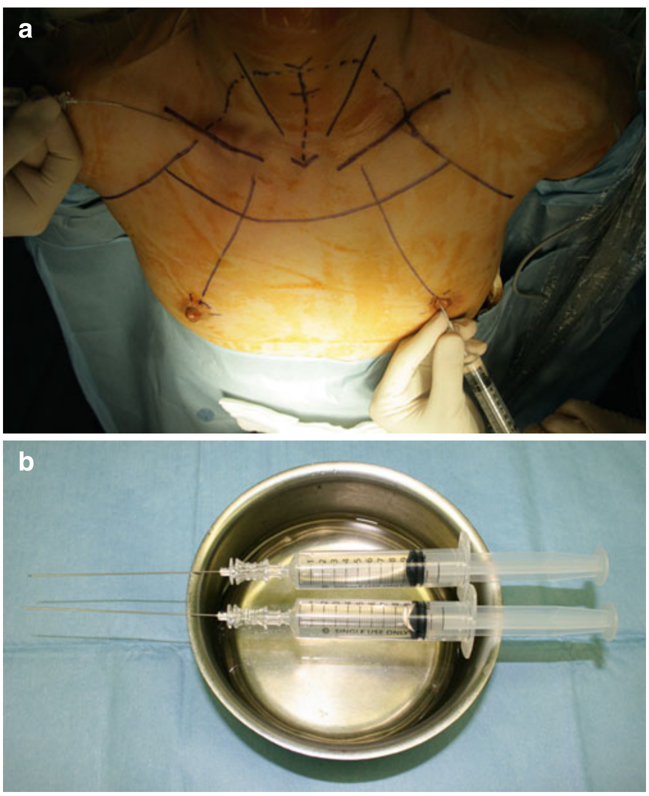


Fig. 3.19 (**a**) Epinephrine-saline injection in the chest, (**b**) epinephrine-saline and syringe

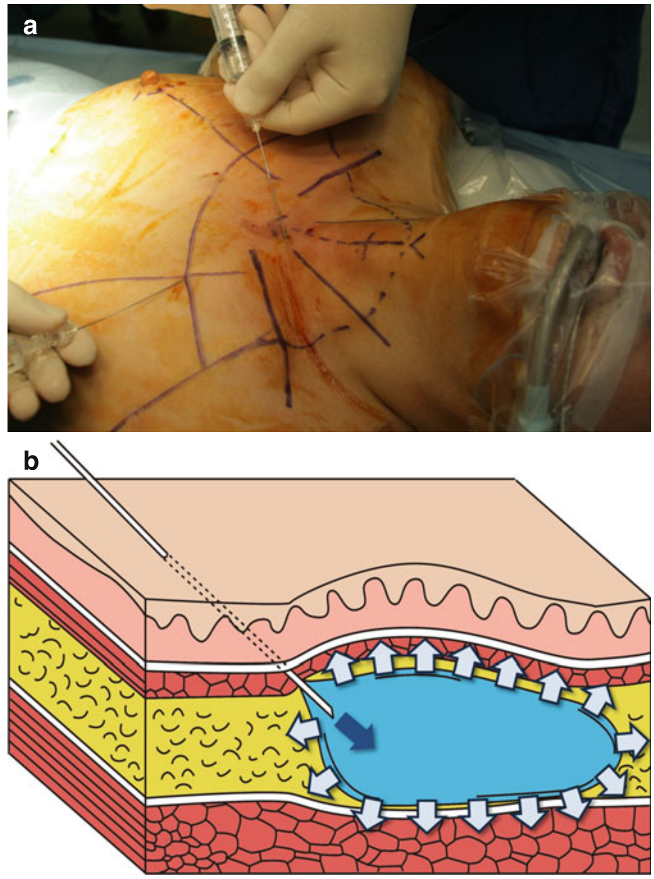


Fig. 3.20 (**a**) Epinephrine-saline injection in the neck, (**b**) the concept of hydrodissection

Fig. 3.21 Pinch and raise technique

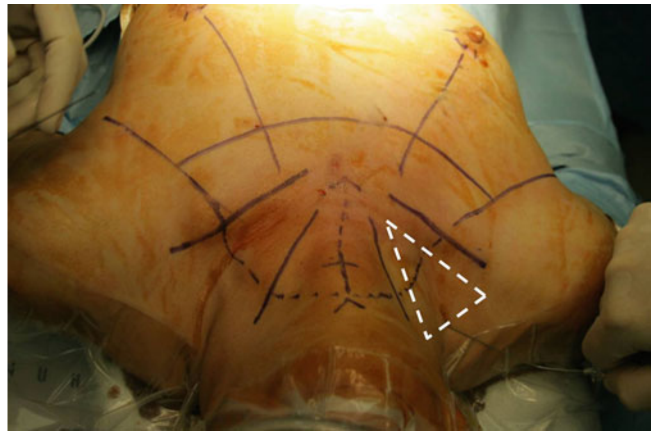


Fig. 3.22 Dangerous zone of puncture

3.3.8 Skin Incision and Blunt Dissection

Make incisions in the superomedial margin of the areolar of the breasts and left and right axillary folds. Make a blunt dissection and elevate the flap, and make working spaces with straight mosquito hemostats, long Kelly clamps, and a vascular tunneler through the incisions subsequently.

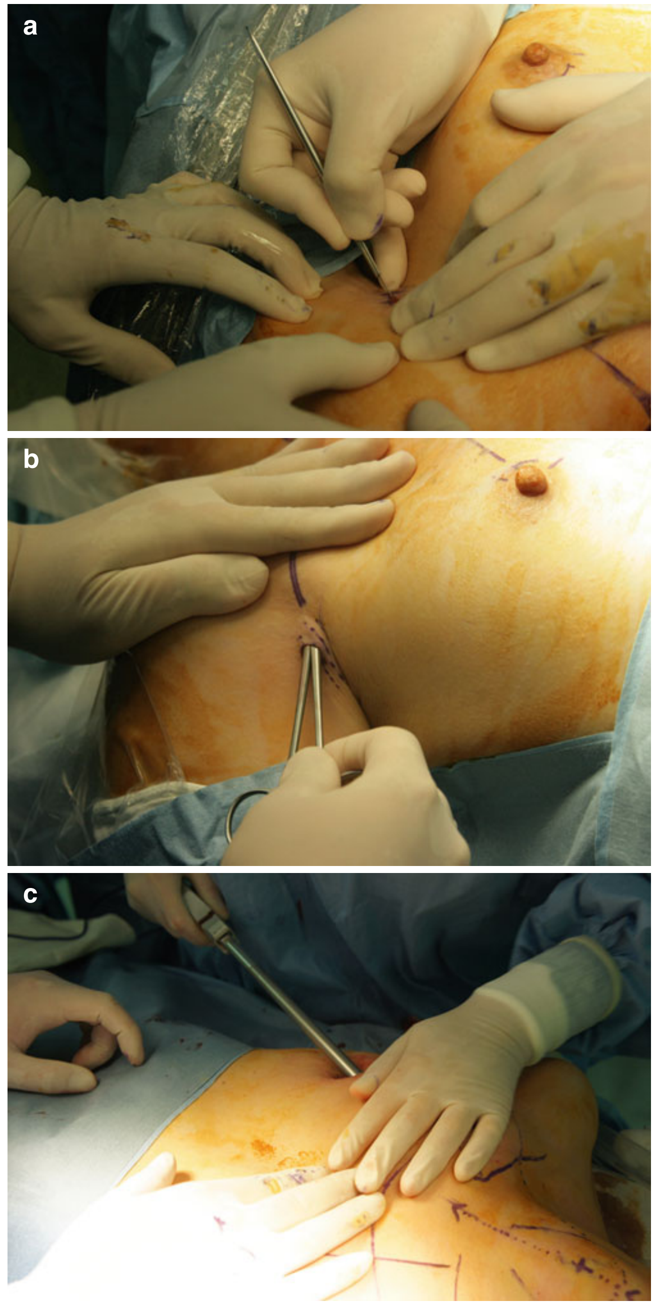


Fig. 3.23 (**a**) Skin incision, (**b**) blunt dissection with mosquito hemostats, and (**c**) blunt dissection with vascular tunneler

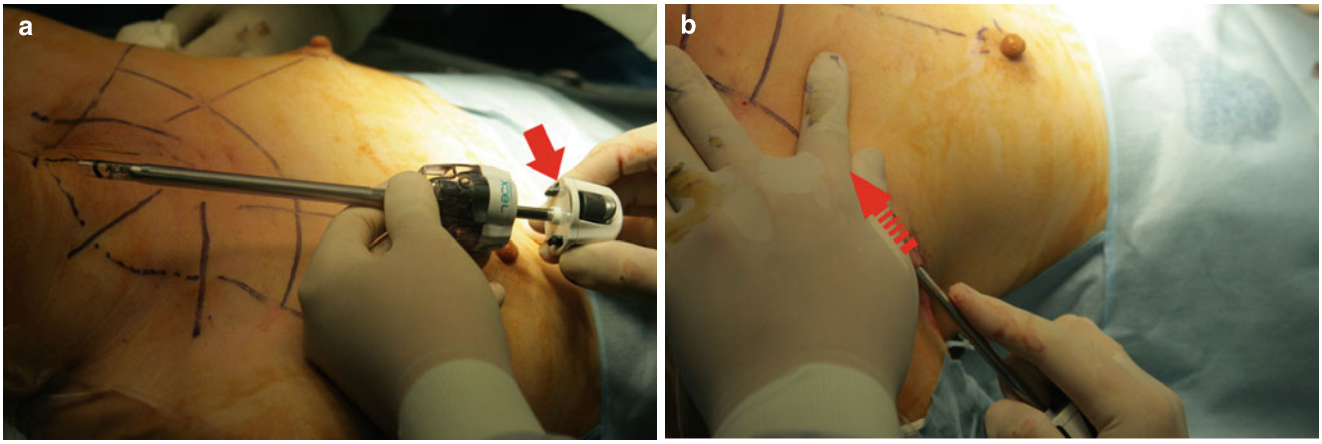


Fig. 3.24 (**a**, **b**) An alternative technique; blunt dissection using an obturator of 5-mm trocar (marked by *arrow*)

3.3.9 Trocar Insertion

After elevating the flap from the port sites up towards the cricoids cartilage, the trocars are inserted through the incisions. For two breast incisions and the left axillary incision, 5-mm trocars are used, while for the right axillary incision, a 12-mm trocar is inserted (Fig. 3.25). A 12-mm port is usually made to the lesion side to extract the specimen.

The working space is insufflated with CO_2 gas at the pressure of 5–6 mmHg via a 12-mm port. The dissection should start in area 2 and the flap is extended to area 1, up to the thyroid cartilage in the cephalad direction, and laterally towards the anterior border of the SCM muscle (Fig. 3.27).

DuoDERM® is applied on bilateral breast incisions in order to protect the nipples before inserting the trocars.

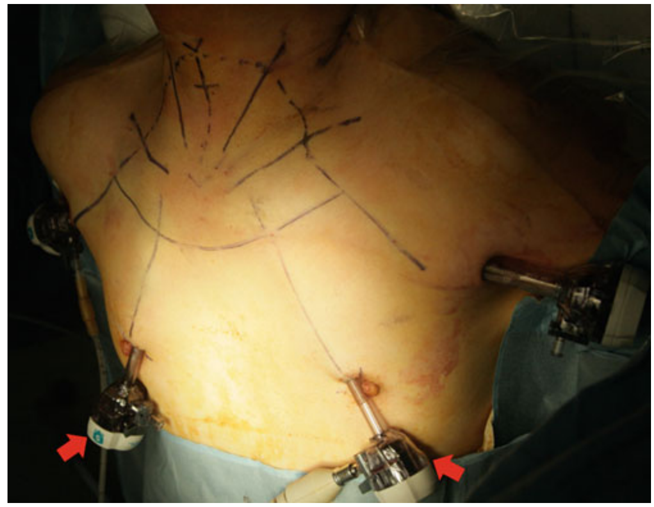


Fig. 3.26 Breast port insertion

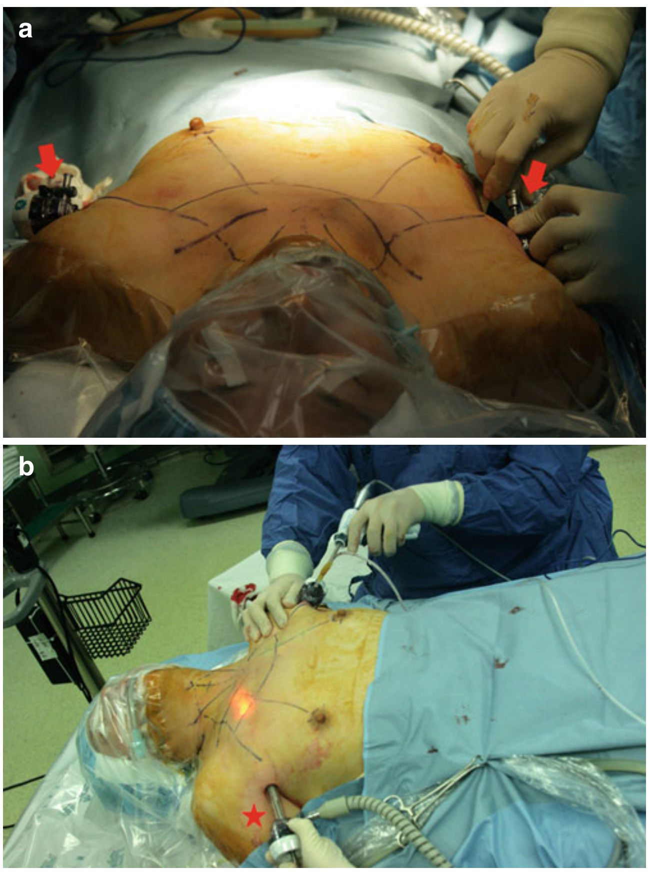


Fig. 3.25 (**a**) Axillary port insertion and (**b**) sharp dissection with Harmonic®. A 12-mm port is made on the right axilla (marked by *star*)

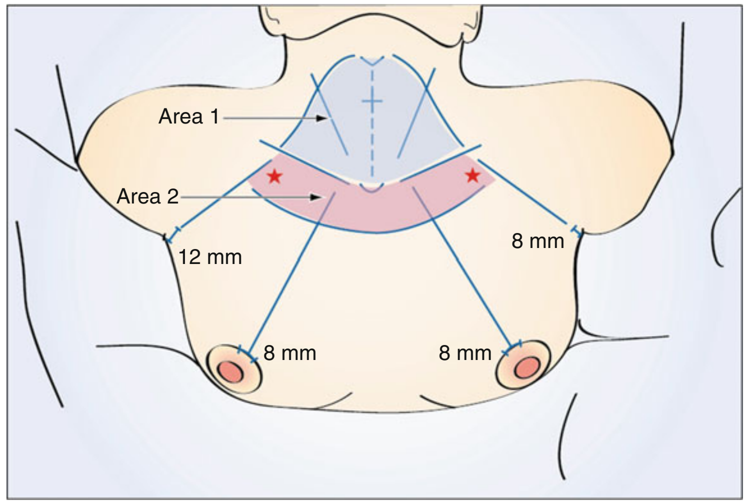


Fig. 3.27 Port (incision) size of BABA endoscopic thyroidectomy. Dissection should start at "area 2" (marked by *red star*) and elongate to "area 1"

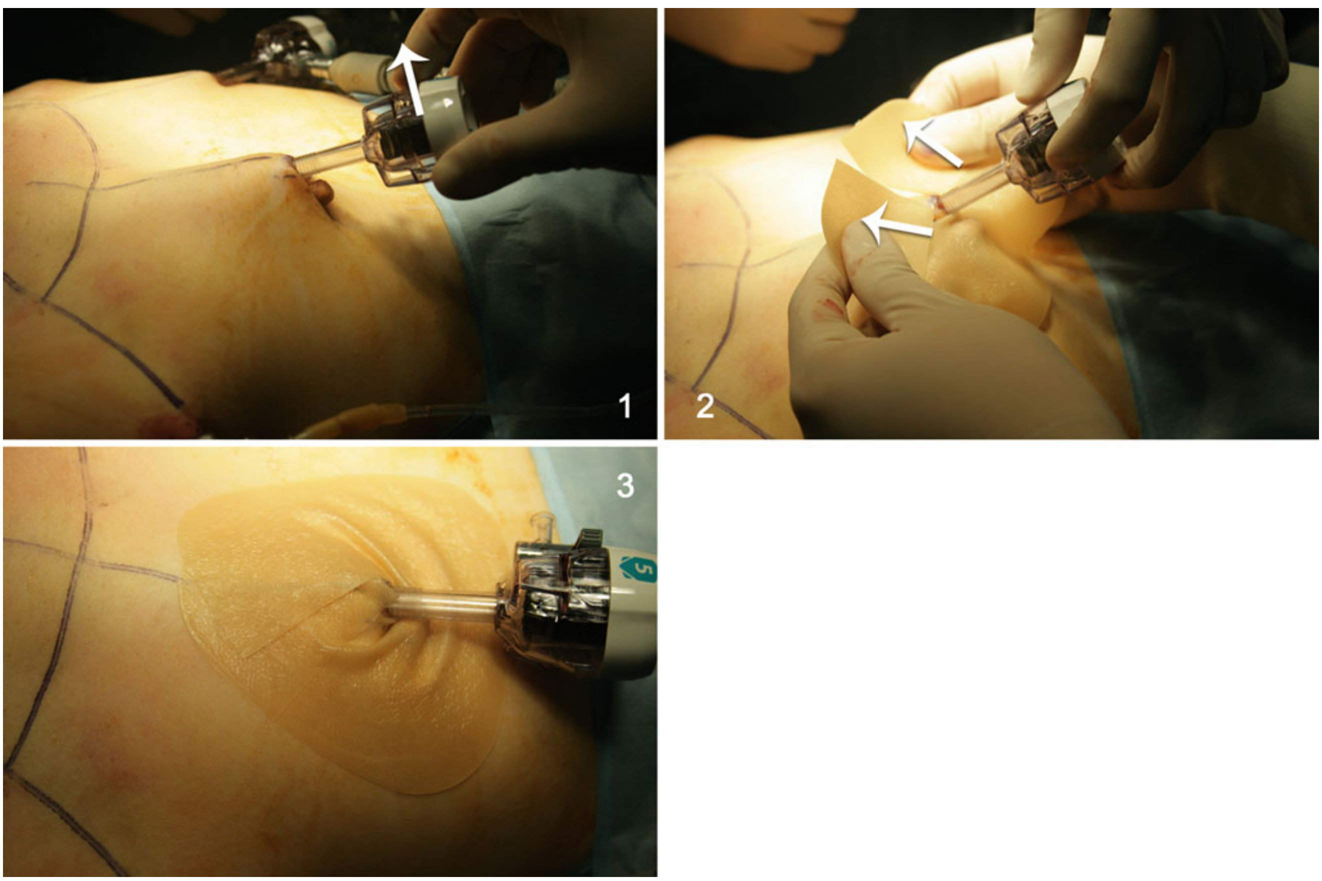


Fig. 3.28 DuoDERM® application to protect the nipple

3.3.10 Midline Incision

To identify the midline, first externally palpate the thyroid cartilage. Make an incision through the cervical fascia in the midline with a hook electrocautery, and extend the incision from the thyroid cartilage to the suprasternal notch to expose the full length of the strap muscle.

When making a dissection of the cephalad portion of the strap muscle, a harmonic scalpel is convenient. After making a midline incision, elevate the sternohyoid and the sternothyroid muscles, and dissect the thyroid capsule away from these muscles with a hook.

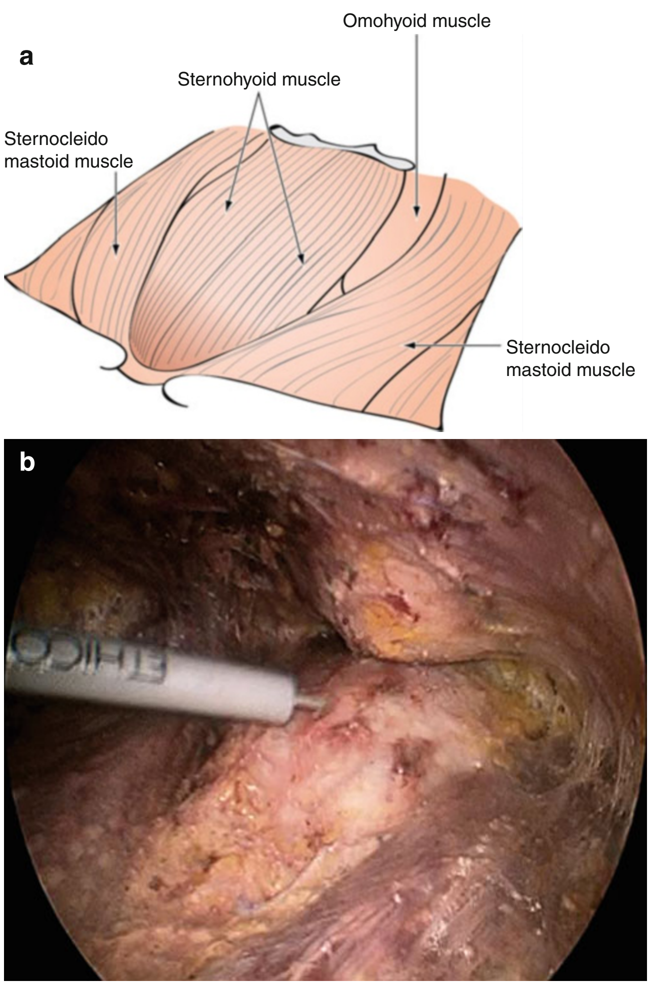


Fig. 3.29 Basic structures of the operative field and identification of the midline by external palpation. (**a**) illustration, (**b**) photo

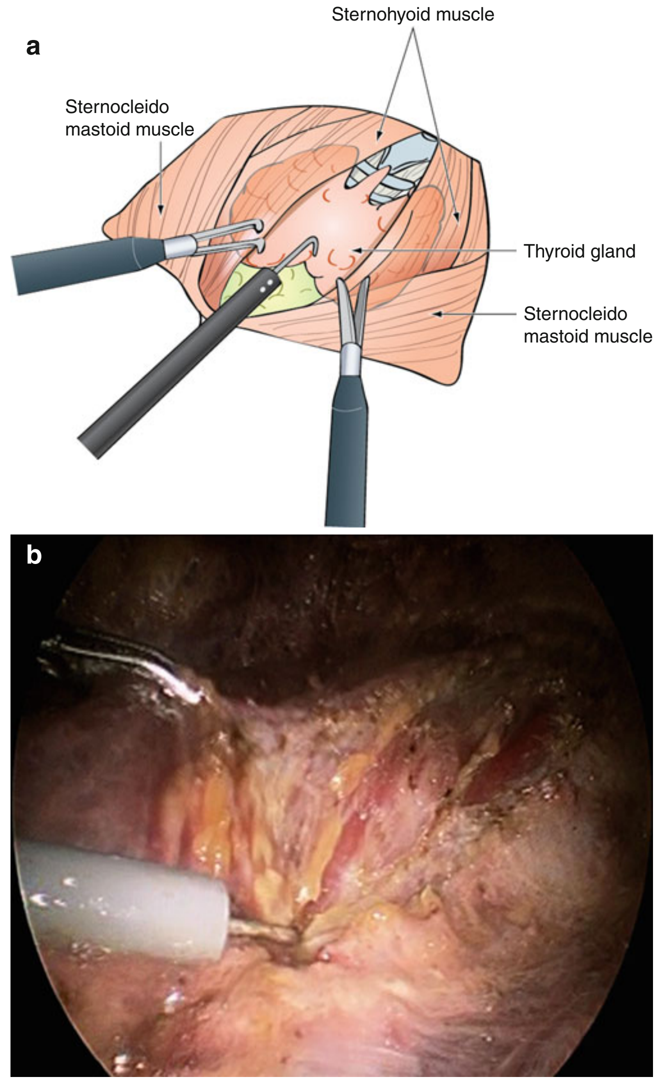


Fig. 3.30 Midline incision. (**a**) illustration, (**b**) photo

3.3.11 Isthmectomy

Using the ultrasonic shears or a hook electrocautery, divide the isthmus in the midline. Prior to isthmectomy, make certain that there are no isthmus lesions on any of the preoperative work-ups such as the ultrasonography.

Due to its close proximity to the trachea – trachea is just underneath the isthmus – isthmectomy should be done with great care.

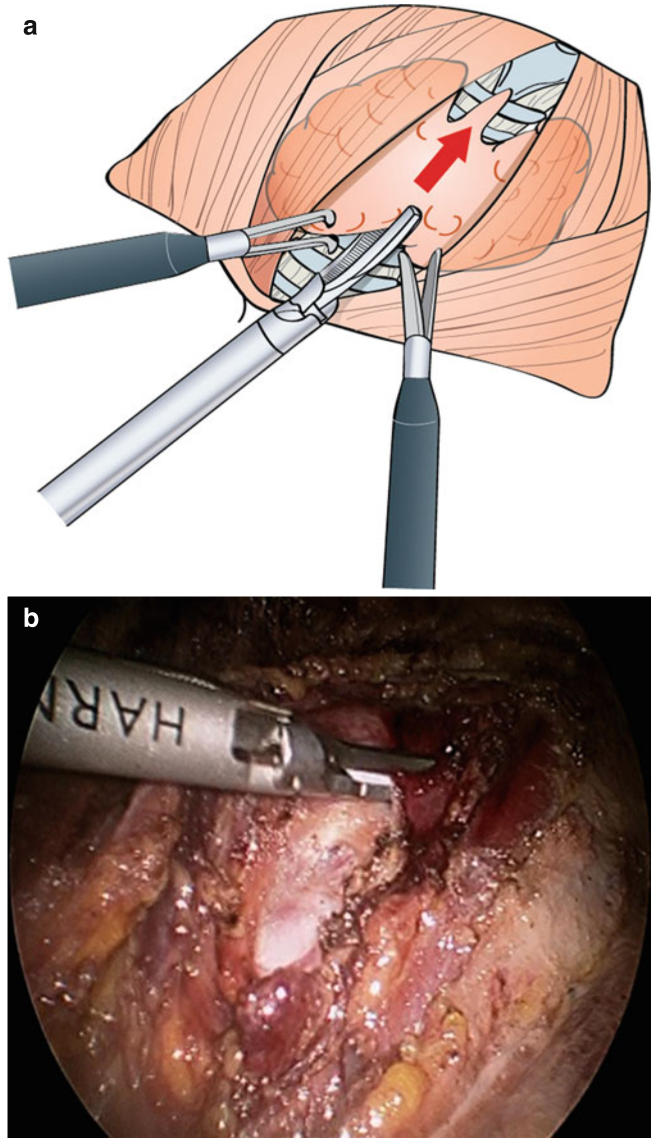


Fig. 3.31 Isthmectomy with Harmonic®. (**a**) illustration, (**b**) photo

3.3.12 Lateral Dissection

Medially retract the thyroid gland with an endograsper. Then, right side of the strap muscles should be retracted laterally with the forceps. It is then dissected down to the deep aspect of the gland to expose the lateral side of the thyroid gland. Continue dissecting away while retracting the strap muscle in the upper-lateral direction using a snake retractor.

Using a hook electrocautery, a layer of thin fibrous tissue is peeled away which will reveal a variable distribution of one or more middle thyroid veins along the anterolateral margin of the thyroid. These veins should be separated with the ultrasonic shears.

With a snake retractor drawing the upper portion of the strap muscles in a cephalad direction, use the ultrasonic shears to dissect the upper pole of the thyroid gland. In order to expose the upper pole of the thyroid gland, the medial and lateral side dissections are made in an alternating fashion (Fig. 3.34. Switching motion).

Before the inferior thyroid artery enters the thyroid glands, it passes directly underneath or above the recurrent laryngeal nerve. Therefore, the inferior thyroid artery can be used as a guide to finding the recurrent laryngeal nerve. If the nerve cannot be exposed immediately, further dissection of the loose fibrous tissue is needed at the inferior point of the artery near the tracheal esophageal groove.

Switching motion consists of four steps:

Step 1: Retract thyroid gland in medial direction with the instrument on right hand.

Step 2: The instrument on left hand passes underneath that on right hand, while the latter retracts the gland more medially.

Step 3: The instrument on left hand retracts the thyroid gland more to the medial part.

Step 4: The instrument on right hand continues with the dissection.

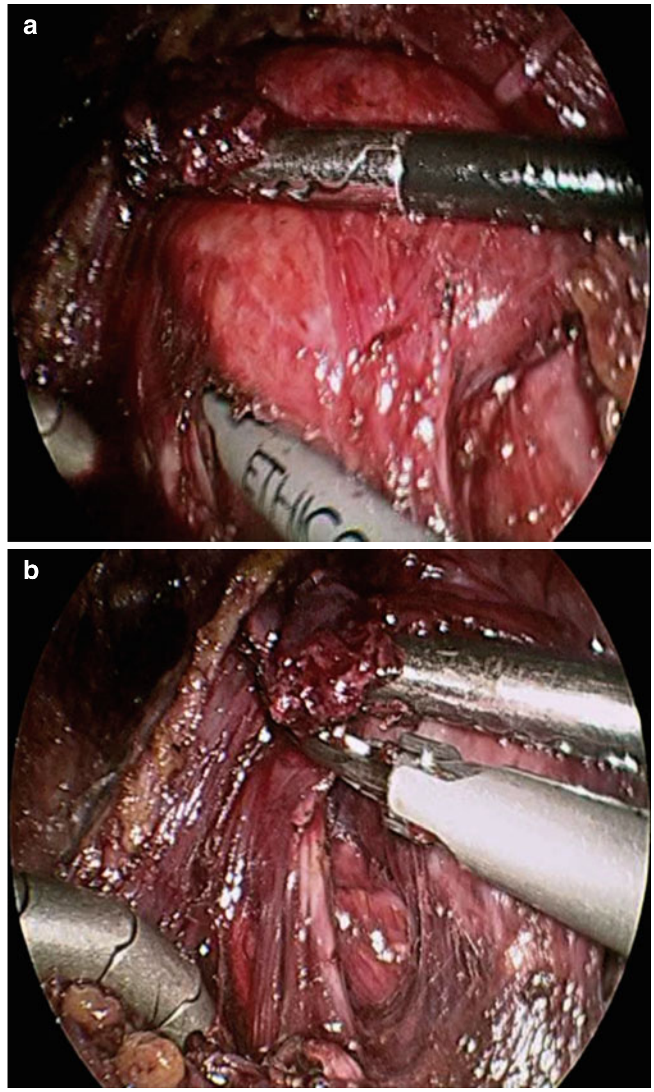


Fig. 3.32 (**a**) and (**b**) Lateral dissection of the thyroid gland

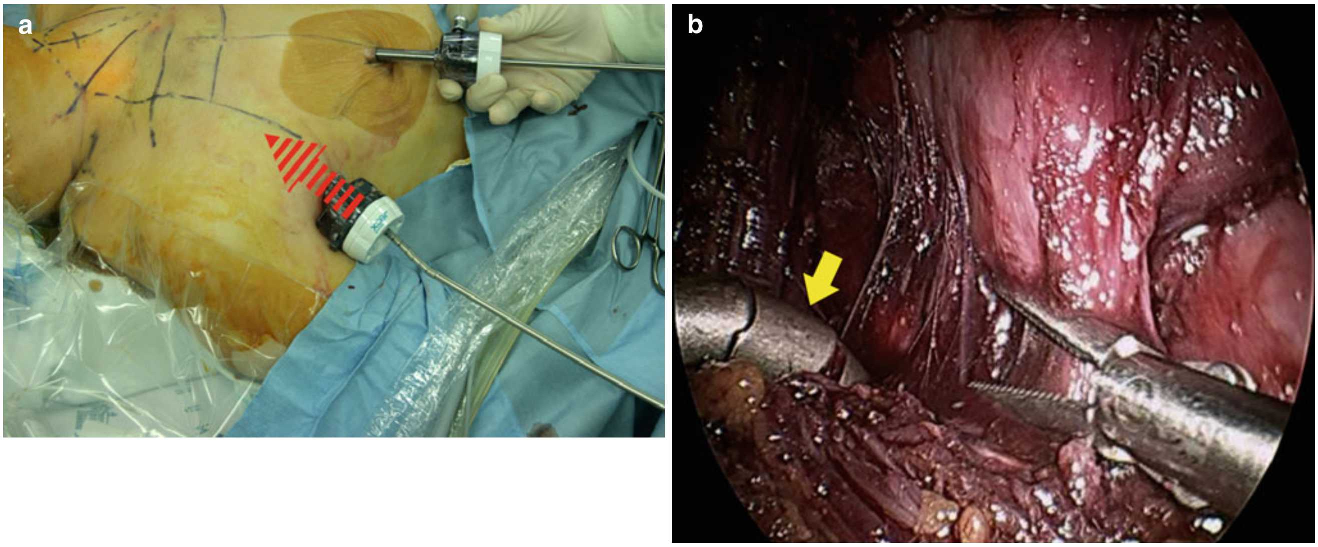


Fig. 3.33 (**a**) Insertion of snake retractor and (**b**) its application (marked by *arrow*)

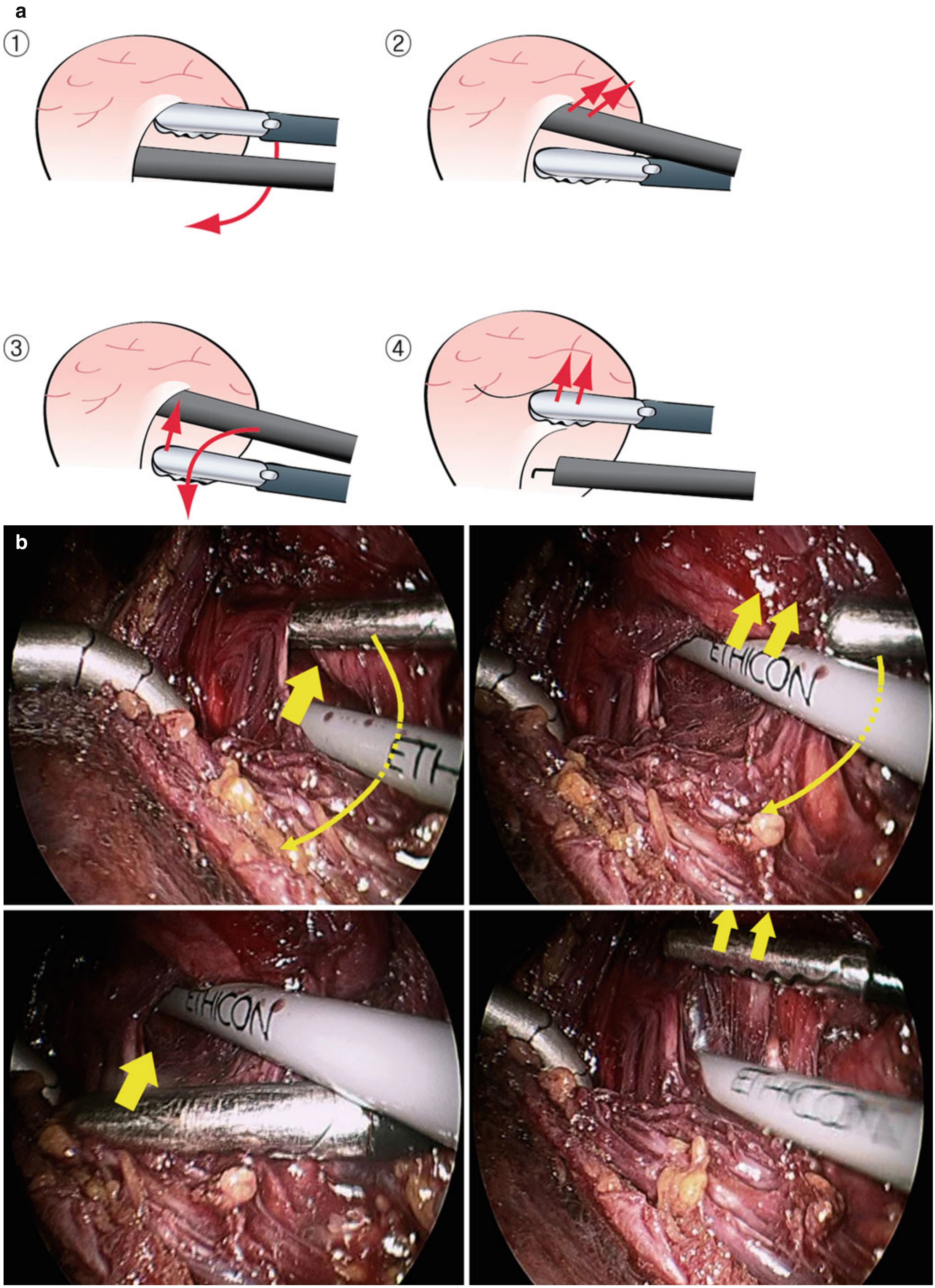


Fig. 3.34 (**a**, **b**) Switching motion in BABA endoscopic thyroidectomy

3.3.13 Preservation of the Inferior Parathyroid Glands

Then identify the inferior parathyroid gland. It is generally located near the branching point of the inferior thyroid artery.

Although it is more difficult to preserve the inferior parathyroid glands than the superior parathyroid glands, it is not impossible if done with surgeon's care.

When preserving the inferior parathyroid glands, avoiding any damage to the feeding vessels in order to maintain the blood supply to the parathyroid is the most critical factor.

If the parathyroid glands could not be saved, reimplantation of the parathyroid gland could be an option. Pectoralis major muscle is often used as a reimplantation site in endoscopic thyroidectomy.

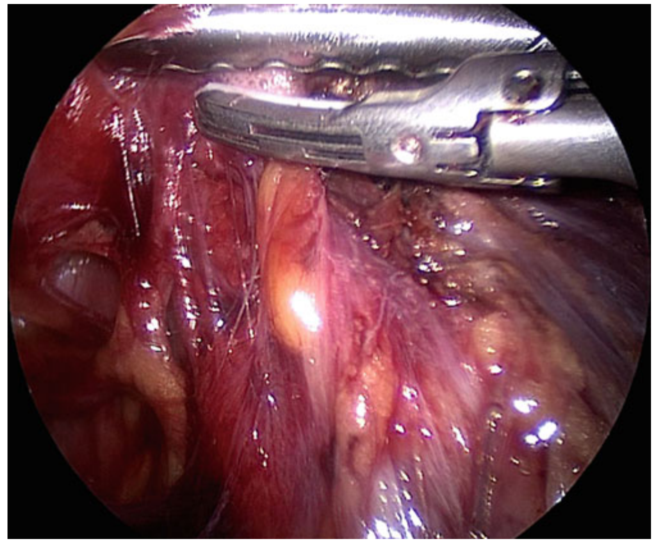


Fig. 3.35 Preservation of the inferior parathyroid gland

3.3.14 Preservation of the Recurrent Laryngeal Nerve

The recurrent laryngeal nerve can easily be found near the entrance of the inferior thyroid artery to the thyroid glands. The tubercle of Zuckerkandl is also the guide to the recurrent laryngeal nerve. Dissection into the post-Zuckerkandl space should be made to preserve the recurrent laryngeal nerve and the superior parathyroid gland.

Once the nerve is identified, delineate the plane just superficial to the nerve with a dissecting tool. Continue following this plane of dissection in a cephalad direction up to the inferior cornu of the thyroid cartilage that is near the nerve entrance point to the larynx. It is important to know that the nerve may divide into two or more branches along its course from the level of the inferior thyroid artery to that of the larynx.

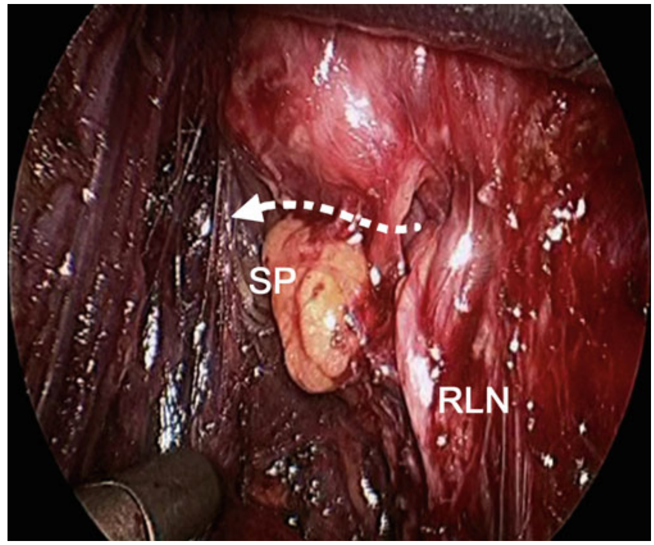


Fig. 3.37 Dissection plain to preserve the recurrent laryngeal nerve and the superior parathyroid gland. *SP* superior parathyroid, *RLN* recurrent laryngeal nerve

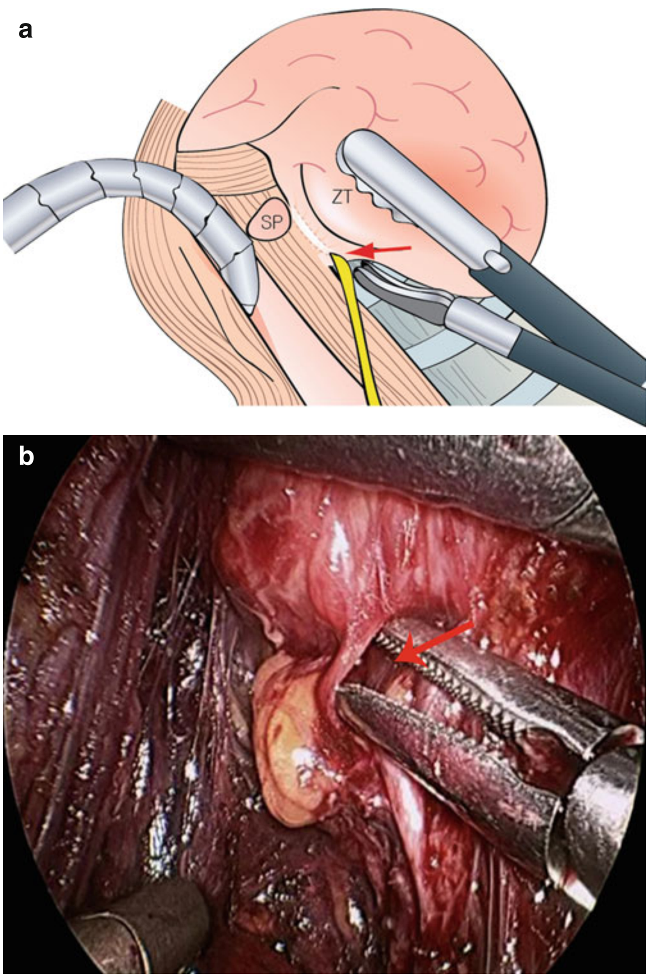


Fig. 3.36 Identification of the recurrent laryngeal nerve. Post-Zuckerkandl space is marked by *arrow*. *ZT* Zuckerkandl tubercle, *SP* superior parathyroid gland. (**a**) illustration, (**b**) photo

3.3.15 Dissection of the Ligament of Berry

The thyroid gland is firmly attached to the two upper tracheal rings by dense fibrous tissue that constitutes the ligament of Berry. The upper portion of the recurrent laryngeal nerve passes near the attachment site of this ligament to the trachea.

This ligament contains a small artery that runs near the recurrent laryngeal nerve. When maneuvering these vessels away from the ligament, extra care is needed in order to avoid nerve injury. When the ligament has been dissected, the thyroid lobes can easily be liberated from the trachea.

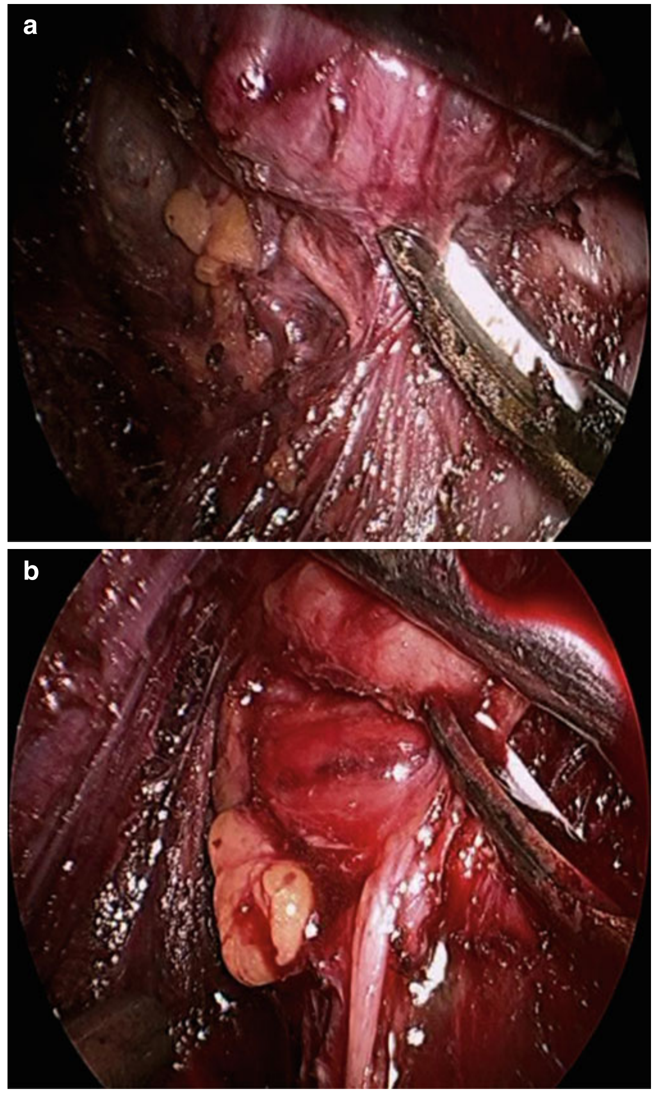


Fig. 3.38 (**a**) and (**b**) Dissection of the ligament of Berry

3.3.16 Dissection of the Thyroid Upper Pole

It is important to preserve the fascia of the cricothyroid muscle, because the external branch of the superior laryngeal nerve is closely associated with the cricothyroid muscle.

One or two small veins may be entering the posterior portion of the upper pole. Identifying and ligating these branches require much attention.

Then identify the terminal branches of the superior thyroidal artery and vein, and carefully separate these vessels with the ultrasonic shears.

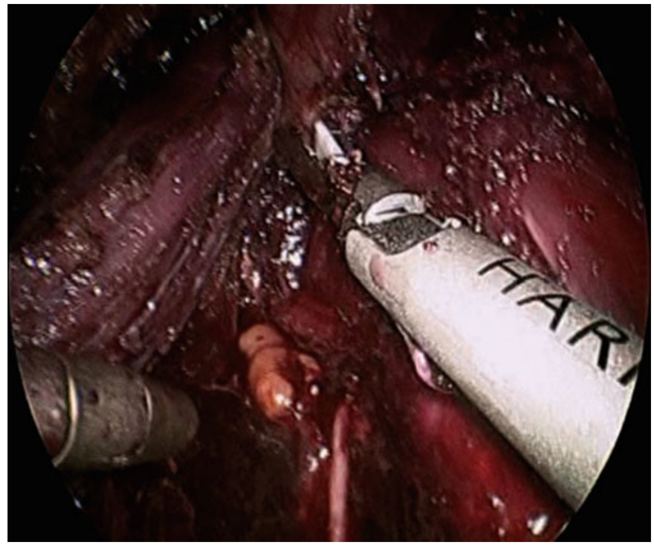


Fig. 3.39 Dissection of the thyroid upper pole

3.3.17 Specimen Removal

After dissecting the thyroid gland away from the trachea, encase the specimen in a plastic bag and remove it via right axillary 12-mm port.

The specimen is inspected with care to find out the parathyroid gland, and the nodules are sent for an intraoperative frozen section to determine the extent of the operation.

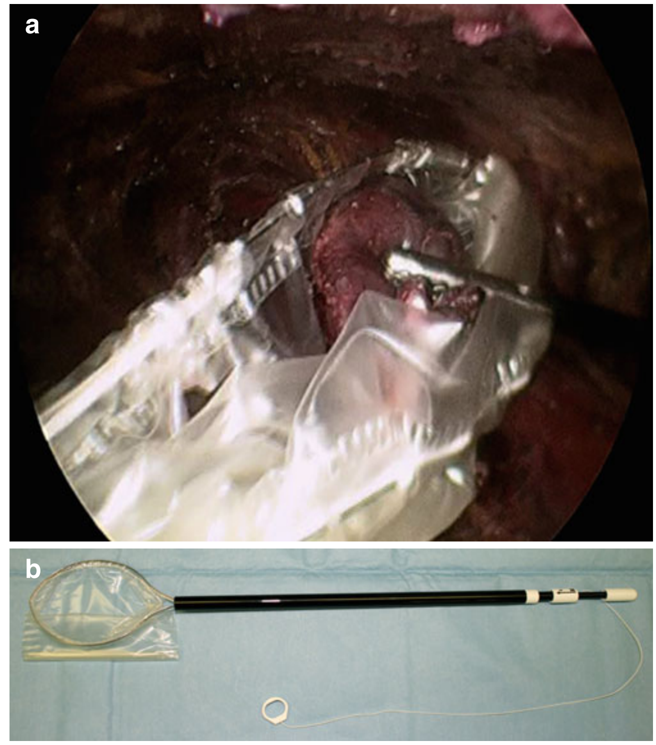


Fig. 3.40 (**a**, **b**) Specimen removal with Endobag

3.3.18 Closure

Irrigate the operative field with saline and obtain complete hemostasis by electrocautery and the ultrasonic shears before the operation is completed. Then the operation field is spread with fibrin glue for hemostasis.

The right and left strap muscles are loosely sutured together with interrupted sutures by means of endo-needle holder and endo-suture.

Then place a Jackson-Pratt (JP) drain into the thyroid pockets through the midline incision, via left axillary ports. The skin of the breasts and axillae is sutured with knot-buried stitching by absorbable sutures.

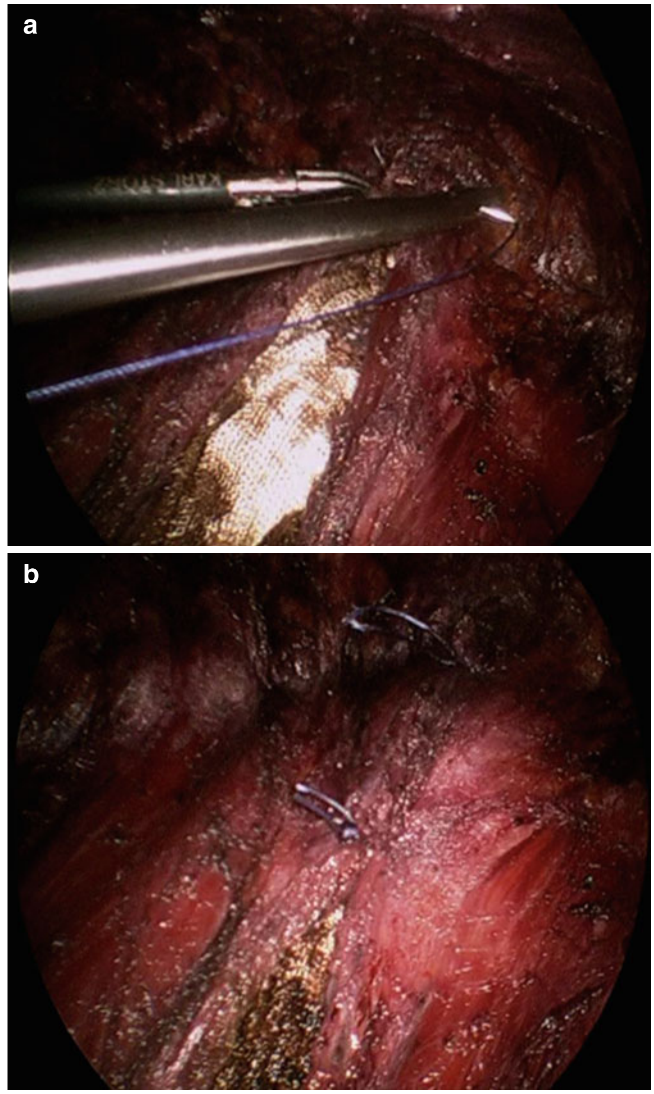


Fig. 3.41 Closure in the midline. (**a**) interrupt suture with endo-needle holder, (**b**) after midline closure

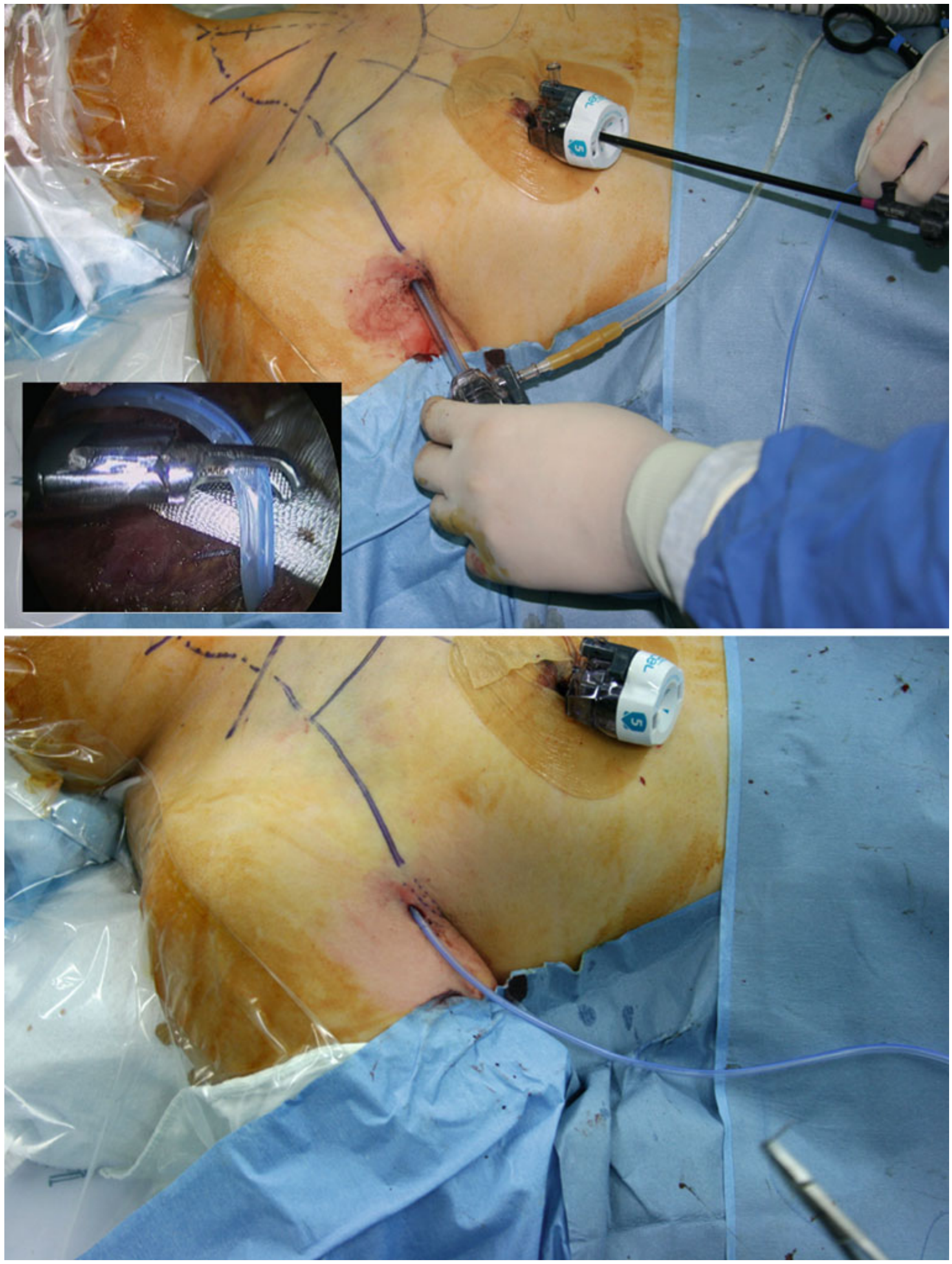


Fig. 3.42 Insertion of the drain through the axillary port

3.3.19 Autotransplantation of the Parathyroid Gland

When a normal parathyroid gland is identified on the excised thyroid specimen, it should be autotransplanted at the end of the operation. It can be autotransplanted in the muscular pockets at any site, and we prefer axillary incision because it is easy to access pectoralis major muscle without making an additional incision.

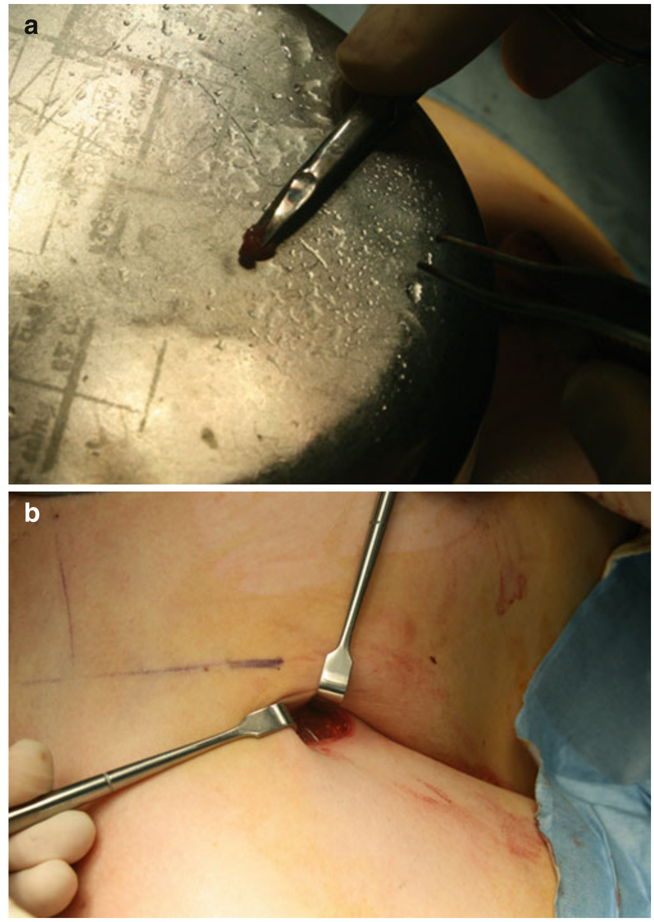


Fig. 3.43 (**a**) Autotransplantation of the parathyroid gland at the pectoralis major muscle through (**b**) the axillary incision

3.3.20 Dressing

Apply Steri-strip® on all of the wounded sites and cover them using appropriate methods. Compress the chest with a Robo-bra®.

Fig. 3.44 Closure of the areolar incision with Steri-strip®

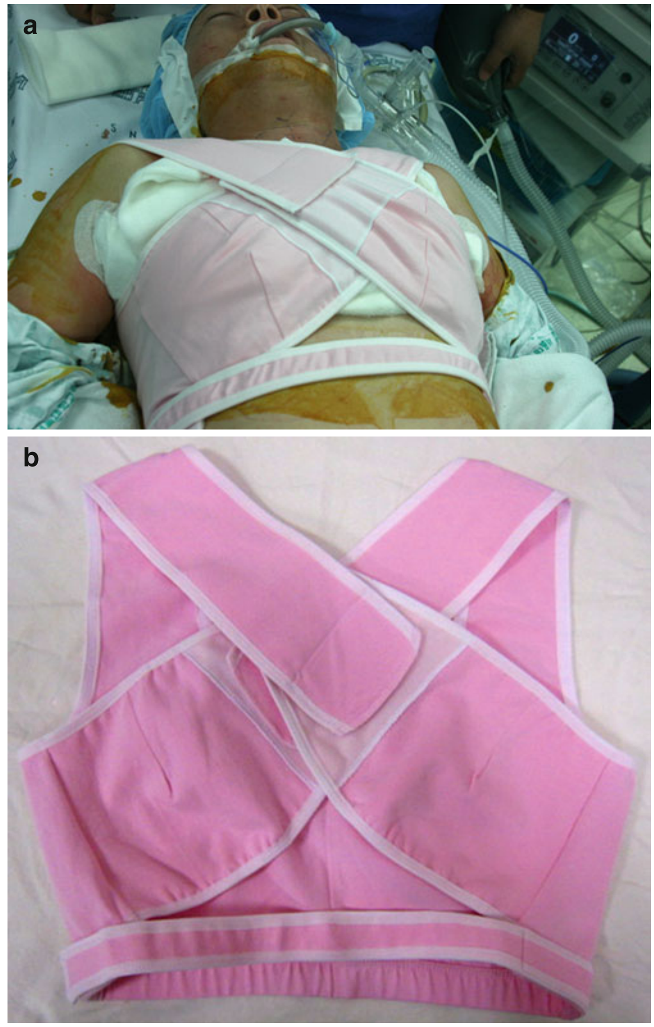


Fig. 3.45 (**a**) Compressive dressing with (**b**) Robo-bra®

3.3.21 Postoperative Wound After 3 Months

After 3 months, there is no visible scar in the neck as well as in the breast and axillae.

Fig. 3.46 Postoperative wound of BABA endoscopic thyroidectomy

3.4 Postoperative Care

3.4.1 Recovery Room

Similar to the open thyroidectomy procedure, patients are sent to the recovery room for 1–2 h where nurses check for signs of respiratory distress due to vocal fold paralysis and bleeding.

3.4.2 O_2 Supply

Patients receive O_2 1–2 days after surgery because surgical brassieres can cause anterior chest compression.

3.4.3 Diet Restriction

There are no restrictions on diet in most patients, except in cases of vocal fold paralysis or bleeding.

3.4.4 Ambulation

After surgery, patients are encouraged to be mobile.

3.4.5 Analgesics

Acetaminophen or an NSAID is administered to patients with neck and anterior chest pain as needed. Patient-controlled analgesics (PCA) can be administered although they are generally not used.

3.4.6 Thyroid Hormone Replacement

Patients who underwent total thyroidectomy or near-total thyroidectomy require thyroid hormone replacement.

3.4.7 Wound Care

Wound care using aseptic techniques is performed 1–2 days after surgery. Before discharge, the wound is drained and dressing is changed. Patients can shower 2–4 days after discharge.

3.4.8 Postoperative Follow-Up

A postoperative follow-up visit is conducted at 10–14 days after discharge at which time pathologic results and plans for additional treatment are discussed.

3.5 Postoperative Complications and Their Treatment

3.5.1 Bleeding and Hematoma

Bleeding from the surgical site and subcutaneous flaps occurs in 1–2 % of endoscopic thyroidectomy cases. The most dangerous type of bleeding is from the superior thyroidal arteries. Arteries that are bigger than 2 mm should be ligated with suture or other ligating materials. Bleeding from the surgical site requires reoperation, while bleeding from subcutaneous flaps can be monitored; however, it is difficult to distinguish between bleeding from these two sites so that formation of a hematoma should be evaluated by reoperation. In our experience, postoperative bleeding is not an indication of open surgery. Instead, bleeding can be controlled endoscopically.

To assess for possible bleeding after thyroidectomy, an anesthesiologist hyperinflates the patient's lungs to increase intrathoracic and blood pressure in the neck veins while the patient is in the Trendelenburg position. After thyroidectomy, the patient is kept in a semi-Fowler position with head elevated 10–20° which minimizes pressure in the neck veins.

3.5.2 Wound Infection

Infections are not common after thyroid surgery. In our institute, less than 1 % of patients suffer from wound infection, with most cases associating with seroma of the postoperative bed. Seroma is treated by aspiration at either the ward or outpatient clinic; however, aspiration can result in infection. Antibiotics are used to treat infections. Surgery is used to treat severe infections with abscesses.

3.5.3 Hoarseness

Intraoperative injury of the recurrent laryngeal nerve is the main cause of postoperative hoarseness, and effects range from minimal changes in voice to severe dyspnea due to bilateral injury of the laryngeal nerve. Nerve injury can be caused by transection, thermal injury from electrocautery, or traction injury. The injured recurrent laryngeal nerve can be preserved by visualizing its extralaryngeal trajectory or applying intraoperative electrical nerve stimulation after nerve visualization. Because of the variability of the anatomy of the recurrent laryngeal nerve, the skillfulness and carefulness of the surgeon can never be overemphasized.

Laryngeal edema or vocal fold inflammation due to prolonged intubation or intubation injury also causes hoarseness. Pre- and postoperative indirect laryngoscopy is useful to distinguish these conditions from nerve injury.

3.5.4 Hypocalcemic Symptoms

Because of the proximity of the parathyroid glands to the thyroid gland, the former glands can be easily injured during thyroidectomy. Ischemia or removal of the parathyroid glands results in temporary or permanent hypoparathyroidism. Based on reports in the literature, permanent hypoparathyroidism occurred in less than 3 % of patients, whereas transient postoperative hypocalcemia occurred in approximately 40 % of patients. To visualize the vascularization of the gland, magnifying glasses (i.e., loupe) are used. When the parathyroid gland cannot be safely dissected from the thyroid gland, it is removed and then reimplanted into sternocleidomastoid (SCM) or brachioradial muscles.

After total or near-total thyroidectomy, the levels of serum calcium, phosphorus, and parathyroid hormone (PTH) are checked. Hypocalcemia is treated with calcium and vitamin D supplements.

3.5.5 Headache and Neck Stiffness

Headache and neck stiffness can be caused by prolonged overextension of the neck during surgery or by poor positioning of the neck and shoulders during surgery. Another mechanism is that the patient shrank back their neck and shoulders in the postoperative period because of stress and nervousness. Postoperative headache and neck stiffness can also be caused by hypocalcemia.

3.5.6 Skin Burn and Perforation

Skin burn and perforation can occur due to carelessness on the part of the surgeon. Dissection with Harmonic® shears is dangerous, and its operation requires considerable expertise. Subcutaneous flap burns often lead to skin perforation because of poor blood supply within this tissue. Demarcated burn areas are re-approximated 2–3 weeks thereafter.

3.5.7 Pneumothorax

Pneumothorax in endoscopic surgery is mainly due to the saline injection in the supraclavicular area. Because the apex of the lung laid superficially in that area. A surgeon should avoid saline injection in this area; however, when pneumothorax occurs, supportive care with serial chest X-ray follow-up is enough to treat the patient. Chest tube insertion is rarely needed in most cases.

3.5.8 Esophageal and Tracheal Perforations

Injury to the esophagus and trachea can occur, especially during early endoscopic thyroidectomy. When this occurs, open thyroidectomy should be performed. A perforation of the esophagus requires full thickness repair, whereas perforation of the trachea requires airproof repair.

3.6 Review of 512 Cases of BABA Endoscopic Thyroidectomy

3.6.1 Patients and Methods

Between February 2004 and March 2008, 512 patients (506 females and 6 males) with thyroid disease underwent endoscopic thyroidectomy via the bilateral axillo-breast approach (BABA) at the Seoul National University Hospital. The mean age of patients was 37.8 ± 8.5 (range, 17–56) years.

3.6.2 Patient Characteristics

Patient demographics are listed in Table 3.1. Preoperative fine needle aspiration cytology results indicated the following diagnoses: malignancy with suspicion of papillary thyroid carcinoma ($n=341$), benign nodules ($n=61$), and indeterminate nodules ($n=93$). Eight patients were diagnosed with Graves' disease, and nine patients underwent endoscopic surgery followed by completion thyroidectomy when the diagnosis was follicular thyroid carcinoma. The mean tumor size was 0.72 ± 0.36 (range, 0.2–2.8), 1.66 ± 1.21 (range, 0.3–5.0), and 3.09 ± 1.49 (range, 0.6–7.0) cm in diameter in patients with papillary thyroid carcinoma, indeterminate nodules, and benign nodules, respectively.

Operation types and operating times are listed in Tables 3.2 and 3.3. Patients with malignant thyroid carcinoma underwent prophylactic ipsilateral central neck lymph node dissection. Selective lateral neck dissection was performed in some cases where metastases were suspected in one or two lateral neck lymph nodes by imaging.

Postoperative pathology reports indicated the following diagnoses: papillary thyroid carcinoma ($n=375$), follicular thyroid carcinoma ($n=22$), and benign disease ($n=106$). Of the eight patients with Graves' disease, one patient had papillary thyroid carcinoma, while the remaining patients had no tumors. Of the nine patients who underwent completion thyroidectomy, there were no tumors in the thyroid. Of the 93 patients with indeterminate nodules, 33 patients were diagnosed with papillary thyroid carcinoma, 22 were diagnosed with follicular thyroid carcinoma, 11 were diagnosed with follicular adenoma, and 27 were diagnosed with nodular hyperplasia.

Table 3.1 Demographics of 512 patients who underwent BABA endoscopic thyroidectomy

Clinicopathologic characteristics	Value
Age (years)	37.8 ± 8.5 (range, 17–56)
Gender ratio (male to female)	1: 84.3 (6:506)
Mean tumor size on preoperative ultrasound (cm)	
Malignancy or suspicious malignancy	0.72 ± 0.36 (range, 0.20–2.80)
Indeterminate nodules	1.66 ± 1.21 (range, 0.30–5.00)
Suspected benign nodules	3.09 ± 1.49 (range, 0.60–7.00)
Pathologic classification	
Malignancy	397
Papillary thyroid carcinoma	375
Follicular thyroid carcinoma	22
Benign	106
Adenomatous hyperplasia	88
Follicular adenoma	11
Graves' disease	7[a]
Mean lymph node retrieval count	
Central compartment	2.86 ± 2.28 (range, 1–15)
Lateral compartment	4.43 ± 3.58 (range, 1–14)
Stage I	392
Stage II	1
Stage III	3
Stage IVa	1
Postoperative hospital stay (d)	3.34 ± 0.8 (range, 3–7)
Mean follow-up period (months)	57.1 ± 17.6 (range, 38.5–71.7)

[a]A final pathology report showed one patient with Graves' disease to develop papillary thyroid carcinoma

Table 3.2 Classification of 512 patients who underwent endoscopic BABA thyroidectomy

Operation type	*n* (%)
Total thyroidectomy only	217 (42.4 %)
Total thyroidectomy with CND	82 (16 %)
Total thyroidectomy with CND and LND	24 (4.7 %)
Near-total thyroidectomy	19 (3.7 %)
Subtotal thyroidectomy	51 (10 %)
Lobectomy	110 (21.5 %)
Completion thyroidectomy	9 (1.8 %)

CND central node dissection, *LND* lateral node dissection

3.6.3 Postoperative Complications

Conversion from endoscopic to open thyroidectomy due to uncontrolled bleeding from the surgical site occurred in three patients. Otherwise, bleeding was controlled with small incisions less than 2 cm in diameter. Postoperative complications included transient hypocalcemia and permanent hypoparathyroidism in 31.1 and 4.2 % of patients, respectively. Temporary hoarseness and permanent vocal cord palsy occurred in 20.3 and 1.7 % of patients, respectively. Bleeding occurred immediately after surgery in two cases and was controlled endoscopically (Table 3.4).

Table 3.3 Operating time according to different operation types

Operation type	Operating time (min)
Total thyroidectomy or near-total thyroidectomy	151.2 ± 38.1 (range, 75–285)
Total thyroidectomy with CND	153.3 ± 37.2 (range, 70–285)
Total thyroidectomy with CND and LND	168.1 ± 36.8 (range, 85–220)
Subtotal thyroidectomy or lobectomy	141.7 ± 50.1 (range, 84–360)
Overall	152.5 ± 39.9 (range, 70–360)

Table 3.4 Incidence of postoperative complications

	Number (%)
Transient hypocalcemia	125/402[a] (31.1 %)
Permanent hypocalcemia	17/402[a] (4.2 %)
Transient RLN palsy	104/512 (20.3 %)
Permanent RLN palsy	9/512 (1.7 %)
Postoperative bleeding	
Immediate	2/512 (0.4 %)
Delayed	1/512 (0.2 %)
Tracheal injury	4/512 (0.8 %)
Esophageal perforation	1/512 (0.2 %)
Wound infection	8/512 (1.6 %)
Horner's syndrome	4/512 (0.8 %)
Intraoperative cervical flap perforation	1/512 (0.2 %)
Pneumothorax	2/512 (0.4 %)
Skin burn	1/512 (0.2 %)

RLN recurrent laryngeal nerve

[a]Number of patients who underwent total, near-total, or subtotal thyroidectomy

3.6.4 Follow-Up and Recurrence Data

The mean postoperative follow-up period was 57.1 ± 17.6 (range, 38.5–71.7) months. Ultrasound and thyroglobulin (Tg) assays were also performed on patients with thyroid malignancy during the postoperative follow-up period. Eight patients (2 %) with recurrent papillary thyroid carcinoma underwent another operation using conventional open methods (Table 3.5).

Table 3.5 Cases of recurrent carcinoma

Name	Sex	Age	Tumor location, size (cm), and pathology	Type of operation	TNM stage during first operation	Site of recurrence and size (cm)	Duration of recurrence (months)	Follow-up modality	Treatment
Paik, H	F	28	Right, 1.2 cm, PTC	Total thyroidectomy, right CND	T3N1aM0 (stage I)	Central neck (right level VI), 0.6 cm	17	Ultrasound, Tg, FNA	Excision (open)
Kim, S	F	46	Left, 0.5 cm, PTC	Total thyroidectomy, left CND	T3N0M0 (stage II)	Central neck (left level VI), 0.7 cm	68	Ultrasound, Tg, FNA	Excision (open)
Lee, J	F	44	Left, 0.7 cm, PTC	Total thyroidectomy, left CND	T1aN0M0 (stage I)	Left level IV, 1.1 cm; right level IV, 1.4 cm	49	Ultrasound, Tg, FDG-PET, FNA	MRND, left level II, III, IV, and right level IV (open)
Kim, S	F	26	Left, 3.0 cm, MIFTC	Left lobectomy	T2NxM0 (stage I)	Right thyroid gland, 0.8 cm	46	Ultrasound, Tg, FNA	Right completion lobectomy (endoscopy)
Kim, J	F	33	Right, 1.0 cm, FTC	Total thyroidectomy	T1aNxM0 (stage I)	Mediastinum	20	Ultrasound, Tg, I-131 scan	Radioactive iodine
Hong, S	F	45	Left, 1.1 cm, PTC	Total thyroidectomy, left CND	T1bN1aM0 (stage III)	Central neck (left level VI), 1.1 cm	32	Ultrasound, Tg, I-131 scan, FNA	MRNT, left level II, III, IV, VI (open)
Kim, H	F	45	Right, 1.2 cm; left, 0.3 cm, PTC	Total thyroidectomy, bilateral CND	T3N1aM0 (stage III)	Central neck (left level VI), 0.4 cm	48	Ultrasound, Tg, FNA	Waiting for surgery (open)
Son, J	F	52	Right, 1.0 cm; left, 0.7 cm, PTC	Total thyroidectomy, bilateral CND	T3N1aM0 (stage III)	Central neck (left level VI), 0.6 cm	34	Ultrasound, Tg, FDG-PET, FNA	Excision (open)

PTC papillary thyroid carcinoma, *MIFTC* minimally invasive follicular thyroid carcinoma, *CND* central neck dissection, *MRND* modified radical neck dissection, *Tg* thyroglobulin, *FNA* fine needle aspiration, *PET* positron emission tomography

Conclusion

Endoscopic thyroidectomy with BABA is a safe and effective method to manage both benign and low-risk malignant thyroid diseases, yielding good operative results with minimal scarring and adverse effects.

4 Robotic Thyroidectomy: Bilateral Axillo-Breast Approach (BABA)

4.1 Basic Equipment and Instruments of Robotic Thyroidectomy

4.1.1 The Operation Theater

The operating theater for robotic thyroidectomy is similar to those of open and endoscopic thyroidectomy. However, the robot system requires more space than that of endoscopic thyroidectomy; the room is usually larger than the ordinary operating theater.

The room is also a clean and sterile space to perform the operation in aseptic manners.

The online version of this chapter (doi:10.1007/978-3-642-37262-9_4) contains supplementary material, which is available to authorized users.

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4.1.2 da Vinci Si HD Surgical System (Intuitive, Sunnyvale, CA)

Fig. 4.1 The da Vinci system. (**a**) Robot system, (**b**) console, (**c**) da Vinci system before use

4.1.3 Instruments

4.1.3.1 Endoscope

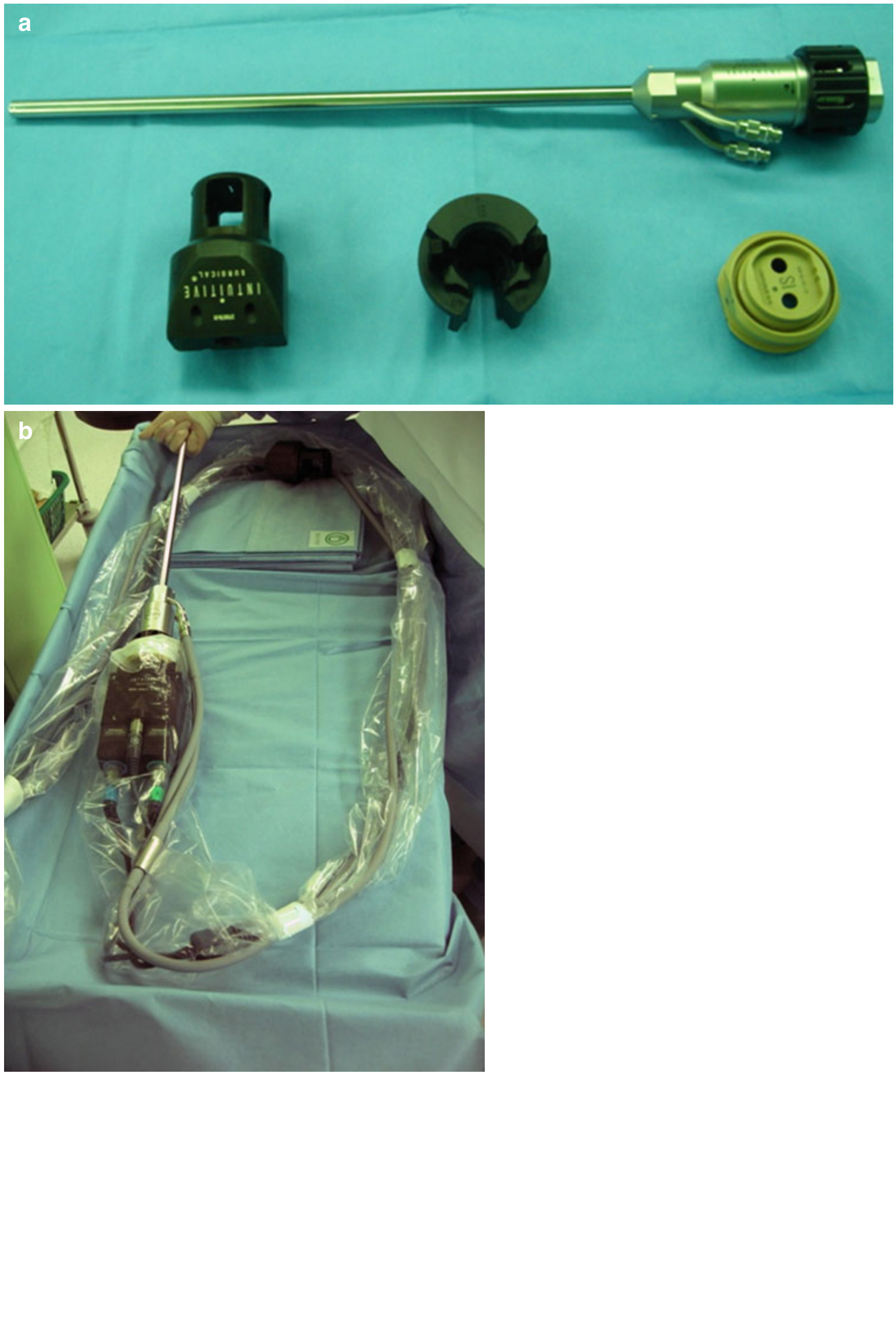


Fig. 4.2 (**a**) **Φ**10–mm, 30° endoscope, (**b**) endoscope before use

4.1.3.2 Thyroid Pillow (Emtas, Korea)

4.1.3.3 EndoWrist Instruments

1 Maryland bipolar forceps, Φ8 mm
1 Prograsp™ forceps, Φ8 mm
1 cautery hook, Φ8 mm
1 large needle driver, Φ8 mm
1 Harmonic®, Φ8 mm

Fig. 4.3 Thyroid pillow

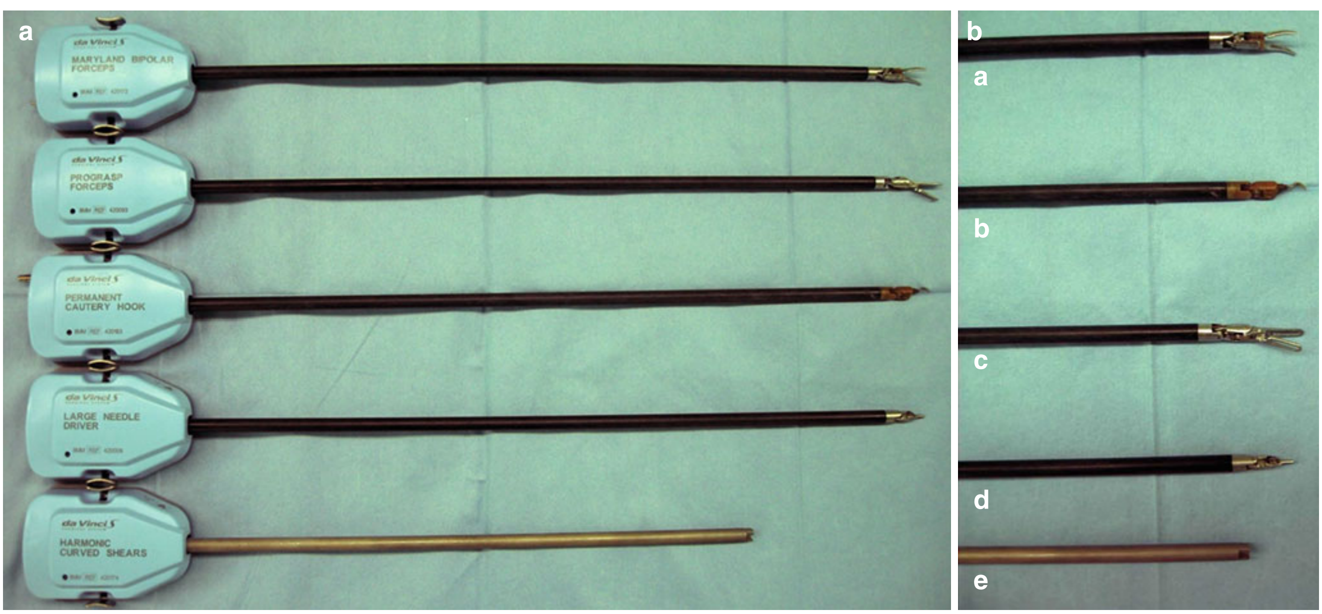


Fig. 4.4 EndoWrist instruments. (**a**) Maryland bipolar forceps, (**b**) Prograsp™ forceps, (**c**) cautery hook, (**d**) large needle driver, (**e**) Harmonic®

4.1.3.4 Harmonic® (Ethicon Endo-surgery, Cincinnati, Ohio, USA)

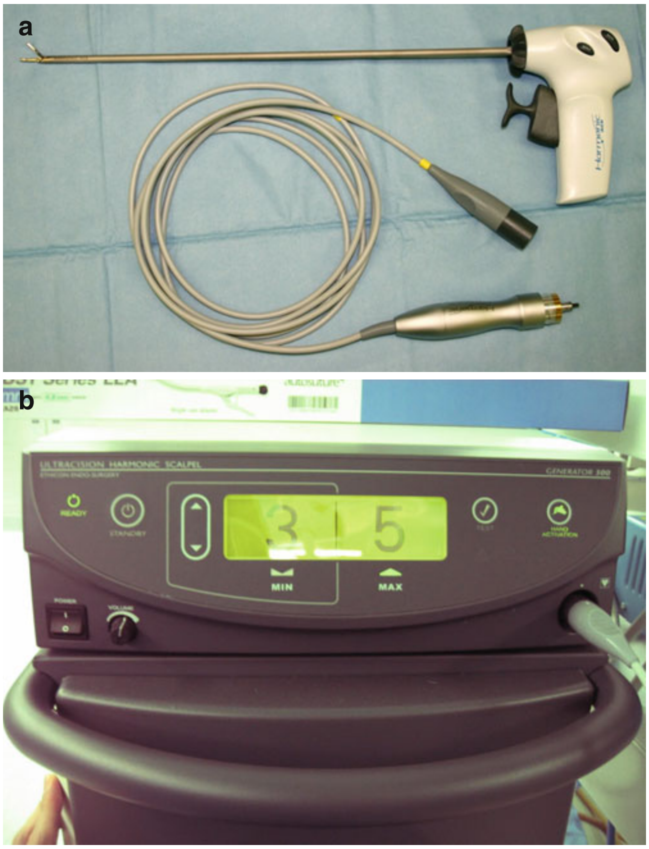


Fig. 4.5 Harmonic®. (**a**) hand piece, (**b**) generator

4.1.3.5 Vascular Tunneler (Gore-Tex)

Fig. 4.6 Vascular tunneler

4.1.3.6 Trocars

3 trocars, Φ8 mm
1 obturator
1 trocar, Φ12 mm

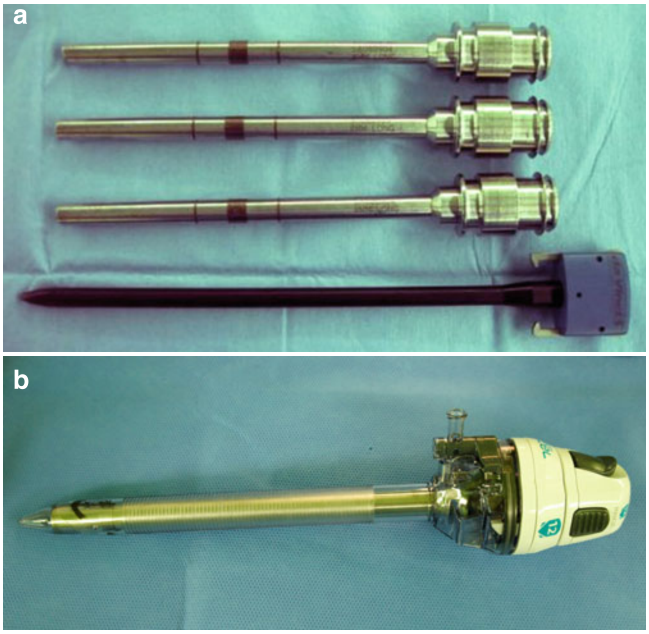


Fig. 4.7 Trocars. (**a**) Φ8-mm trocars and obturator, (**b**) Φ12-mm trocar

4.1.3.7 Endobag, 10 mm

Fig. 4.8 Endobag. (**a**) closed, (**b**) open

4.1.3.8 Suction-Irrigator for Robotic Surgery

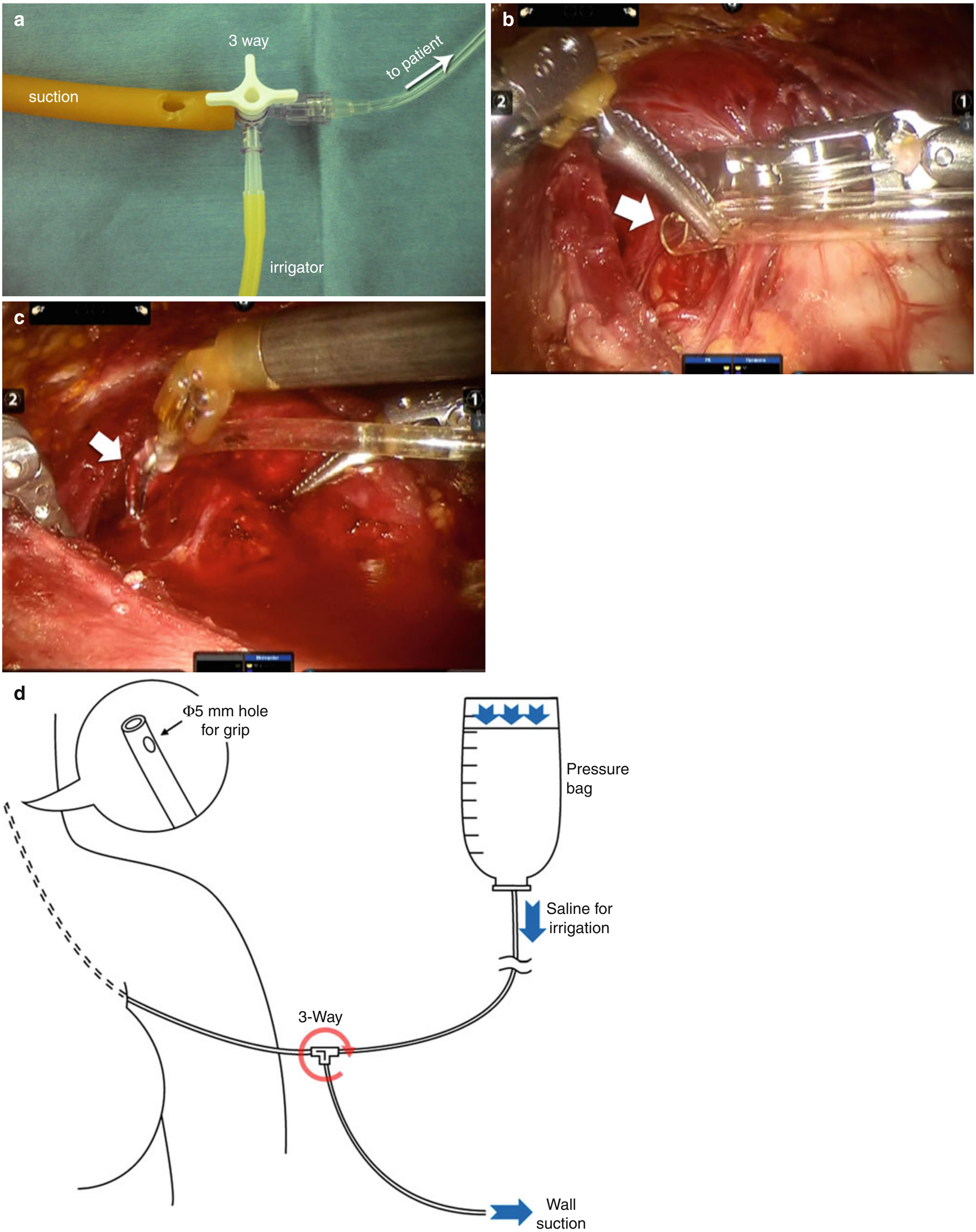


Fig. 4.9 Suction-irrigator. (**a**) Each part of suction-irrigator, (**b**) suction, (**c**) irrigation, (**d**) concept of suction-irrigator

4.1.3.9 Other Instruments

1 Thermos
1 CO_2 line
1 alignment target
2 camera arm sterile adapter
1 camera sterile adapter

Fig. 4.10 Other instruments

4.2 Advantages and Disadvantages of Robotic Surgery

Unlike endoscopic instruments which are rigid and provide finite degrees of movement so that central and lateral node dissection poses a challenge, robotic system has advantages as follows: (1) the high-definition and three-dimensional magnified vision that can allow to identify the major structure and to operate easier and (2) the EndoWrist function of the instruments that can overcome limited access of confined operative field. With these reasons, robotic system is intuitive and easy to handle, and thus the learning curve is relatively short even in the beginner group.

However, there are some disadvantages of robotic surgery as follows: (1) lack of tactile sensation which can cause severe harm to the patient, (2) unawareness of severe complications since the operator is far from the patient, (3) impossibility of immediate reaction against unexpected events, and (4) very high cost even in developed countries. For the first disadvantage of lack of tactile sensation, robotic arms should not be moved out of surgeon's view.

4.3 Patient Selection: Indications and Contraindications

Indications for robotic thyroidectomy are as follows: (1) cytologic diagnosed well-differentiated thyroid carcinoma such as papillary thyroid carcinoma and follicular thyroid carcinoma (the size of the cancer less than 2–3 cm is recommended), (2) the patient with Graves' disease, (3) male patient with thyroid nodules that are needed to be excised, and (4) large size of the thyroid nodule more than 5 cm.

Absolute contraindications for robotic thyroidectomy are the patient with previous open neck surgery, thyroid malignancy which expected to be recurred easily (i.e., medullary thyroid cancer, advanced papillary thyroid cancer, and poorly differentiated thyroid cancer), with deep-lying carcinoma which is very close to the recurrent laryngeal nerve(Fig.4.11), and with overt breast malignancy.

Relatively not recommended patients for robotic thyroidectomy are with large size thyroid nodules over 8 cm in diameter, with thyroid malignancy with suspicious for lateral neck lymph node metastases and goiter with substernal portion. Previous breast operation due to breast carcinoma or breast augmentation is not to be considered as contraindication, and we experienced scores of patients with breast augmentation. Moreover, with BABA robotic thyroidectomy, lateral neck dissection can be effectively performed and patients suspicious for lateral neck metastases are not considered as relative contraindication recently.

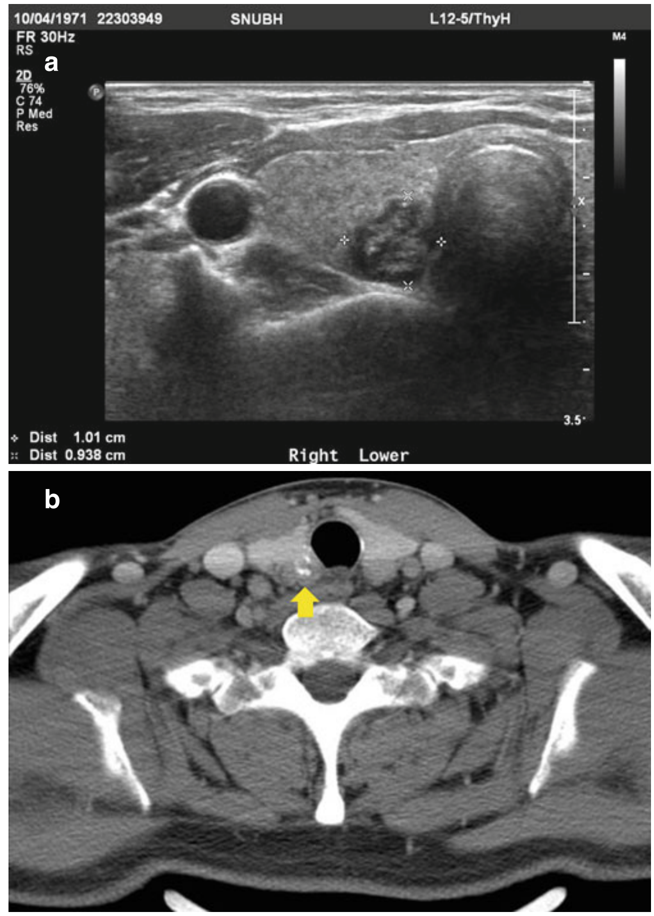


Fig. 4.11 (**a**) USG of deep-lying carcinoma, (**b**) CT scan of deep-lying carcinoma

4.4 Procedures of Bilateral Axillo-Breast Approach (BABA) Robotic Thyroidectomy

4.4.1 Positioning

The patient should be placed in the supine position on the operating table with the arms tucked close to the side.

A folded sheet or a pillow (Q-pillow) is placed vertically under the patient's shoulders to extend the head and neck.

This neck extension should be performed with great caution and with the assistance of the anesthesiologists to ensure endotracheal tube is secured and avoid overextending the neck.

The patient's head may be covered with a mesh cap to avoid contamination of the field. An adhesive tape may be applied to cover up both ears.

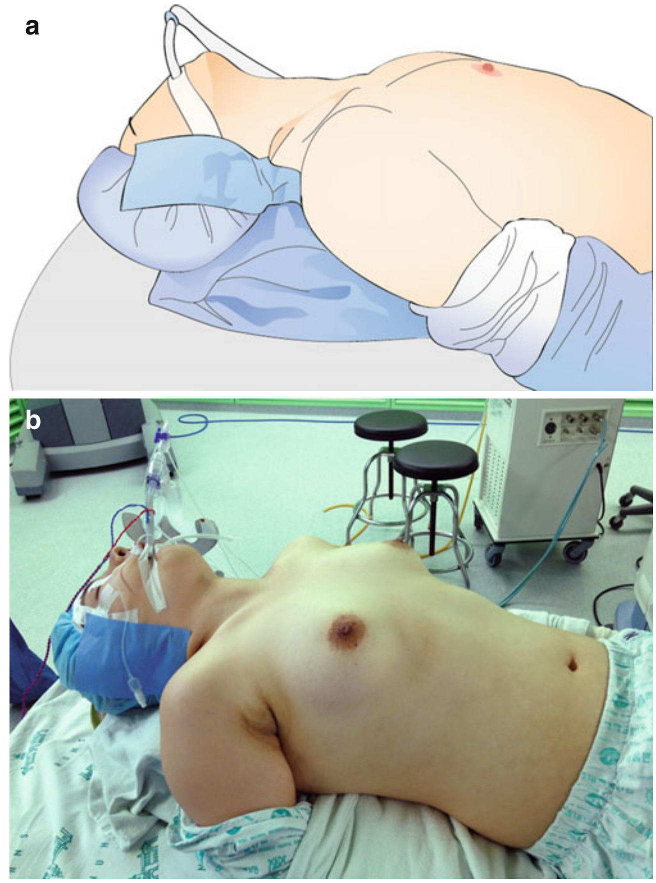


Fig. 4.12 Position of patient (**a**) illustration, (**b**) photo

4.4.2 Skin Preparation and Draping

The operative field is then prepared with a routine surgical maneuver.

The anterior cervical region is prepared bilaterally from the angles of the mandible, posteriorly to the anterior borders of the trapezius, and inferiorly to the xiphoid process of sternum.

Axillae and proximal regions of arms are also prepared with antiseptic solution.

When the surgical prep solution is completely dry, an aseptic draping is applied using a universal draping package so that the anterior neck, bilateral axilla, and bilateral breast area are exposed.

We cover the patient's head and face with a transparent plastic sheet in order to maintain the visual field of the patient's face and the endotracheal tube. And a large sterile drape is covered over the patient's shoulder, anterior chest wall, and the lower body to complete the draping.

Fig. 4.13 Skin preparation

4.4.3 Operating Room Setup

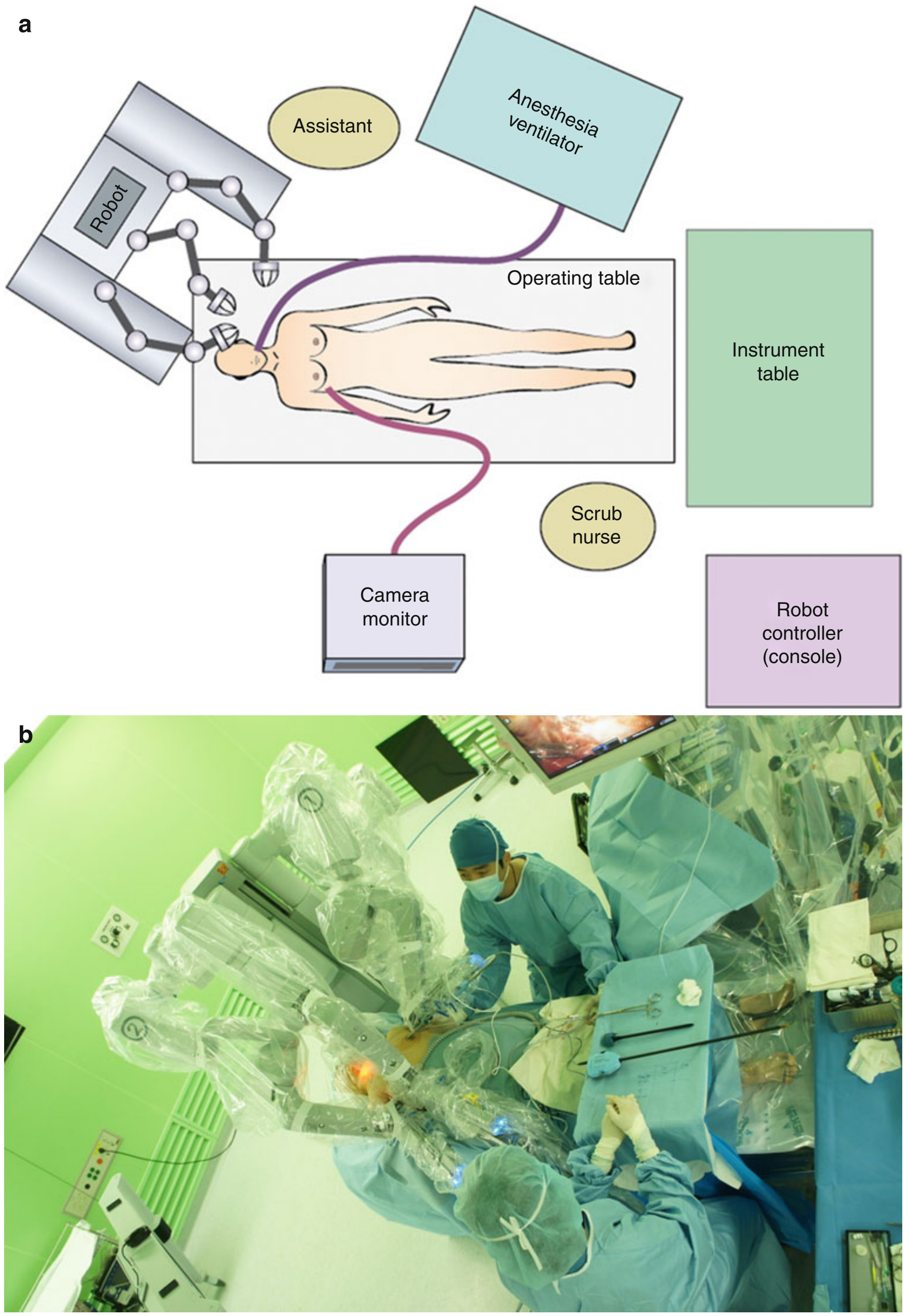


Fig. 4.14 (**a**) Schematic depiction and (**b**, **c**) the aerial view of the operating room setting for robotic thyroidectomy

Fig. 4.14 (continued)

4.4.4 Drawing Guidelines on the Body

Guidelines are drawn along the landmarks of the chest and the neck (midline, thyroid cartilage (V), cricoid cartilage (+), anterior border of the SCM muscle, superior border of the clavicle, suprasternal notch (U), incisions, trajectory lines from the port site to the thyroid gland, and the working spaces).

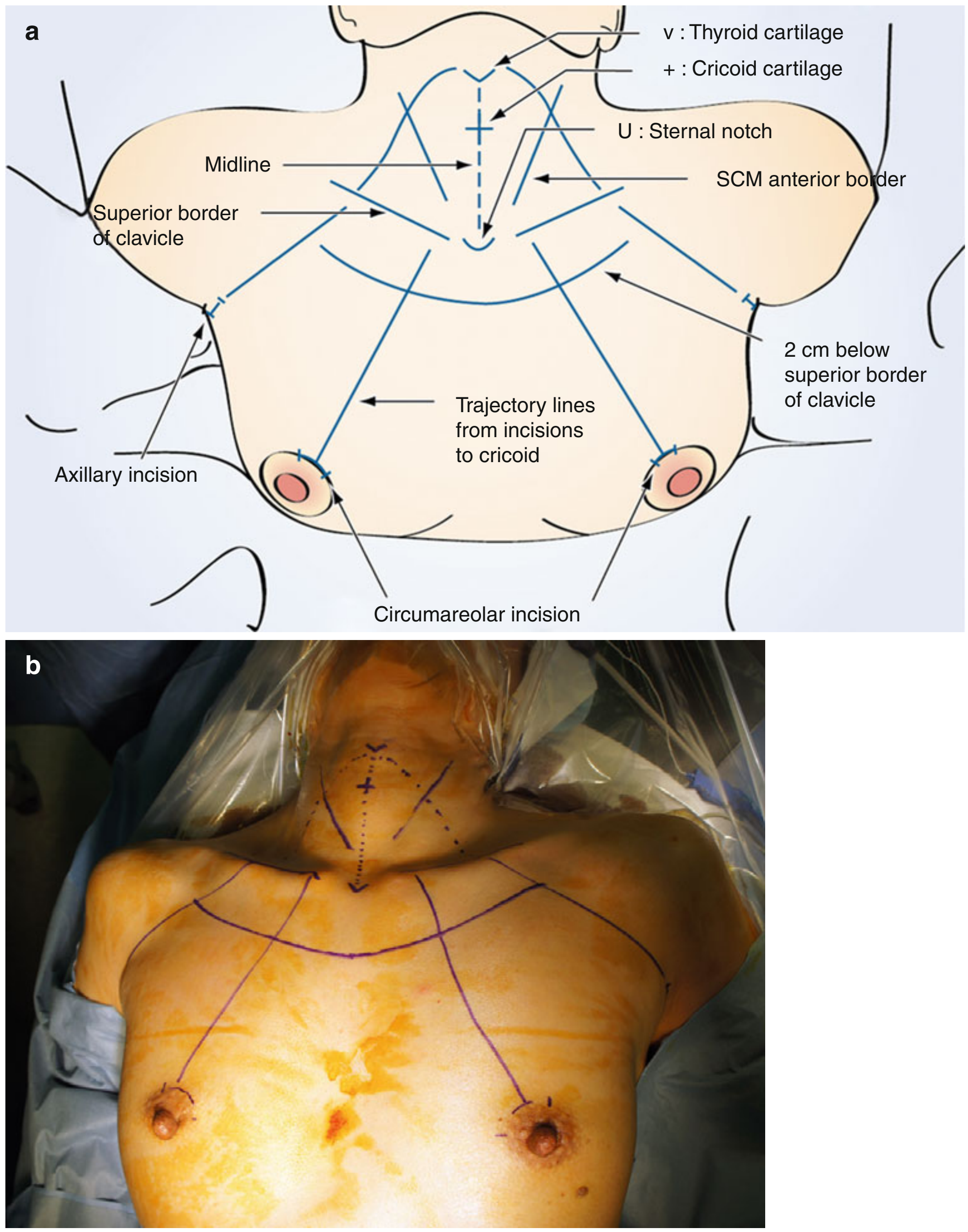


Fig. 4.15 Guidelines of BABA robotic thyroidectomy. (**a**) illustration, (**b**) photo

4.4.5 Saline Injection

Diluted epinephrine solution (1:200,000) is injected in the working area under the platysma in the neck and subcutaneously in the anterior chest. In the neck area, a “pinch and raise” maneuver of the skin facilitates the injection of saline into the subplatysmal area. This “hydrodissection” technique results in the formation of a saline pocket in the subplatysmal layer, which decreases the bleeding in the flap area and makes the subsequent dissection easier.

Inadvertent intravenous injection can be avoided by drawing the plunger backward slightly before making the injection.

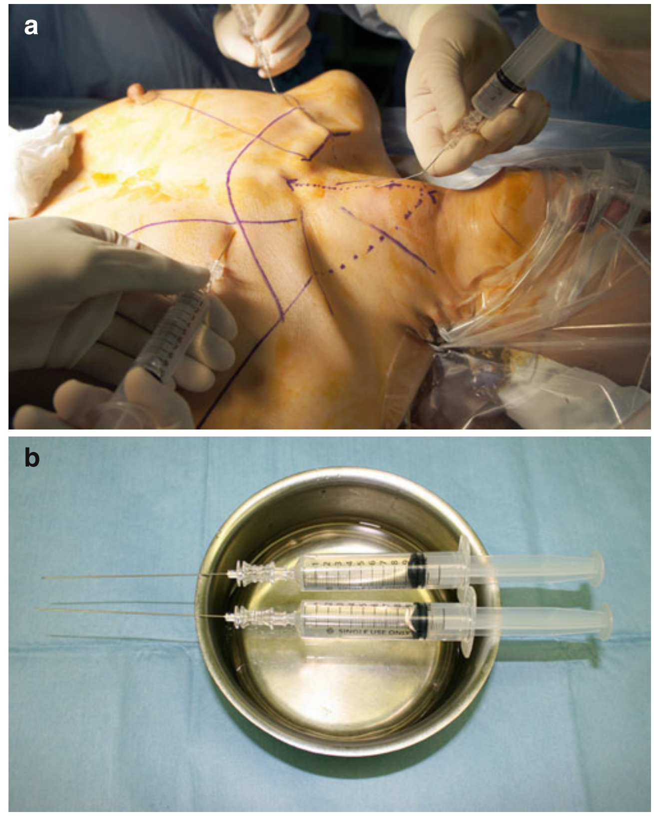


Fig. 4.16 (**a**) Epinephrine-saline injection and (**b**) 1:200,000 epinephrine-saline

4.4.6 Skin Incision and Blunt Dissection

Circumareolar incisions are made bilaterally along the supero-medial margin of each areola. Each incision is further deepened by electrocautery.

Blunt dissections are held with a straight mosquito hemostat, a long Kelly clamp, and a vascular tunneler to elevate the flap. When performing the blunt dissection near the sternal notch, one should try to avoid using excessive force. Dissection should start "area 2" (marked by ★) and elongate to "area 1".

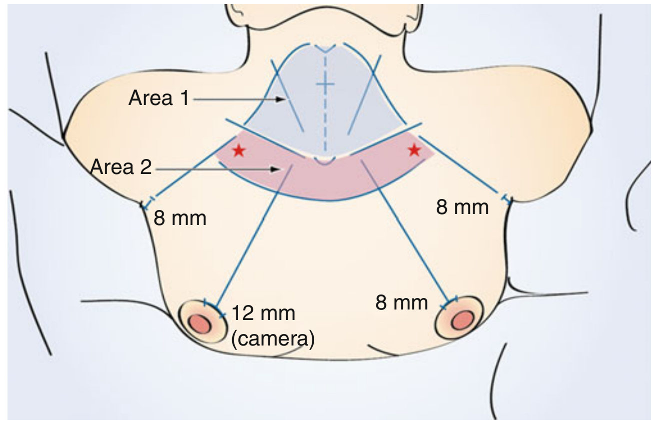


Fig. 4.17 Port (incision) size of BABA robotic thyroidectomy

4.4.7 Port Insertion

After elevating the flap from the incision sites to the cricoid cartilage, the ports are inserted through the incisions. A 12-mm port is inserted through the right breast incision and an 8-mm port through the left breast incision. The camera is put through the 12 mm port to visually transmit the intracorporeal working space. And the ultrasonic shears are put through the 8-mm port. The working space is insufflated with CO_2 gas at the pressure of 5–6 mmHg via a 12-mm port.

DuoDERM® is applied to the incision sites of the breasts in order to protect the nipples after making the port insertion.

When the ultrasonic shears come into the view, make a cut in the connective tissues (or trabeculae).

After making the working space on the anterior chest, two 8-mm axillary incisions are made.

Two 8-mm ports are inserted through the axillary incisions.

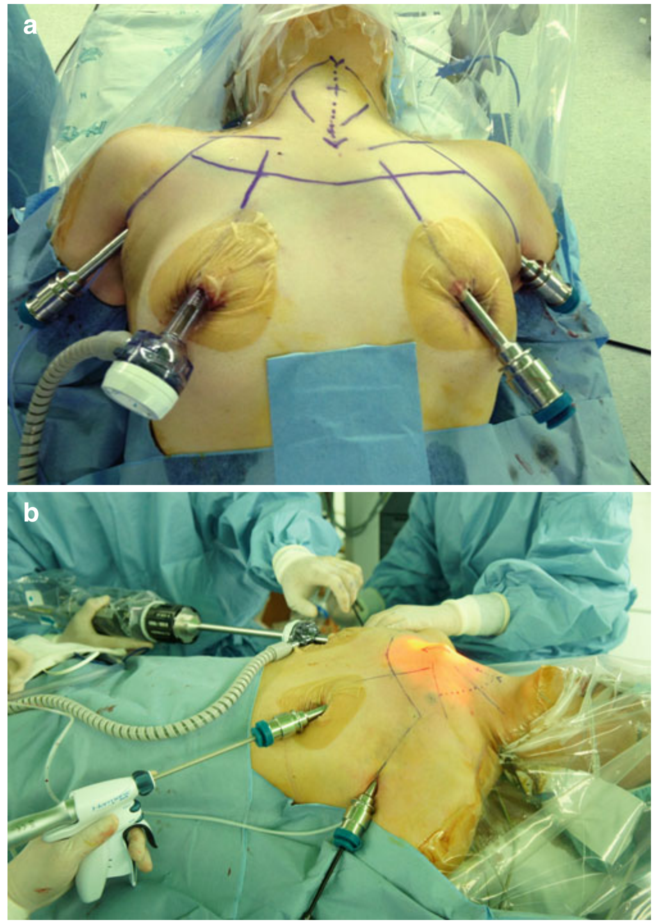


Fig. 4.18 (**a**) Port insertion and (**b**) sharp dissection with Harmonic®

4.4.8 The Patient Cart Positioning

The patient is positioned in the reverse Trendelenburg position at 30° angle.

The patient's head is positioned towards the cart. Align the center column of the cart and the camera arm in a straight line with the camera port. Position the arms of patient cart as high as possible to clear patient's head and operation table.

Note: All overhead lights, booms, and equipments should be temporarily placed aside to avoid contamination of the fields and robotic arms.

Patient cart is rolled into position on the patient's left with the center column in line with the camera port, slightly angled to the operation table and patient's head.

Robot docking: The camera arm is docked first. The camera port is, then, aligned to the target anatomy (i.e., thyroid gland) and the center column of the patient's cart.

The instrumental arms are docked one by one. They should be kept in the center range of motion. The da Vinci instrumental ports are directed towards the center of the target anatomy (or cricoid cartilage) using setup joint release or port-clutch button.

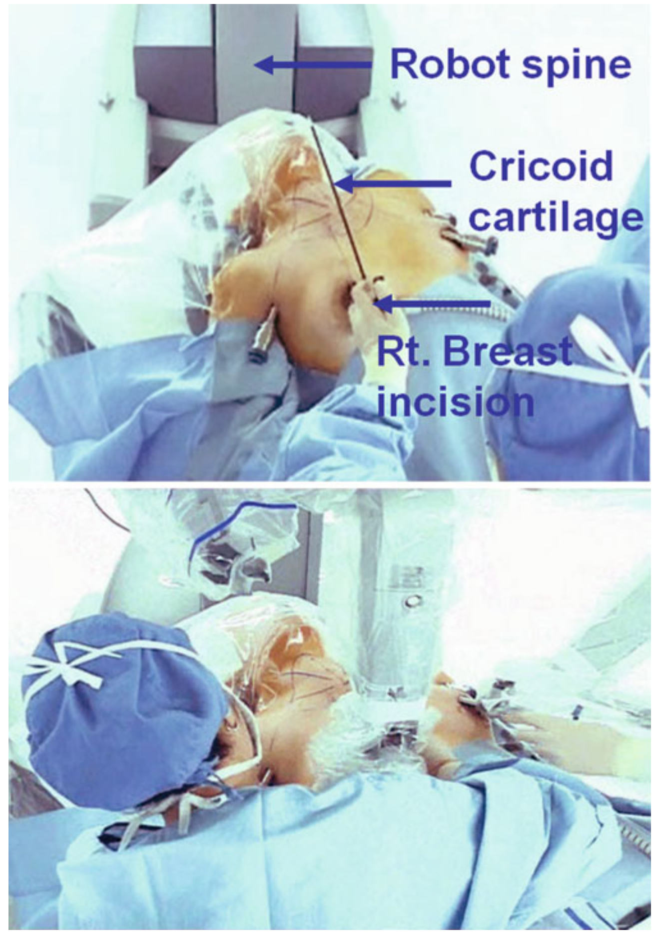
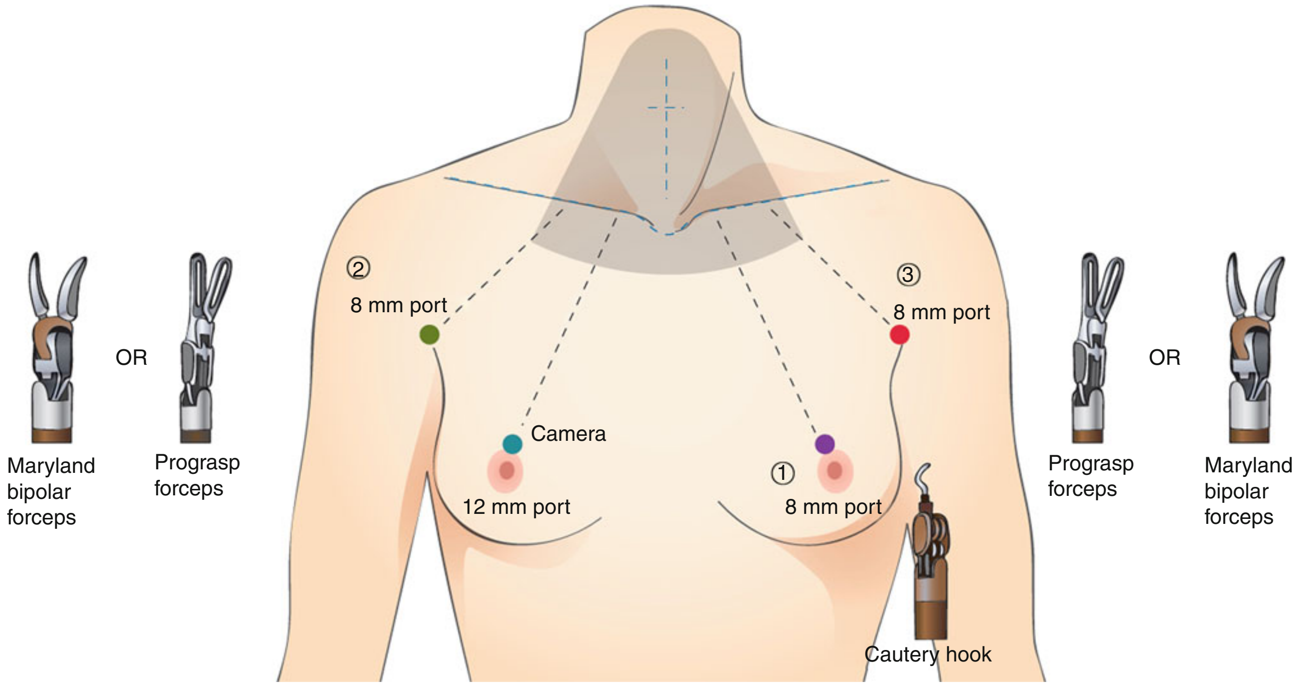


Fig. 4.19 Robot docking



da Vinci camera port: 12 mm (*blue*) camera port
da Vinci instrument arm ① port: 8 mm (*purple*) instrumental port
da Vinci instrument arm ② port: 8 mm (*green*) instrumental port
da Vinci instrument arm ③ port: 8 mm (*red*) instrumental port

Fig. 4.20 Placement of instruments

4.4.9 Complete Elevation of the Flap

The intracorporeal fields are inspected with the camera, and the fields are cleared with an ultrasonic shears. The flap is extended in the cephalad direction to the thyroid cartilage and laterally to the sternocleidomastoid (SCM) muscle.

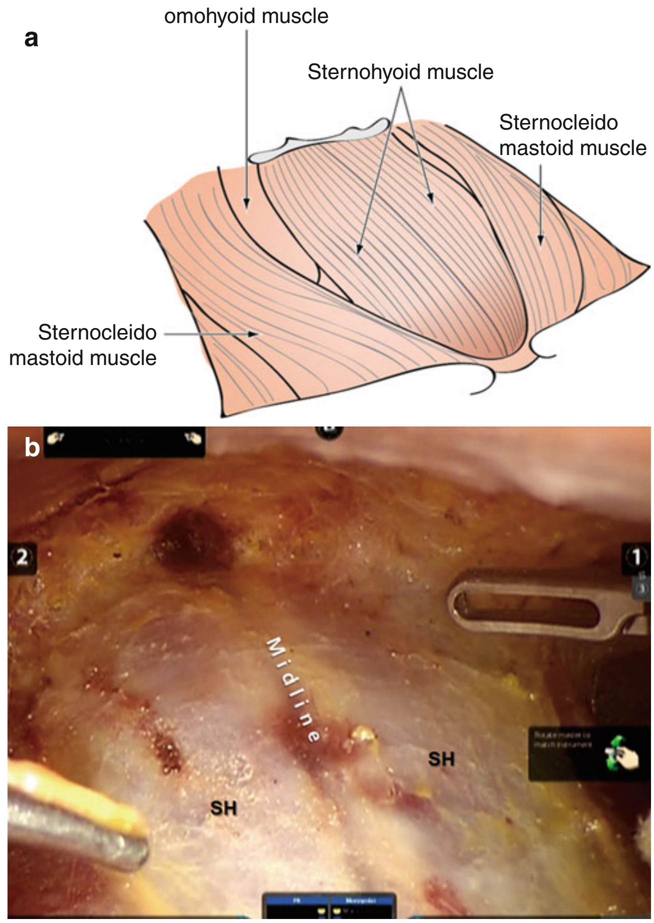


Fig. 4.21 Basic structures of the operative field. *SH* sternohyoid muscle. (**a**) illustration, (**b**) photo

4.4.10 Midline Incision

To identify the midline, the first assistant should externally palpate the prominence of the thyroid cartilage, while the operator marks the midline with the hooked electrocautery which is held in ① arm.

The cervical fascia is opened in the midline from the thyroid cartilage to the suprasternal notch to expose the full length of the strap muscles. It is easier to dissect the most of the cephalad portion of the strap muscle with the ultrasonic shears than a hook electrocautery.

After making the midline incision, the sternohyoid muscles and the sternothyroid muscles are elevated from the thyroid capsule with a hook electrocautery.

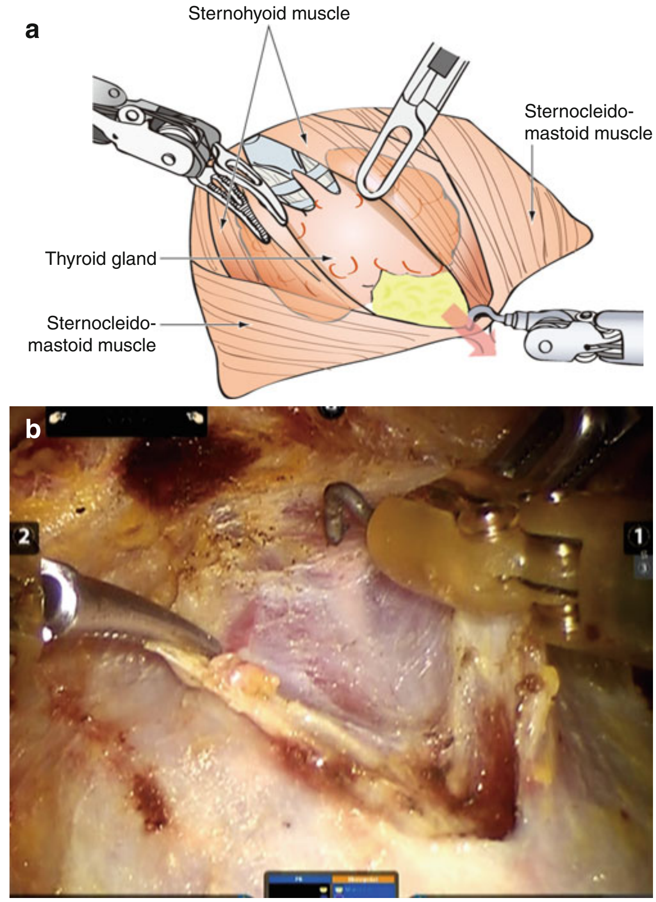


Fig. 4.22 Midline incision. (**a**) illustration, (**b**) photo

4.4.11 Isthmectomy

The isthmus is divided in the midline with a hook or a harmonic scalpel.

The trachea is easily found caudal to the thyroid gland (i.e., central compartment).

When the isthmus is divided, one should make certain that there are no lesions in the isthmus according to the preoperative work-ups.

Isthmectomy should be carefully performed to avoid giving injury to the trachea.

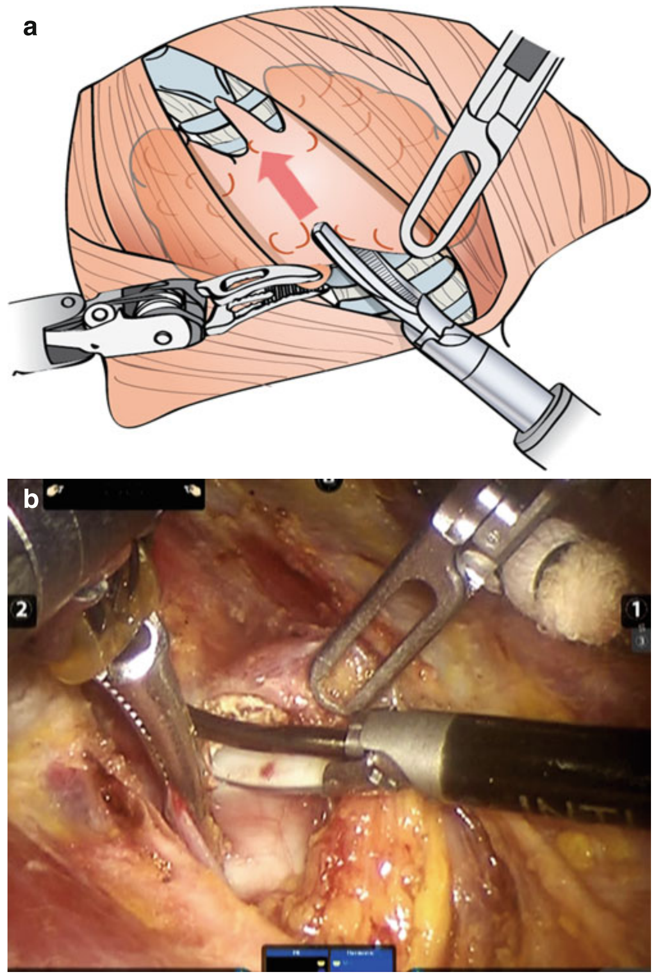


Fig. 4.23 Isthmectomy. (**a**) illustration, (**b**) photo

4.4.12 Lateral Dissection and Ligation of Middle Thyroid Vein

The thyroid gland is retracted in medial direction with a Prograsp™ forceps, and the right side of the strap muscles is retracted laterally using a Maryland forceps.

The strap muscles are separated from the capsule of the thyroid gland, and this dissection is continued down to the deep aspect of the gland to expose the lateral side of the thyroid gland.

Use the ultrasonic shears to reduce unnecessary bleeding from the muscles and the thyroid capsular vessels. To facilitate the medial traction of the thyroid lobe, the surgeon can gradually grasp the thyroid gland on its medial portion by manipulating both robot arms with the so-called switching motion (Fig. 4.25).

When lateral dissection is made to expose the lateral side of the gland, the middle thyroid vein can be seen. The middle thyroid vein is separated with the ultrasonic shears.

Switching motion consists of four steps:

Step 1: Retract thyroid gland in medial direction with hand (1).

Step 2: Hand (3) passes underneath hand (1), while the latter retracts the gland more medially.

Step 3: Hand (3) takes over the role of hand (1) and continues to retract the thyroid gland medially.

Step 4: Hand (3) further retracts the gland in medial direction and hand (1) continues with the dissection.

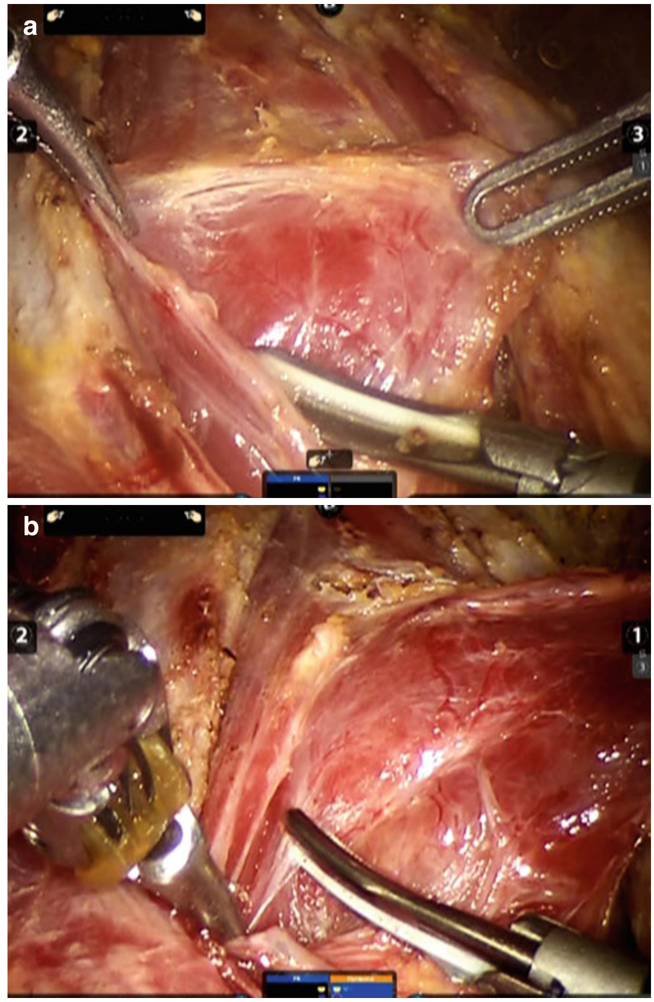


Fig. 4.24 (**a**, **b**) Lateral dissection of the thyroid gland

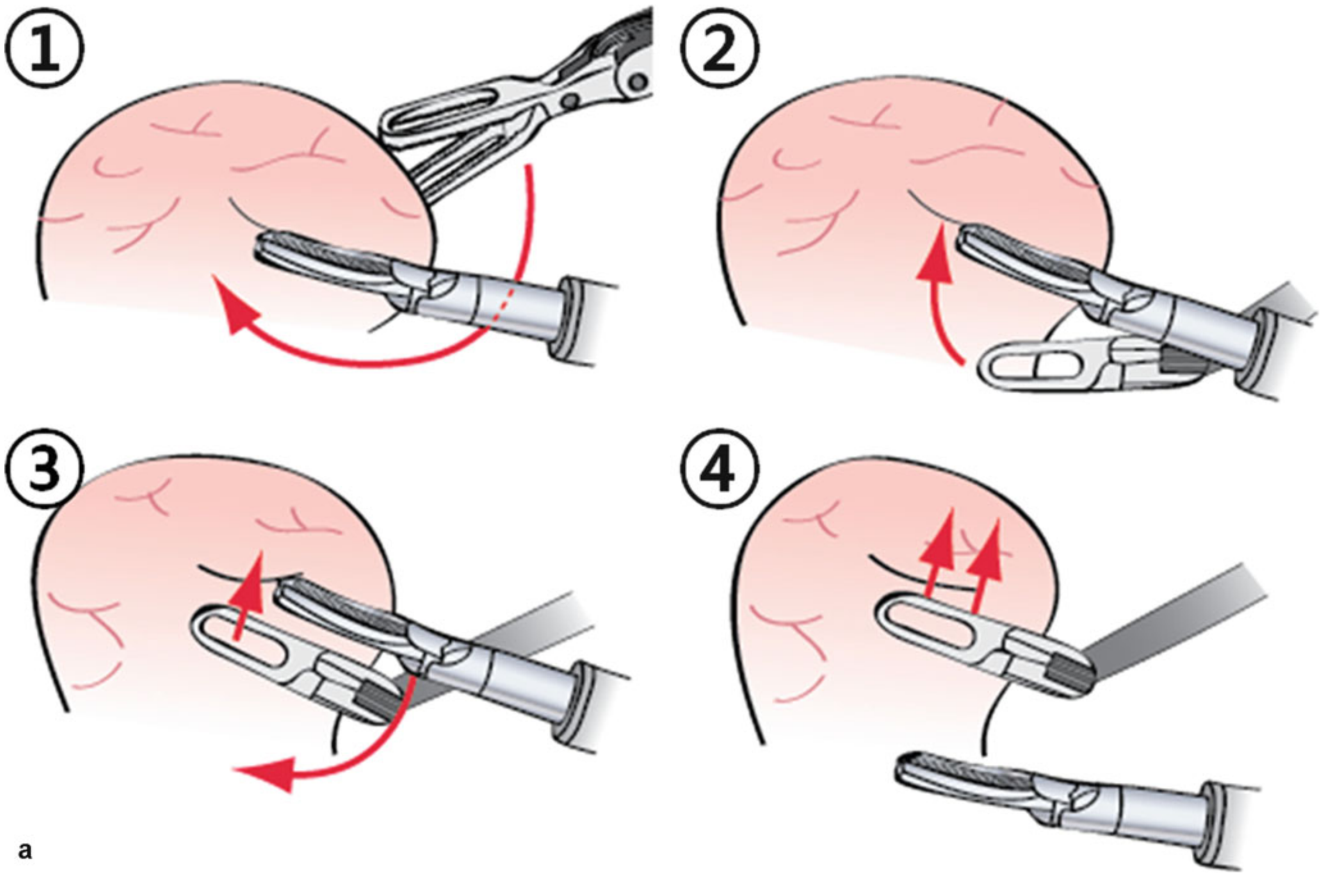


Fig. 4.25 Switching motion in BABA robotic thyroidectomy. (**a**) illustration, (**b**) photo

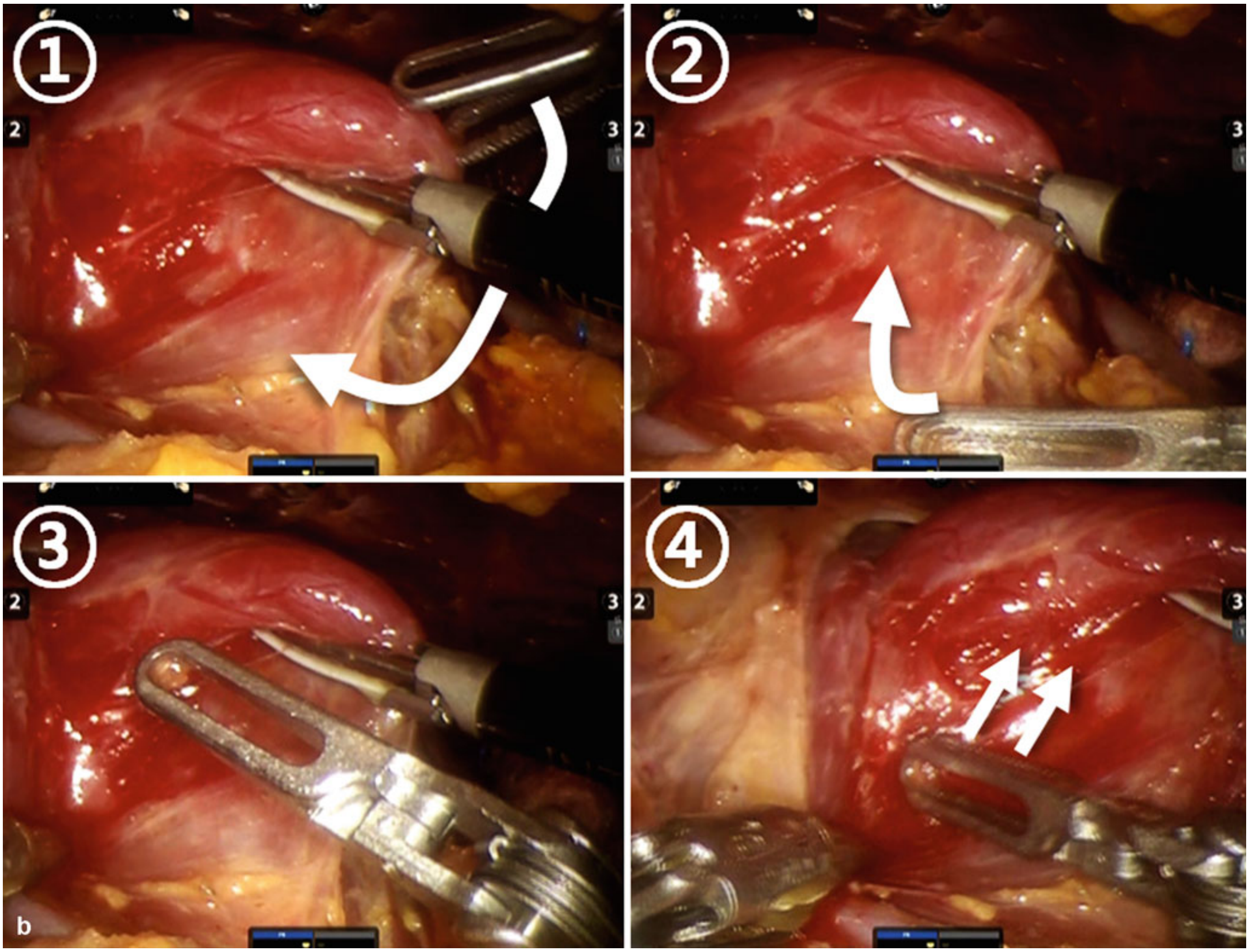


Fig. 4.25 (continued)

4.4.13 Dissection of the Inferior Pole and Inferior Thyroid Vessels

The lateral aspect of the thyroid gland is fully dissected, and the inferior portion of the thyroid gland should become the focus.

The inferior part of thyroid gland is dissected bluntly with the ultrasonic shears because the inferior thyroid passes directly underneath or crosses over the recurrent laryngeal nerve prior to entering the thyroid gland.

Therefore the inferior thyroid artery can be used as a guide to finding the recurrent laryngeal nerve.

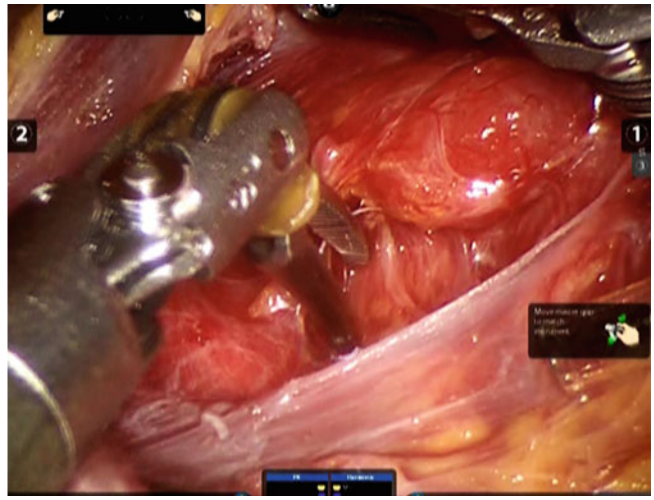


Fig. 4.26 Dissection of the inferior pole and inferior thyroid vessels

4.4.14 Preservation of the Recurrent Laryngeal Nerve

If the nerve cannot be exposed immediately, further dissection of the loose fibrous tissue is needed at the inferior point of the artery near the tracheal esophageal groove. At this point, the inferior parathyroid gland can be found which can be used as a guide to the recurrent laryngeal nerve.

As mentioned before, the inferior pole vessels provide blood supply to the inferior parathyroid gland, so the inferior vessels of the thyroid gland should be ligated close to the thyroid gland. If the nerve is not seen around the tracheoesophageal groove, the inferior thyroid vessels would rather be preserved.

The tubercle of Zuckerkandl can also be used as a guide to the recurrent laryngeal nerve, so the area under the tubercle of Zuckerkandl should be dissected with the Maryland forceps with great care. The ultrasonic shears are used to retract the strap muscles at this moment.

If preservation of the parathyroid gland is not feasible, reimplantation should be considered. We prefer pectoralis major muscle for autotransplantation of the parathyroid gland.

Once the nerve is identified, plane just superficial to the nerve is delineated with the ultrasonic shears. To avoid thermal injury from the ultrasonic shears, one should be careful not to use the shears near the nerve immediately after activating them.

According to our canine model study about the lateral thermal injury of the ultrasonic shears, it was safe when there was 3 mm distance from the nerve to the ultrasonic shears. The dissection is continued in the cephalad direction near the point of the nerve entering the larynx. Nerve may divide into two or more branches along its course from the level of the inferior thyroid artery to that of the larynx.

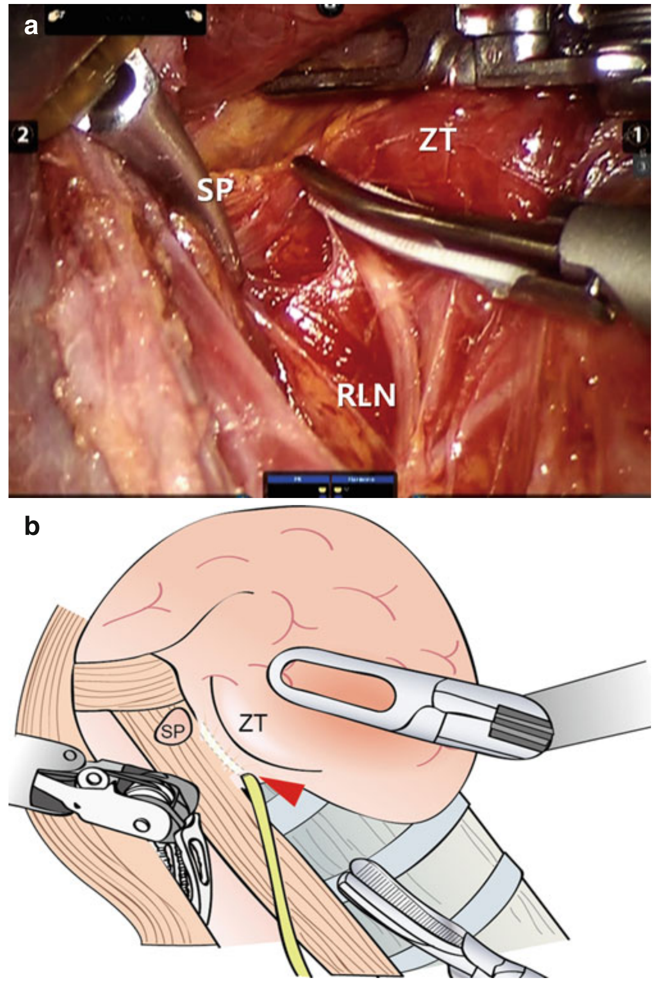


Fig. 4.28 Preservation of the recurrent laryngeal nerve. Post-Zuckerkandl space is marked by *arrowhead*. (**a**) photo, (**b**) illustration

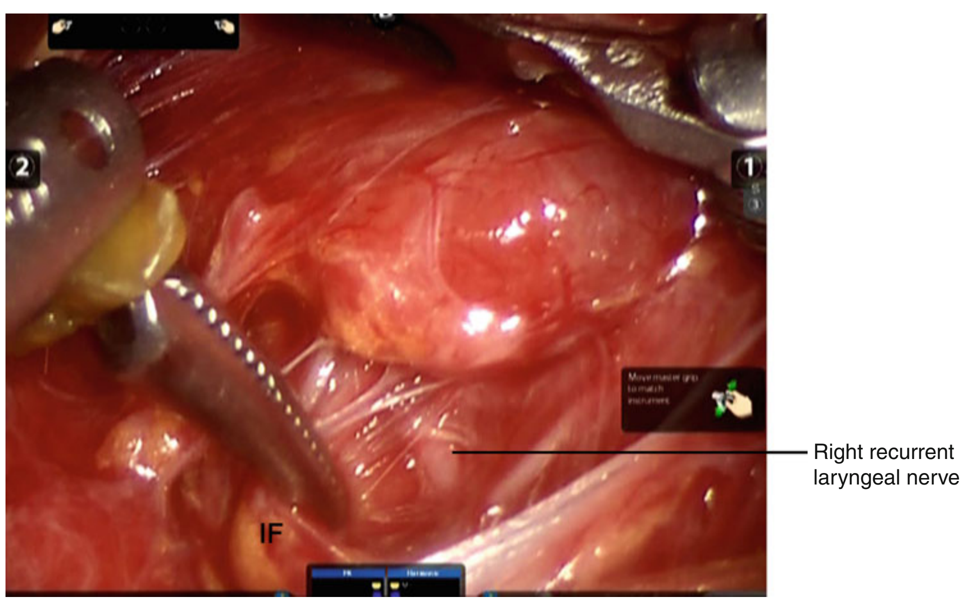


Fig. 4.27 Dissection with Maryland dissector (PK dissector in this picture)

4.4.15 Dissection of the Ligament of Berry

The thyroid gland is firmly attached to the two upper tracheal rings by a dense fibrous tissue that constitutes the ligament of Berry.

The distal part of the recurrent laryngeal nerve passes close to this ligament.

Often, there are small arteries in this ligament which can make unnecessary bleeding and make the dissection more difficult. Once the ligament of Berry is dissected without injuring the nerve, the thyroid lobes can be easily deliberated from the trachea.

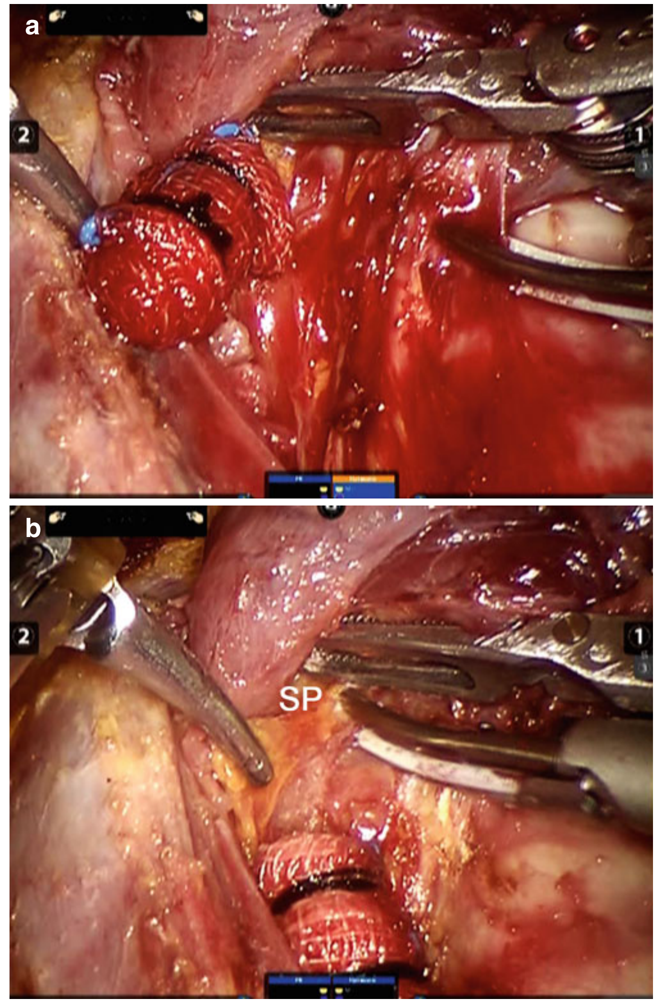


Fig. 4.29 (**a**, **b**) Dissection of the ligament of Berry. *SP* superior parathyroid gland

4.4.16 Dissection of the Thyroid Upper Pole

With the retractor drawing the upper portion of the strap muscles in a cephalad direction, the ultrasonic shears are used to dissect the upper pole of the thyroid gland.

The medial and lateral sides are dissected alternately to free the upper pole of the thyroid gland.

It is important to preserve the fascia of the cricothyroid muscle, because the external branch of the superior laryngeal nerve is closely associated to the cricothyroid muscle.

And one or two small veins may be entering the posterior portion of the upper pole. These branches should be identified and ligated meticulously.

Then the terminal branches of the superior thyroid artery and vein should be identified and divided carefully with the ultrasonic shears.

Three ways to dissect the upper thyroid pole are (1) lateral approach, (2) anteromedial approach, and (3) posteromedial approach.

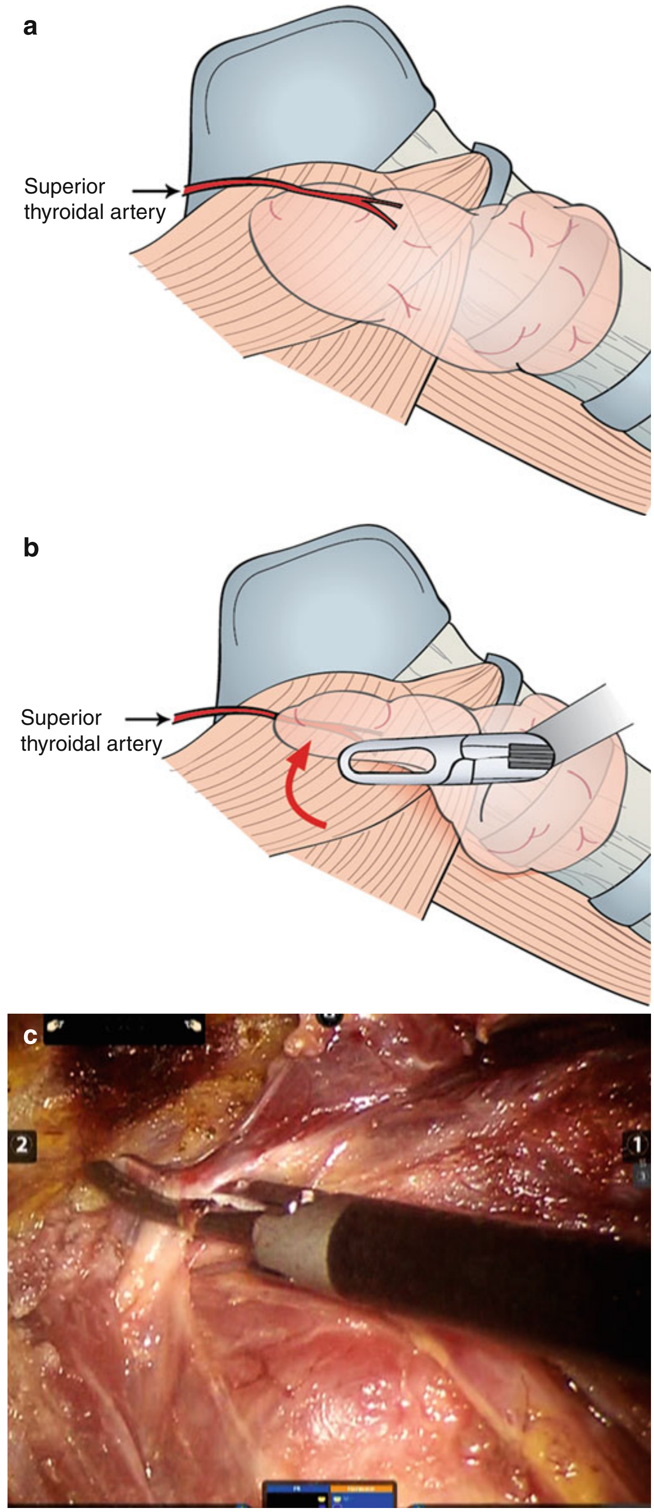


Fig. 4.30 (**a**, **b**, **c**) Dissection of the thyroid upper pole

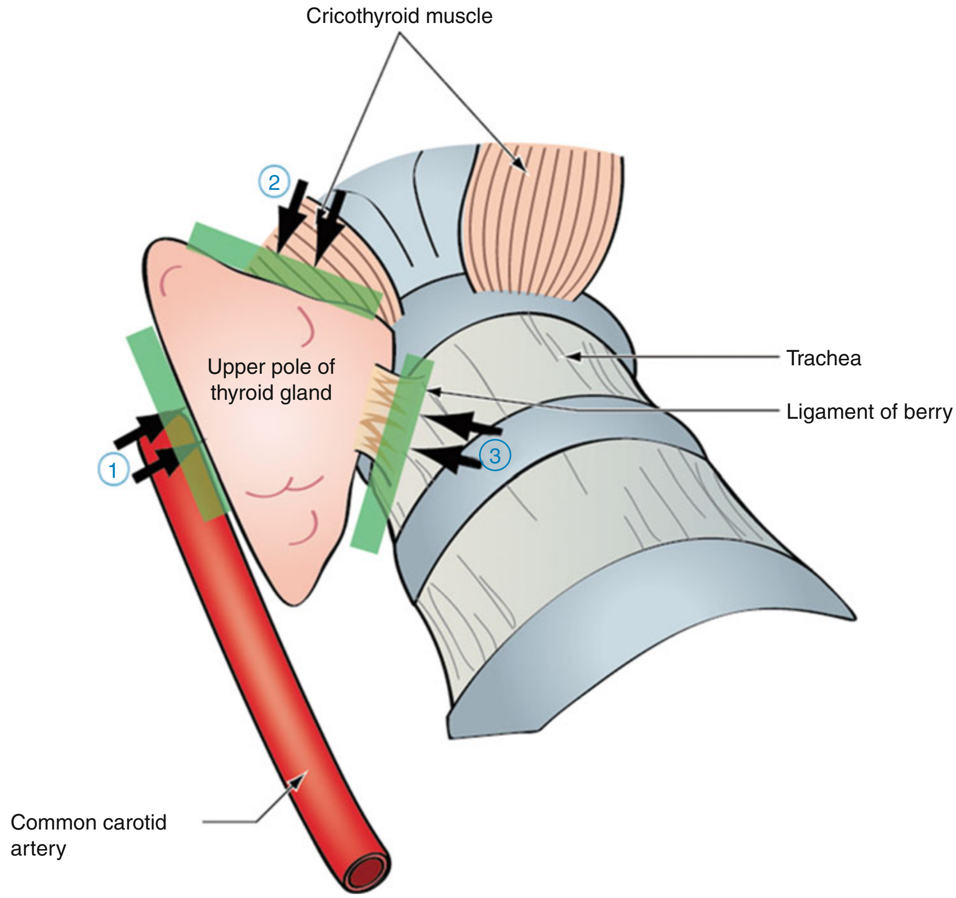


Fig. 4.31 Dissection of the thyroid upper pole

4.4.17 Specimen Removal

After dissecting the thyroid gland away from the trachea, the specimen is wrapped with the plastic bag and taken out via left axillary port. If the incision of left axilla is not enough to extract the specimen, the incision may be widened with a knife.

Once the specimen is extracted, an intraoperative frozen section is obtained to determine the extent of the operation.

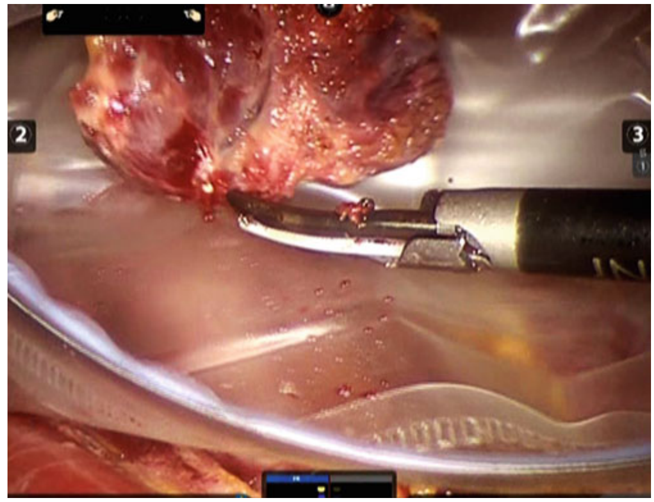


Fig. 4.32 Specimen removal using Endobag

4.4.18 Dissection of Pyramidal Lobe

Dissection of pyramidal lobe and Delphian node and after dissecting pyramidal lobe; one can see the hyoid bone with BABA

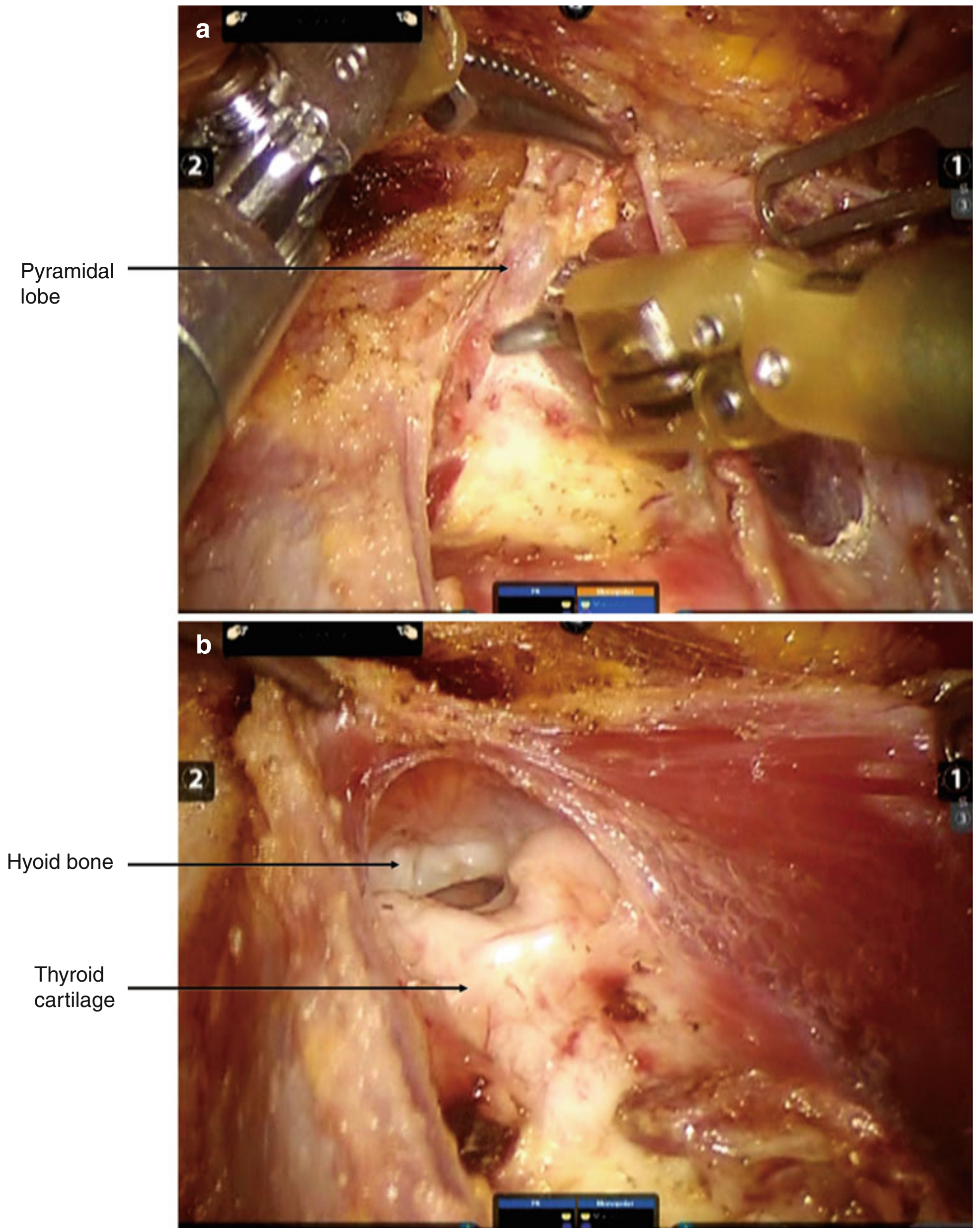


Fig. 4.33 (**a**) Dissection of pyramidal lobe, (**b**) visualization of the hyoid bone

4.4.19 Central Compartment Dissection

When the frozen section is proved to be malignant, central compartment dissection and contralateral lobectomy are performed. Lesion-side central compartment dissection is performed with care to ensure that the recurrent laryngeal nerve is not damaged.

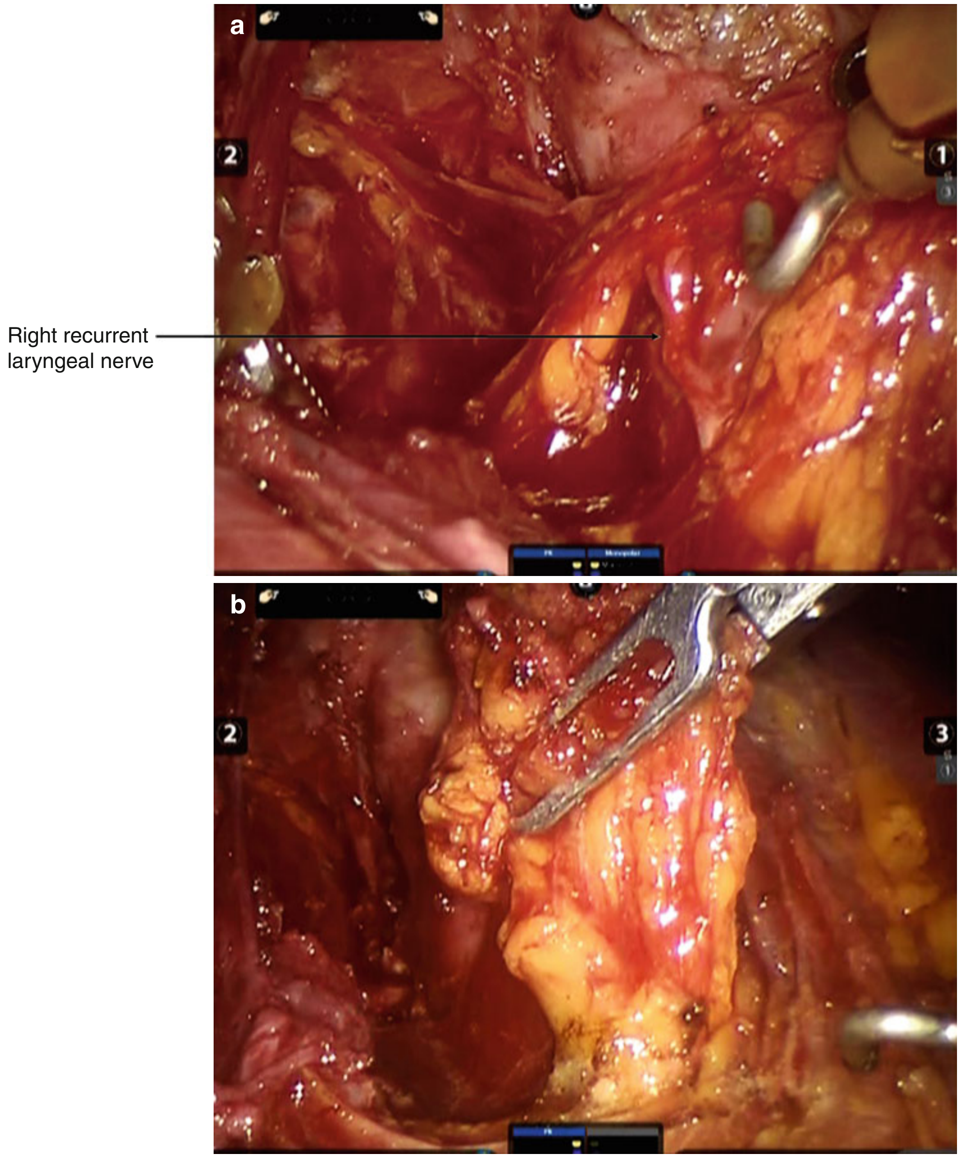


Fig. 4.34 (**a**, **b**) Central compartment dissection

4.4.20 Contralateral Thyroidectomy with the Same Manners

The contralateral lobe was dissected in the same fashion. As shown in figures, the operator has the comfortable and symmetric view of each side of the operative field with BABA.

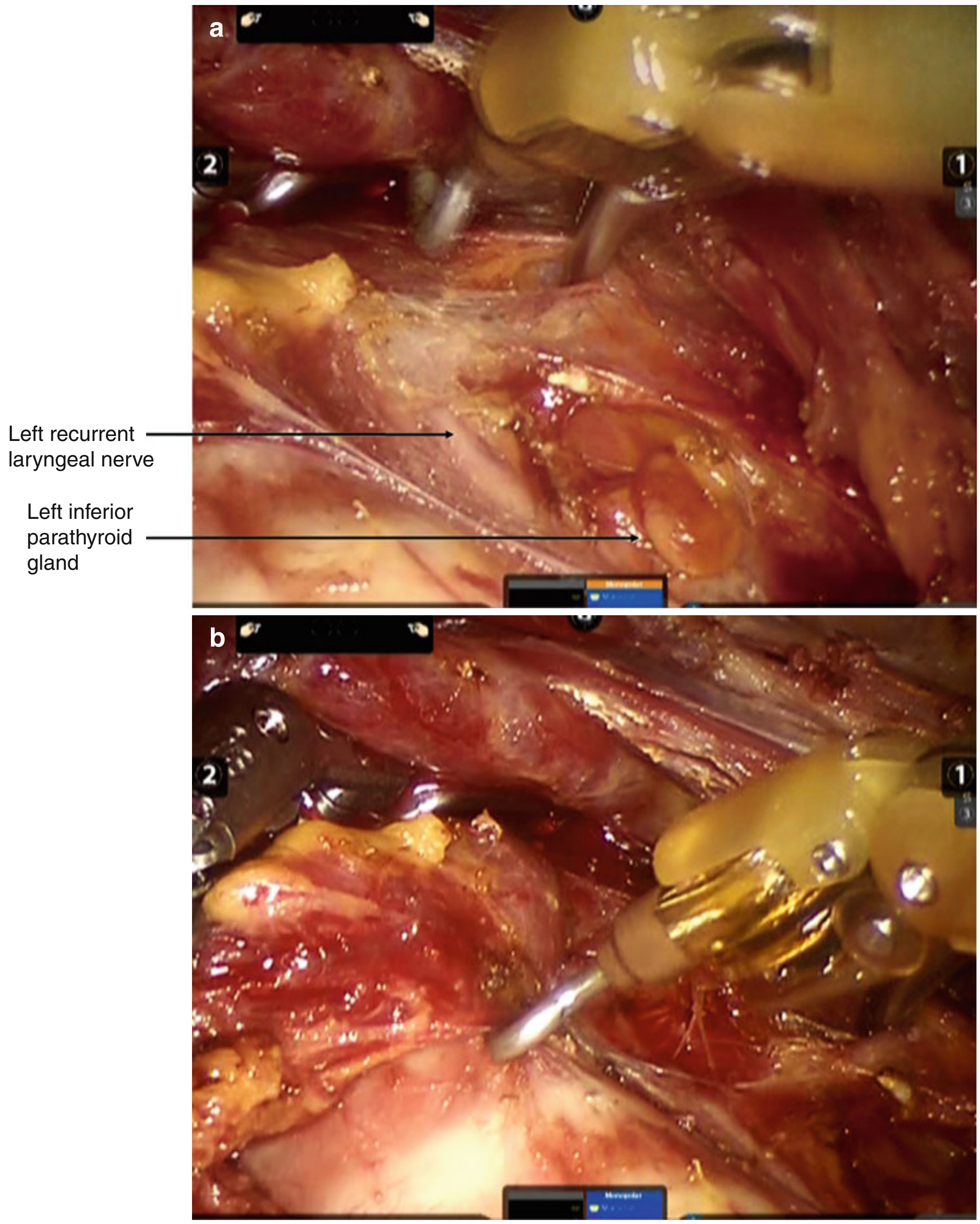


Fig. 4.35 Contralateral thyroidectomy. (**a**) preservation of the recurrent laryngeal nerve and the inferior parathyroid gland, (**b**) dissection of the ligament of Berry

4.4.21 Closure

When the thyroid lobectomy is all done, the operative field is irrigated with warm saline. Meticulous and complete hemostasis should be achieved with ligatures and electrocautery before the operation is over.

After achieving hemostasis, the operative bed should be spread with Tissucol® around the operative bed. Right and left strap muscles are then sutured together with continuous running sutures. Then two Jackson-Pratt (JP) drains are placed into both thyroid pockets via both axillary incisions. Lastly, the skin of the breasts and axillae is closed with knot-buried stitches by an absorbable suture.

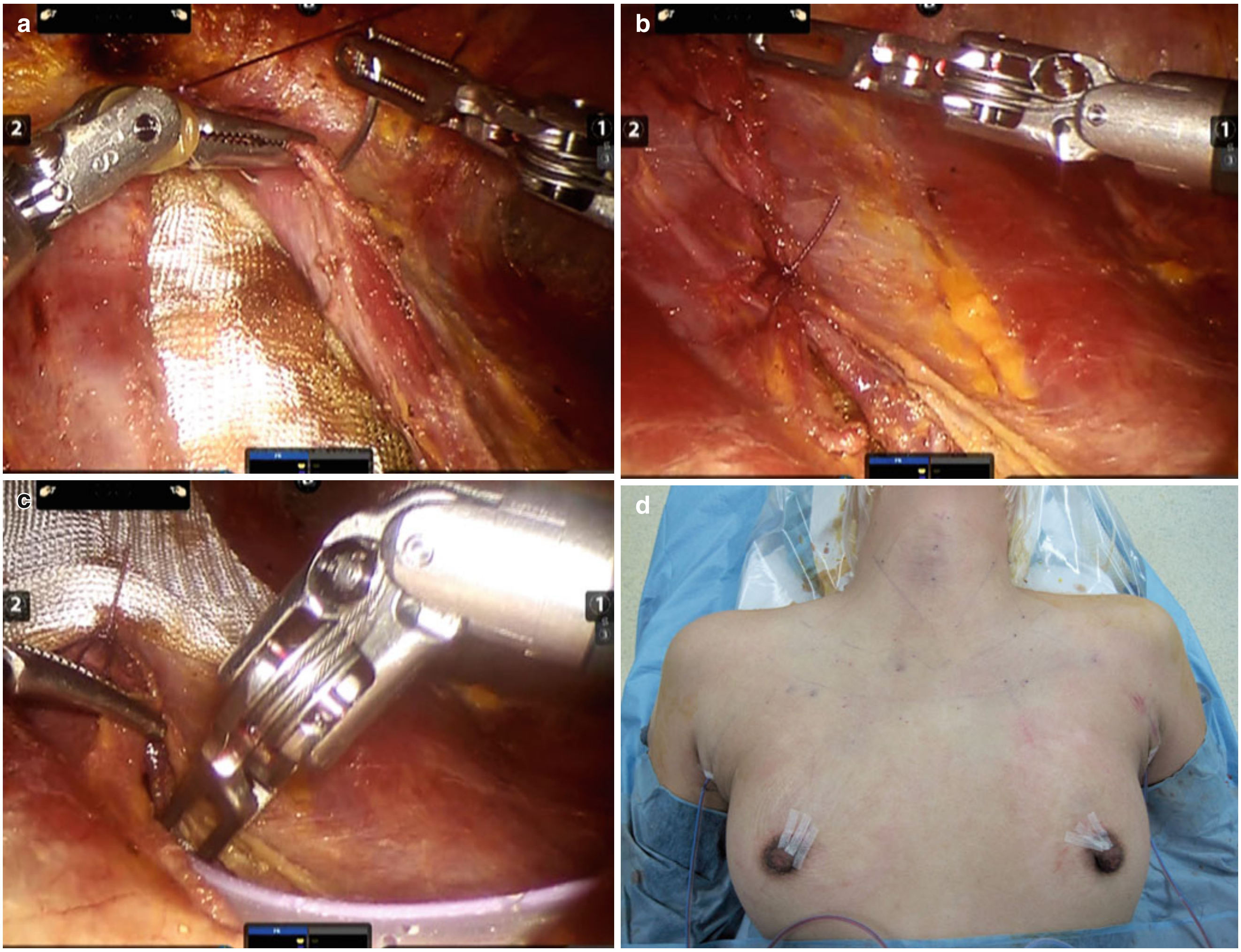


Fig. 4.36 Closure. (**a**) midline closure with suture, (**b**) after midline closure, (**c**) anti-adhesive and drain insertion, and (**d**) closure of the wound

4.4.22 Postoperative Wound

Postoperative result of BABA robotic thyroidectomy is very good. No scar in the neck and both breasts and axillae can be seen in Fig. 4.37.

Fig. 4.37 Postoperative wound after 3 months

4.5 Postoperative Care

4.5.1 Recovery Room

After surgery, patients are sent to the recovery room for 1–2 h where nurses monitor patient status. Since postoperative bleeding can occur, nurses check for signs of drainage from the wound and swelling of the neck.

4.5.2 O_2 Supply

Patients receive O_2 because surgical brassieres cause anterior chest compression.

4.5.3 Diet Restriction

There are no restrictions on diet, and most patients take in water and solid food 4–6 h after surgery. Hospital staff monitor patients to ensure that water and food do not enter the trachea.

4.5.4 Ambulation

Patients are encouraged to move about to avoid deep vein thrombosis.

4.5.5 Analgesics

Acetaminophen or an NSAID is administered to patients with pain as needed. Narcotic painkillers are rarely administered. Postoperative headache from prolonged overextension of the neck is controlled by acetaminophen or an NSAID.

4.5.6 Thyroid Hormone Replacement

Patients who underwent total thyroidectomy or near-total thyroidectomy require thyroid hormone replacement, while patients who underwent lobectomy do not.

4.5.7 Voice Care

After surgery, patients can have a hoarse voice due to edema of the subglottis caused by irritation of the endotracheal tube or injury to the recurrent laryngeal nerve (RLN). Temporary recurrent nerve injury occurs in 10 % or less of cases, and permanent nerve injury occurs in less than 1 % of cases. RLN injury and vocal cord fixation are assessed by indirect laryngoscopy (rigid or flexible) at bedside. If vocal cord fixation persists for more than 6 months, consultation with a voice specialist is recommended.

4.5.8 Wound Care

Wound care using aseptic techniques is performed 1–2 days after surgery. Before discharge, the wound is drained and dressing is changed. Patients can shower 2–4 days after discharge.

4.5.9 Postoperative Follow-Up

A postoperative follow-up visit is conducted at 10–14 days after discharge at which time benign disease is confirmed. At this point, patients are requested to visit their primary care physician and/or endocrinologist. Surgeons often follow patients with confirmed thyroid cancer at 6-month intervals for 2 years and then annually if thyroglobulin, RAI scans, cervical ultrasounds, and clinical follow-up examinations remain negative for recurrent disease.

4.6 Postoperative Complications and Their Treatment

4.6.1 Bleeding and Hematoma

Similar to the BABA endoscopic thyroidectomy procedure, bleeding from the surgical site and subcutaneous flaps occurs in 1–2 % of BABA robotic thyroidectomy cases. Bleeding from the surgical site can be life-threatening because it can result in a blocked airway and respiratory failure, and it requires reoperation. However, bleeding in BABA robotic thyroidectomy seldom makes such a catastrophic event rare due to the operative field being relatively larger than that in open thyroidectomy. In our experience, all postoperative bleeding could be controlled with endoscopic instruments, so re-docking of robot is not needed.

4.6.2 Hoarseness

Intraoperative injury of the RLN is the main cause of postoperative hoarseness. Nerve injury can be caused by transection, thermal injury from electrocautery, or traction injury. Hoarseness is usually temporary, but it can be permanent. The rates of temporary and permanent vocal fold paralyses after BABA robotic thyroidectomy were approximately 16 % and less than 1 %, respectively. To avoid nerve injury, the entire length of the RLN from the thoracic inlet to the cricothyroid muscle should be identified. Caution should be exercised when using thermal devices (i.e., Harmonic® shears) near the ligament of Berry.

4.6.3 Hypocalcemic Symptoms

Hypocalcemia and its symptoms can occur after thyroidectomy due to the removal, injury, or devascularization of the parathyroid glands. Hypocalcemia symptoms such as a tingling sensation of the hands are often severe, but symptoms can be controlled by normalizing the calcium level. The rates of transient or permanent hypoparathyroidism after BABA robotic thyroidectomy are approximately 20 % and less than 2 %, respectively. With a magnified vision of the robot system, it is easier to save the parathyroid glands when great care is taken. When the parathyroid gland cannot be preserved, it is removed and then autotransplanted into the left pectoralis major muscle through an axillary incision.

4.6.4 Headache and Neck Stiffness

Headache and neck stiffness can be caused by prolonged overextension of the neck during surgery.

4.6.5 Wound Infection

Infections are not common after BABA robotic thyroidectomy, and less than 1 % of patients suffer from wound infection. Antibiotics and frequent changes of dressing are used to treat infections. Seroma is treated by aspiration at the ward; however, aspiration can result in infection. Surgery and drainage of abscesses are rarely needed.

4.7 Surgical Completeness of BABA Robotic Thyroidectomy: Comparison Between Open and Robotic Thyroidectomy

4.7.1 Patients and Methods

Between February 2008 and February 2010, 750 patients with papillary thyroid carcinoma underwent total thyroidectomy with central node dissection (CND; either prophylactic or therapeutic) at the Seoul National University Hospital. The BABA robotic method was used on 327 of 750 patients, and the open thyroidectomy method was used on 423 patients. Patients were categorized as either radioactive iodine (RAI)-positive or RAI-negative on the basis of RAI ablation. The indications for RAI ablation were as follows: all patients with stage III or IV disease, all patients with stage II disease who were younger than 45 years of age, most patients with stage II disease who were 45 years of age or older, and selected patients with stage I disease, especially those with multifocal disease, nodal metastases, extrathyroidal or vascular invasion, and/or aggressive histology.

To evaluate the surgical completeness of BABA robotic thyroidectomy (RoT), RAI ablation-positive groups were chosen from both BABA RoT and open thyroidectomy (OT) patients. Of 327 BABA RoT patients, 174 (53.2 %) received RAI ablation; of 423 OT patients, 237 (56 %) received RAI ablation (Fig. 4.38). A total of 108 patient sets were selected after matching propensity scores that were composed of three demographic and five pathologic factors to avoid selection and information bias.

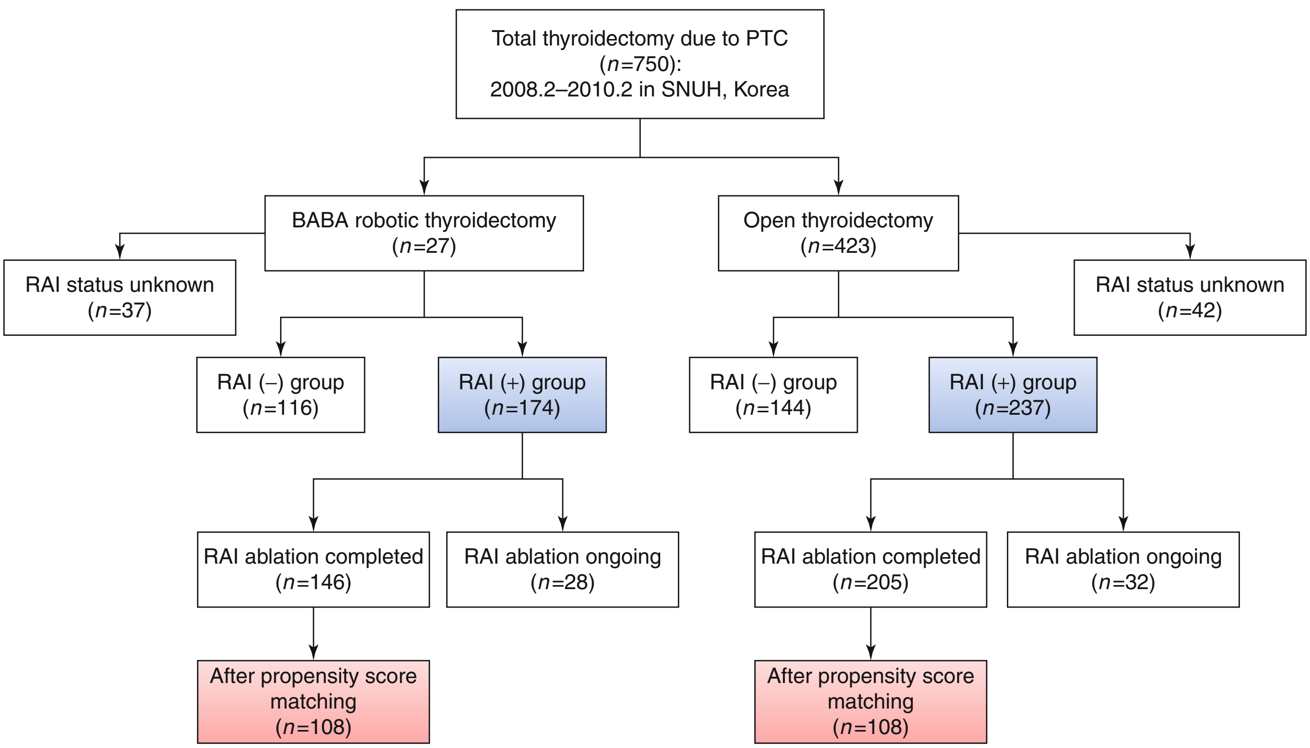


Fig. 4.38 Schematic depiction of 327 and 423 patients who underwent BABA robotic total thyroidectomy and open total thyroidectomy, respectively. Patients were stratified according to whether RAI ablation was given. *BABA* bilateral axillo-breast approach, *PTC* papillary thyroid carcinoma, *RAI* radioactive iodine

4.7.2 RAI Ablation and Measurement of the RAI Uptake Ratio

Selected patients received RAI ablation therapy 8–12 weeks after surgery. During RAI ablation therapy, patients received an oral administration of I-130 (30 mCi), with the exception of six and seven RoT and OT patients who received >100 mCi, respectively. RAI was administered after an injection of human recombinant thyroid-stimulating hormone (TSH) to 12 of 174 (6.9 %) BABA RoT patients and to 4 of 237 (1.7 %) OT patients. Thyroxine (T4) was withdrawn for all other patients for 4 weeks. Commercial radioimmunoassay kits were used to measure serum-stimulated Tg and TSH levels on the day of RAI administration. A whole-body scan was performed 3 days after RAI administration. Thyroid function was also assessed by measuring RAI uptake during the first ablation scan. In brief, a rectangular region of interest (ROI) was drawn to encircle all remnant activity within the thyroid bed. Thereafter, another ROI of the same size and shape was drawn on the brain to serve as background (Fig. 4.39). The counts of both ROIs were measured, and the count ratio was calculated. This thyroid bed-to-background ratio (TBR) represents the amount of thyroid tissue remaining. RAI ablation therapy was repeated until scans showed no remnant thyroid tissue. The number of RAI ablation sessions and the dose needed to achieve complete ablation were also included as measures of the surgical completeness of the two operative methods.

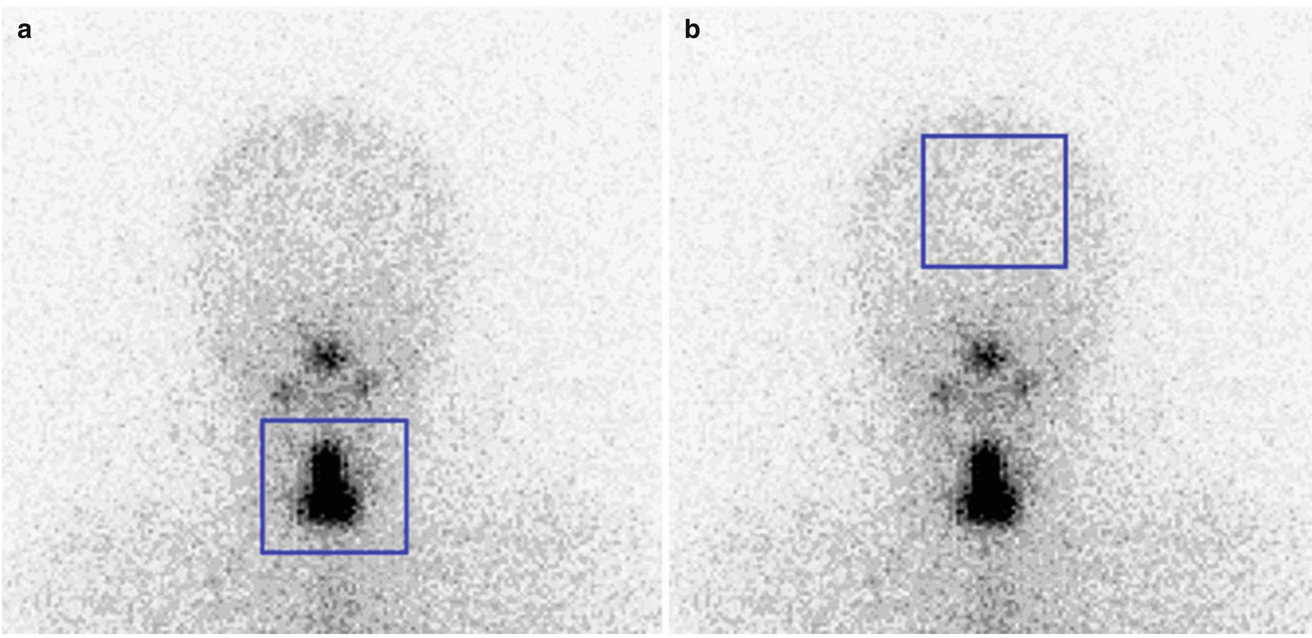


Fig. 4.39 Assessment of the remnant thyroid on the first ablative scan by measuring the TBR of RAI uptake. (**a**) Region-of-interest count of the thyroid bed (*target region*). (**b**) Region-of-interest count of the brain (reference region, i.e., background)

4.7.3 Characteristics of the Study Population Before Matching

Patient baseline characteristics after BABA RoT and OT are listed in Table 4.1. The BABA RoT group was comprised of significantly more females than the OT group. In addition, females in the former group were younger and had a lower BMI. There were no differences in mean tumor size, the prevalence of multifocality or bilaterality, extrathyroid extension, and lymph node metastases between groups; however, patients who underwent BABA RoT had a higher prevalence of thyroiditis. Moreover, there was no difference in T stage between groups according to the American Joint Committee on Cancer's Cancer Staging Manual, 7th edition; however, the BABA RoT group was more likely to have stage I disease, while the OT group was more likely to have stage III disease.

Except for seven patients with distant metastases or abnormal RAI uptakes, there was no difference in the proportion of patients whose Tg levels were <1.0 ng/mL on the first ablation in both groups (Table 4.2). While the OT group required more RAI ablation sessions to remove the thyroid completely, BABA RoT and OT groups did not differ with regard to the total RAI dose needed to achieve complete ablation.

Table 4.1 Baseline characteristics of 411 patients who received RAI ablation therapy after BABA robotic or open thyroidectomy

Variables	BABA RoT ($n = 174$)	OT ($n = 237$)	p value
Clinical demographics			
Female sex	154 (88.51 %)	187 (78.9 %)	0.012
Age (years)	39.9 ± 8.8 (18–63)	51.1 ± 11.1 (21–78)	<0.0001
Body mass index (kg/m^2)	22.9 ± 3.0 (17.0–31.8)	23.9 ± 3.1 (17.1–38.2)	<0.0001
Clinicopathologic characteristics			
Tumor size on histology (cm)	0.80 ± 0.36 (0.2–2.7)	0.90 ± 0.49 (0.1–3.6)	0.054
Multifocality/bilaterality	78[a] (45.1 %)/42[a] (24.3 %)	88 (37.1 %)/43 (18.1 %)	0.218
Extrathyroid extension	131[b] (76.2 %)	178[a] (75.4 %)	0.862
Lymph node metastasis	82 (48.4 %)	97 (40.9 %)	0.137
Thyroiditis (Hashimoto or lymphocytic)	70[a] (40.5 %)	60 (25.3 %)	0.001
Stage I/II/III (%)	123 (70.7 %)/0/51 (29.3 %)	78 (32.9 %)/1 (0.4 %)/158 (66.7 %)	<0.001

BABA bilateral axillo-breast approach, *BMI* body mass index, *OT* open thyroidectomy, *RoT* robotic thyroidectomy
[a]One case unknown
[b]Two cases unknown

Table 4.2 Clinical parameters for surgical completeness of 411 patients who received RAI ablation after BABA robotic thyroidectomy or open thyroidectomy

Clinical parameters	BABA RoT ($n = 174$)	OT ($n = 237$)	p value
TBR of RAI uptake on 1st ablation	12.2 ± 13.1 (1.0–86.7)	13.8 ± 13.4 (1.4–76.6)	0.078
TSH (μIU/mL) on 1st ablation	109 ± 64[a] (0.34–445)	101 ± 62 (<0.05–268)	0.144
Stimulated Tg (ng/mL) on 1st ablation	1.4 ± 3.9[a] (<0.1–36.4)	1.2 ± 3.1[b] (<0.1–38.7)	0.998
Proportion of stimulated Tg <1.0 ng/mL (%) on 1st ablation	114[a] (69.1 %)	162[b] (68.6 %)	0.924
RAI ablation sessions[c]	1.95 ± 0.49 (1–3)	2.05 ± 0.51 (1–4)	0.050
RAI ablation dose (mCi) [c]	62.2 ± 19.1 (30–150)	66.8 ± 27.3 (30–300)	0.113

BABA bilateral axillo-breast approach *OT* open thyroidectomy, *RAI* radioactive iodine, *RoT* robotic thyroidectomy, *TBR* thyroid bed-to-background ratio, *Tg* thyroglobulin, *TSH* thyroid-stimulating hormone
[a]Two cases unknown
[b]One case unknown
[c]Seven cases excluded from distant metastasis or abnormal radioactive iodine uptake

4.7.4 Outcomes of Matched Cohorts

Propensity score matching of 174 patients in BABA RoT and 237 patients in OT groups yielded 108 sets. Matched cohorts did not differ in terms of the eight covariates that were used, as determined by appropriate statistical methods (Table 4.3). Matched cohorts also did not differ in terms of the clinical parameters that reflect surgical completeness, the total number of RAI ablation sessions, and the dose needed to achieve complete ablation.

Conclusions

After adjusting patient cohorts by propensity score matching, BABA RoT and OT groups did not differ with regard to surgical completeness parameters, including the TBR of RAI uptake, the stimulated Tg levels on the first RAI scan, and the total number of sessions and doses needed to ablate the remnant thyroid completely. Therefore, the surgical completeness (i.e., oncologic safety) of BABA RoT is not inferior to that of OT. The oncologic safety of BABA RoT, together with its safety and excellent cosmetic outcome, illustrates that it may be suitable for patients with papillary thyroid carcinoma who prefer scar-free necks.

Table 4.3 Baseline characteristics and clinical parameters for surgical completeness of BABA robotic and open total thyroidectomy groups ($n = 108$ for both) after propensity score matching using eight covariates

Characteristic	BABA robotic ($n = 108$)	Open ($n = 108$)	p value
1. Female sex	91 (84.3 %)	91 (84.3 %)	1.000
2. Age (years)	43.7 ± 7.4 (23–62)	43.8 ± 8.8 (21–66)	0.939
3. Body mass index (kg/m^2)	23.4 ± 3.0 (17.2–31.8)	23.1 ± 2.7 (17.1–30.6)	0.869
4. Tumor size on histology (cm)	0.82 ± 0.38 (0.2–2.3)	0.83 ± 0.40 (0.1–2.7)	0.827
5. Multifocality/bilaterality	47 (43.5 %)/27 (25 %)	37 (34.2 %)/17 (15.7 %)	0.220
6. Extrathyroid extension	83 (77.9 %)	82[a] (76.8 %)	0.974
7. Lymph node metastasis	52[b] (49.5 %)	44 (40.7 %)	0.338
8. Thyroiditis (Hashimoto or lymphocytic)	37 (34.3 %)	40 (37 %)	0.776
Stimulated Tg (ng/mL)	1.4 ± 3.8[a] (<0.1–36.4)	1.4 ± 3.9 (<0.1–38.7)	0.564
Proportion of stimulated Tg <1.0 (ng/mL) (%)	70[a] (64.2 %)	78 (69 %)	0.593
TSH (μIU/mL)	107 ± 69[a] (0.6–445)	110 ± 62 (<0.05–265)	0.385
TBR: RAI uptake	12.8 ± 13.3 (1.0–83.6)	13.5 ± 13.3 (1.4–65.7)	0.319
RAI ablation sessions	1.97 ± 0.46 (1–3)	1.98 ± 0.52 (1–3)	0.774
RAI ablation dose (mCi)	65.8 ± 35.4[b] (30–380)	68.3 ± 34.6[b] (30–300)	0.468

BABA bilateral axillo-breast approach, *RAI* radioactive iodine, *TBR* thyroid bed-to-background ratio, *Tg* thyroglobulin, *TSH* thyroid-stimulating hormone

[a]One case unknown

[b]Four cases excluded from distant metastasis or abnormal RAI uptake

Robotic Thyroidectomy: Bilateral Axillo-Postauricular Approach (BAPA)

5

5.1 Introduction

While the bilateral axillo-breast approach (BABA) to endoscopic neck surgery resolves various benign and malignant thyroid and parathyroid diseases with minimal adverse effects and excellent cosmetic outcomes, it involves circumareolar incisions. Many patients, especially young female patients in westernized countries, are reluctant to have their breast involved. Consequently, we developed the bilateral axillo-postauricular approach (BAPA) that uses axillary and postauricular incisions.

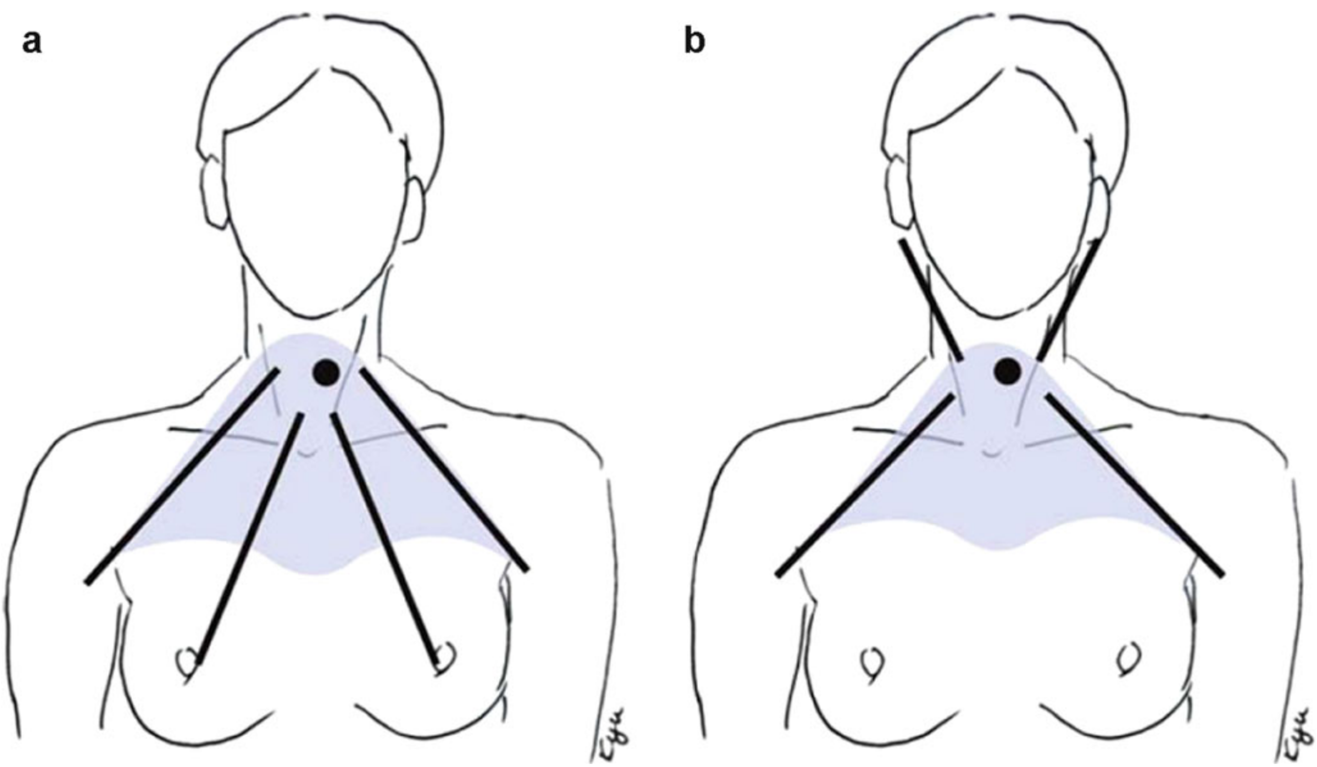


Fig. 5.1 Comparison between (**a**) BABA and (**b**) BAPA robotic thyroid surgery

The online version of this chapter (doi:10.1007/978-3-642-37262-9_5) contains supplementary material, which is available to authorized users.

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5.2 Patient Selection

We used the same eligibility criteria as for the BABA operation, namely, benign thyroid mass less than 5 cm in its largest diameter, papillary thyroid carcinoma not larger than 1 cm with low risk, follicular neoplasm, and parathyroid adenoma localized preoperatively. All patients consented to undergo BAPA robotic thyroid surgery.

5.3 Patient Position and Operating Room Setting

Under general endotracheal anesthesia, the patient was placed in a supine position. The neck was slightly extended, and both arms were mildly abducted to provide space for the insertion of the axillary ports. The operating room setting is shown in Fig. 5.2.

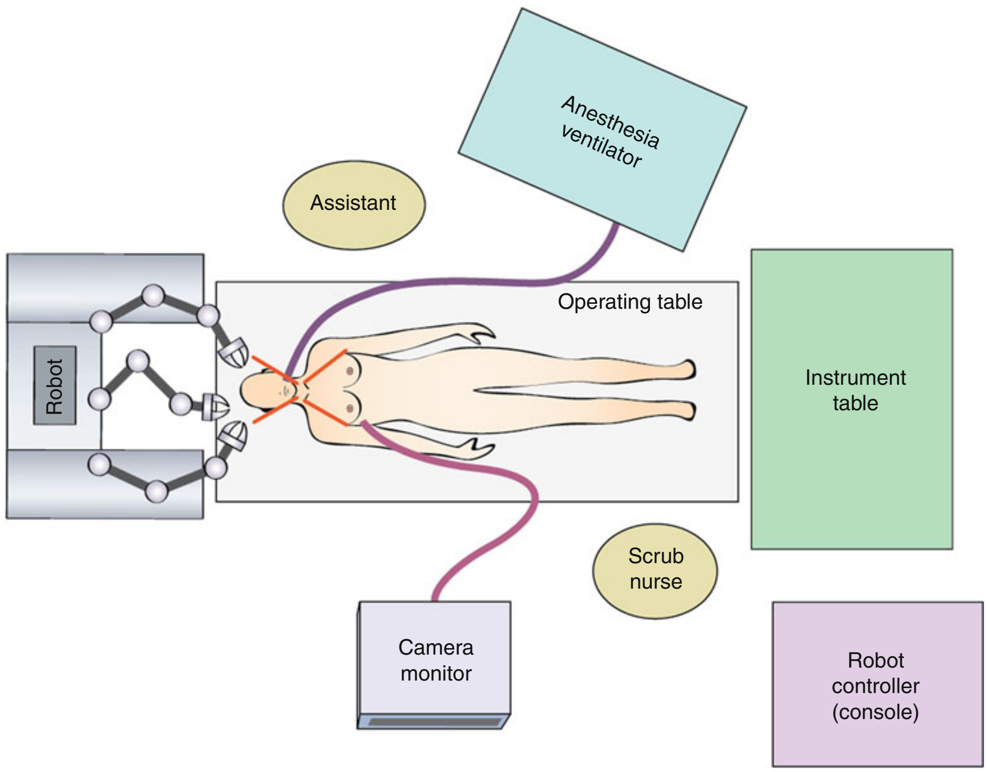

Fig. 5.2 Operative room setting for BAPA robotic thyroidectomy

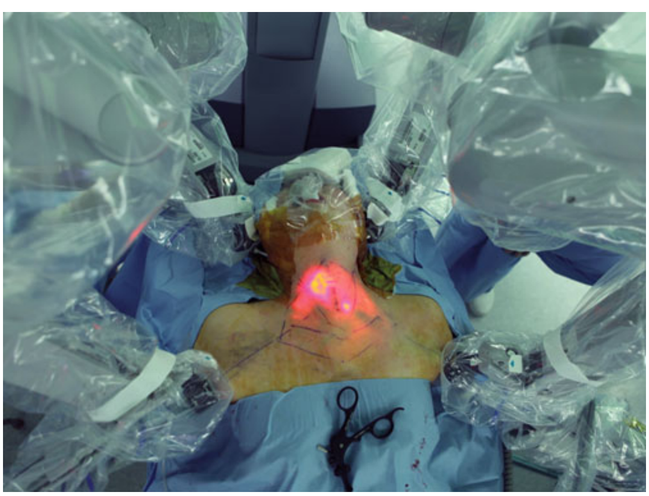

Fig. 5.3 Operative view of bilateral axillo-postauricular (BAPA) robotic thyroidectomy. One 12-mm trocar and one 8-mm trocar are inserted through axillary incisions, and two 8-mm trocars are inserted through postauricular incisions

5.4 Procedures of Bilateral Axillo-Postauricular Approach (BAPA) Robotic Thyroidectomy

5.4.1 Flap Dissection

We use 21-gauge spinal needles to subcutaneously infiltrate the subplatysmal space of the neck and the subcutaneous space of the axillary and anterior chest area with 1:200,000 diluted epinephrine solutions (1 mL of 1 % epinephrine in 200 mL of saline). Infiltration creates space for flap dissection and prevents bleeding. A 12-mm axillary incision is made at the lesion side, and subplatysmal and subcutaneous spaces are dissected bluntly with a vascular tunneler. The working space is extended superiorly, laterally, and inferiorly to the thyroid cartilage, the medial border of each sternocleidomastoid muscle, and the anterior chest, respectively. Thereafter, a 12-mm trocar is inserted, and the space under the flap is insufflated with low-pressure carbon dioxide gas (5–6 mmHg). Another incision is made at a contralateral axillary region, and an 8-mm trocar is inserted. Ultrasonic shears (i.e., Harmonic®; Ethicon Endo-Surgery, Cincinnati, OH, USA) are used to complete the dissection. Then, bilateral postauricular incisions are made and two 5-mm trocars are inserted.

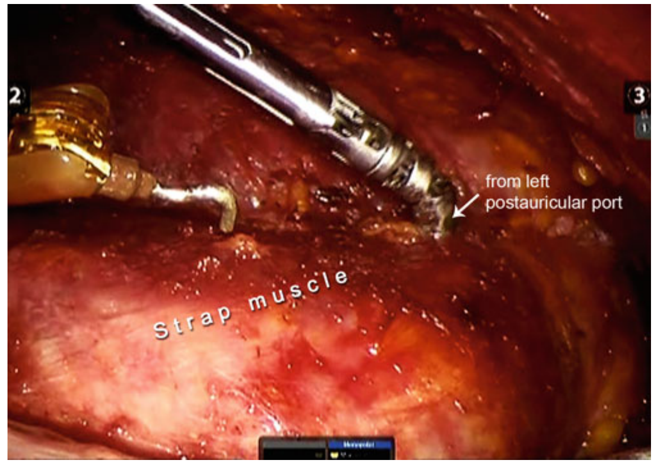

Fig. 5.4 Flap dissection

5.4.2 Midline Incision

The midline between the strap muscles is estimated by external palpation. By using a monopolar electrocautery hook, a midline incision is made between the strap muscles from the level of the thyroid cartilage to the suprasternal notch. During the dissection, bilateral strap muscles are retracted laterally with a Schertel grasper and a Maryland dissector.

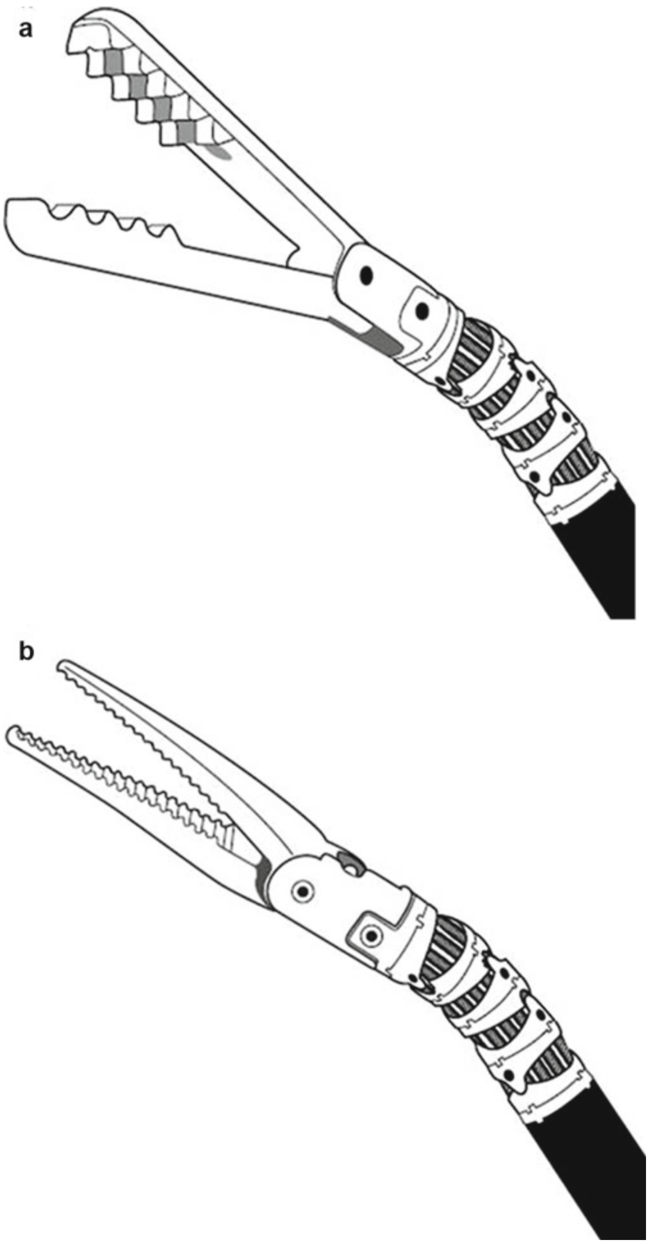

Fig. 5.5 5-mm da Vinci instruments for BAPA robotic thyroidectomy. (**a**) Schertel grasper and (**b**) Maryland dissector

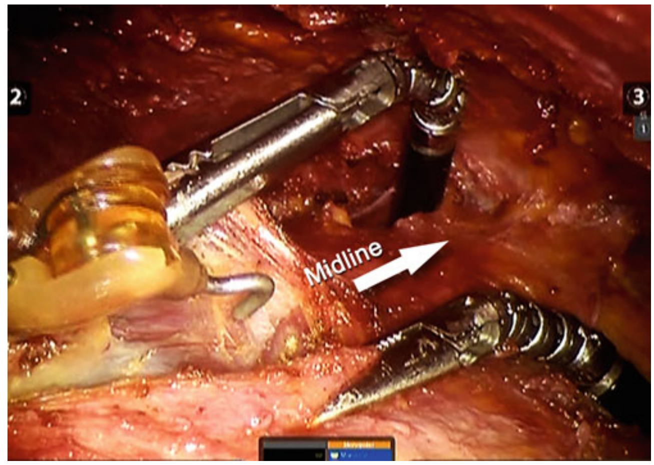

Fig. 5.6 Midline division

5.4.3 Isthmectomy and Lateral Dissection

The isthmus is divided by using ultrasonic shears or electrocautery. The thyroid gland is retracted in the medial direction with a Schertel grasper, and strap muscles are retracted laterally using a Maryland dissector. Thereafter, strap muscles are separated from the capsule of the thyroid gland. This dissection continues downwards towards the deep aspect of the gland which exposes the lateral side of the thyroid gland and the middle thyroid vein. The middle thyroid vein is separated with ultrasonic shears.

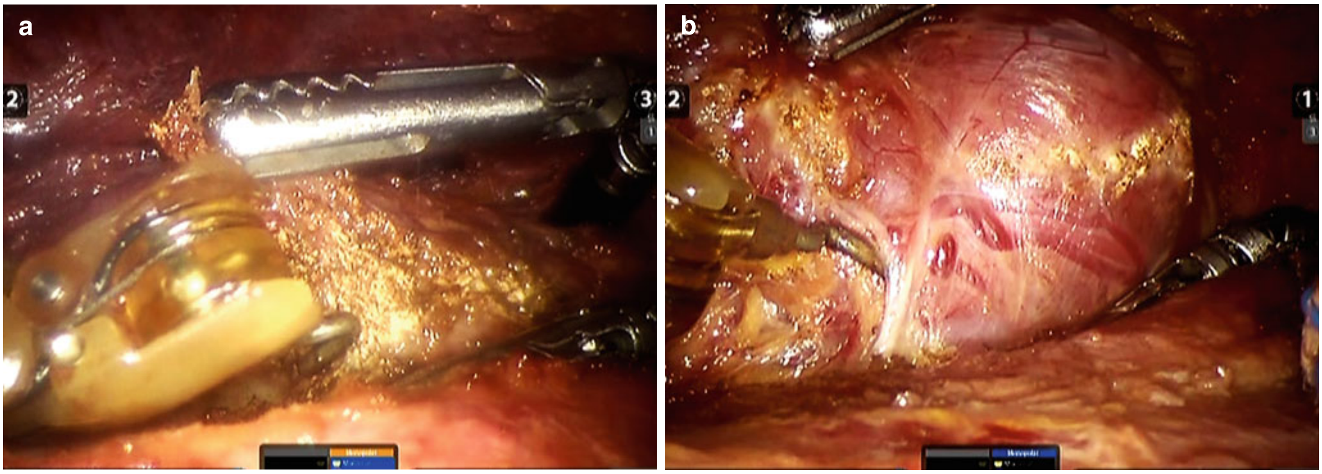

Fig. 5.7 (**a**) Isthmectomy and (**b**) lateral dissection

5.4.4 Preservation of the Recurrent Laryngeal Nerve

After dissecting the lateral region of the thyroid gland, the lower region is dissected. The inferior parathyroid gland, found at the lower pole of the thyroid gland, can guide the surgeon to the recurrent laryngeal nerve. After the nerve is marked, delineation of the nerve to the cricothyroid muscle is done carefully. The ligament of Berry is divided with ultrasonic shears.

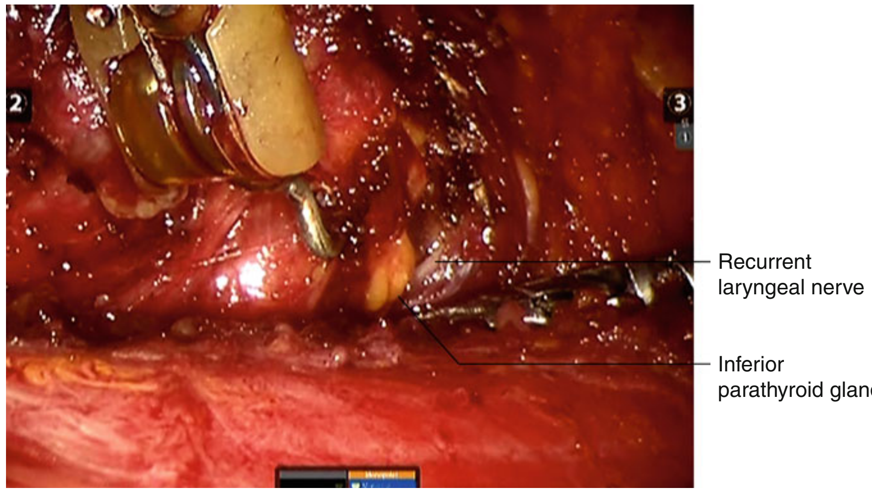

Fig. 5.8 Preservation of the recurrent laryngeal nerve

5.4.5 Specimen Removal and Closure

The specimen is pulled out through the 12-mm axillary port by using an Endobag. A frozen section of the resected specimen is examined histologically. Thereafter, hemostasis is reached, and the midline is repaired with absorbable sutures. A suction drain (Jackson-Pratt) is left in place. The skin is re-approximated with absorbable sutures and Steri-strip® skin closures.

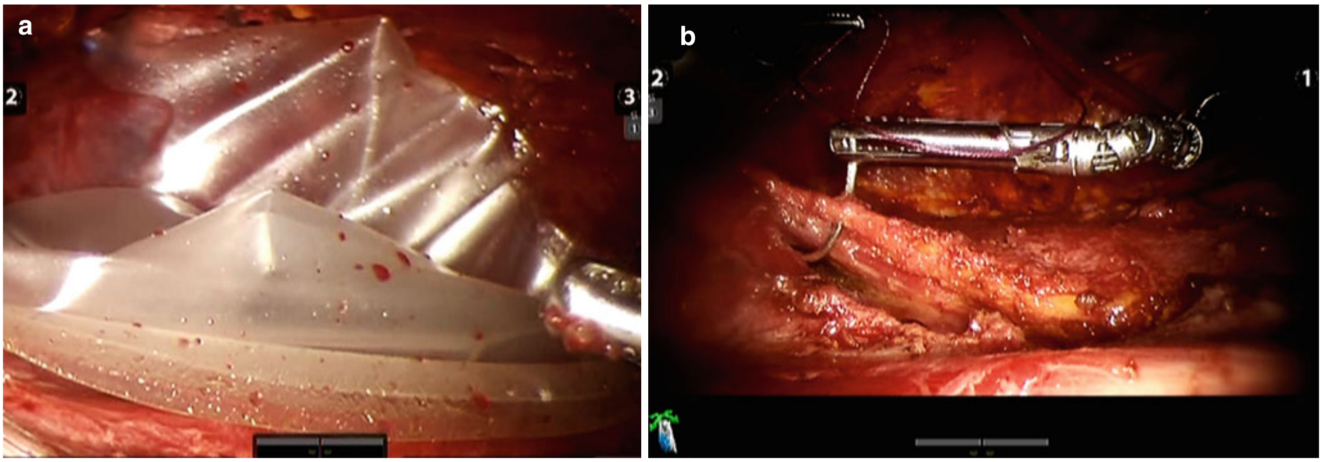

Fig. 5.9 (**a**) Specimen removal and (**b**) midline closure

5.4.6 Postoperative Result

No scars is visible in the neck and anterior chest, as well as in the axillary and postauricular area. When it comes to postauricular scars, it can be easily hid with hair.

Fig. 5.10 Postoperative results of BAPA robotic thyroidectomy after 6 weeks

6 New Energy Sources in Surgery

6.1 Evolution of the Ultrasonic Shears

6.1.1 Background

The ideal dissecting instrument is safe, selective, able to cut and coagulate, relatively easy to learn, and affordable. The search for such an instrument led us to the ultrasonic dissector. Harmonic® shears, which use 55,000 Hz of vibration to cut and coagulate, elicit minimal lateral tissue damage, charring and desiccation, and smoke for good visibility of the surgical site, as well as allowing no electricity to pass to the patient. It is widely used in general, gynecologic, urological, and minimally invasive surgeries. Harmonic shears® are also widely used in thyroid surgery.

6.1.2 High-Frequency Sound Wave Techniques

Ultrasound has had a strong impact on the practice of modern medicine, and depending on ultrasound frequency, it can be used in different ways. At low frequency, ultrasound causes no tissue damage and is mainly used for diagnostic purposes. At high frequency, by contrast, ultrasound can be used to dissect, cut, and coagulate. Several high-frequency ultrasonic devices are available.

Extracorporeal shock wave lithotripsy, which has been used to treat cholelithiasis and nephrolithiasis, is another beneficial adaptation of acoustic wave technology. In brief, the patient is placed in a water bath and a high-energy acoustic shock wave is generated by piezoelectric or electromagnetic technology. The water-tissue interface allows the wave to pass through normal tissue without injuring it. The energy of the shock wave is focused on the offending stone by ultrasound and causes disruption and fragmentation of the calculus, which is then passed via the ureter.

6.1.3 Harmonic® Shears

Harmonic® shears use ultrasound to dissect tissue with minimal collateral tissue damage. The high-frequency vibration of molecules within tissues generates stress and friction, which in turn generates heat and protein denaturation. Because of its unique ability to dissect and coagulate tissue simultaneously, this device has gained popularity among surgeons.

6.1.4 Ultrasonic Cavitation Devices

The Cavitron® ultrasonic surgical aspirator is an ultrasonic instrument that uses low-frequency ultrasound to fragment and aspirate tissue with low fiber (i.e., collagen) but high water content. It is basically an ultrasonic probe combined with an aspirator. The Cavitron® ultrasonic surgical aspirator has a wide variety of applications. Because it can fragment and aspirate tissues of low fiber and high water content, it is especially useful for liver and pancreatic procedures (e.g., for resecting lesions in noncirrhotic livers and for removing small pancreatic tumors in the absence of fibrosis). It has also been used for partial nephrectomy, salvage splenectomy, head and neck procedures, and gynecologic tumors. This device also elicits minimal blood loss and tissue injury and produces good visibility of the surgical site.

The online version of this chapter (doi:10.1007/978-3-642-37262-9_6) contains supplementary material, which is available to authorized users.

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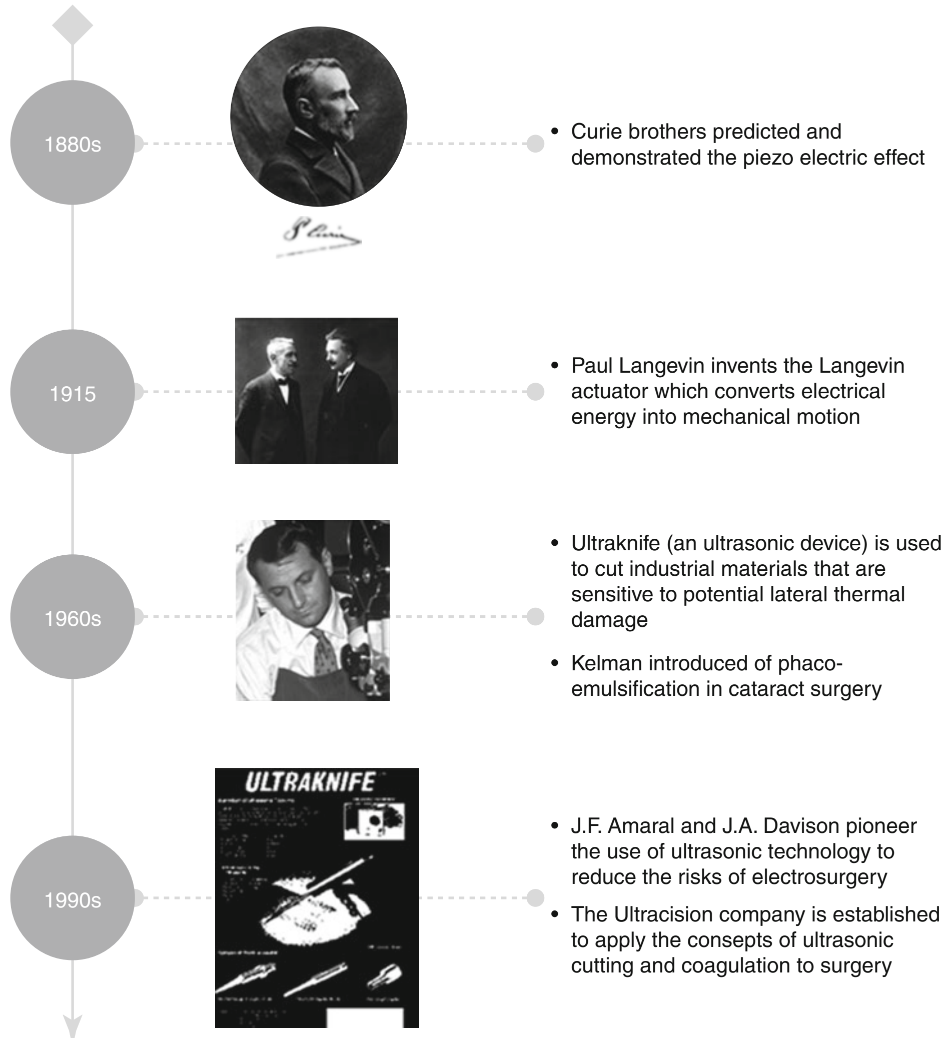
Fig. 6.1 History of the ultrasonic shears



6.2 Mechanism of Action of the Ultrasonic Shears

Harmonic® shears denature proteins which form a sticky coagulum. Blood vessels collapse and hemostatic seals form when tissue pressure is applied with the blade surface. Instrument precision is controlled by adjusting the power level, blade edge, tissue traction, and blade pressure.

Fig. 6.2 Harmonic® shears (Image courtesy of Ethicon Endo-Surgery). (**a**) The transducer generates ultrasonic vibration that makes an active blade vibrating 55,500 times a second. This mechanical energy allows simultaneously cuts and coagulates tissue, (**b**) various types of the tips

6.3 Advantage of Using the Ultrasonic Shears

Harmonic® shears provide atraumatic surgical dissection and hemostasis. Surgeons and patients benefit from the Harmonic® ultrasound technology in several ways:

(1) No electrical energy is passed to or through the patient.
(2) There is minimal thermal tissue damage, resulting in little tissue charring and desiccation.
(3) Great precision is achieved by accurate cutting and coagulation.
(4) There are few instrument changes, which simplifies the procedure.
(5) There is minimal blood.
(6) There is minimal smoke.

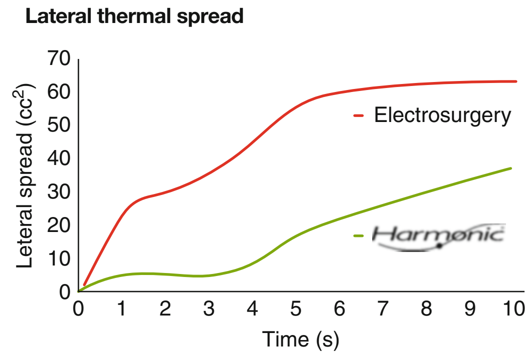


Fig. 6.3 Lateral thermal spread of the ultrasonic shears compared with electrocautery (Data courtesy of Ethicon Endo-Surgery)

6.4 Investigating the Safety of the Ultrasonic Shears on Canines

6.4.1 Introduction

Safety concerns exist with regard to damage of recurrent laryngeal nerve (RLN) by Harmonic® shears (HS). Preserving RLN integrity is of utmost importance during thyroid surgery. So there is concern about the safety margin of HS application near the RLN. A safety margin of at least 5 mm was used in a randomized trial, and there was no difference in postoperative vocal cord palsy between conventional and the ultrasonic shears. The aim of this study was to determine the least safe distance in a large-sized animal thyroidectomy model. To accomplish this aim, we used a canine model and compared three distances (i.e., 1, 2, and 3 mm) between the RLN and the application of HS. Results were assessed by laryngoscopic examination of vocal cords and histologic examination of morphological changes.

Fig. 6.4 Laryngoscopic evaluation of the vocal fold in a canine model

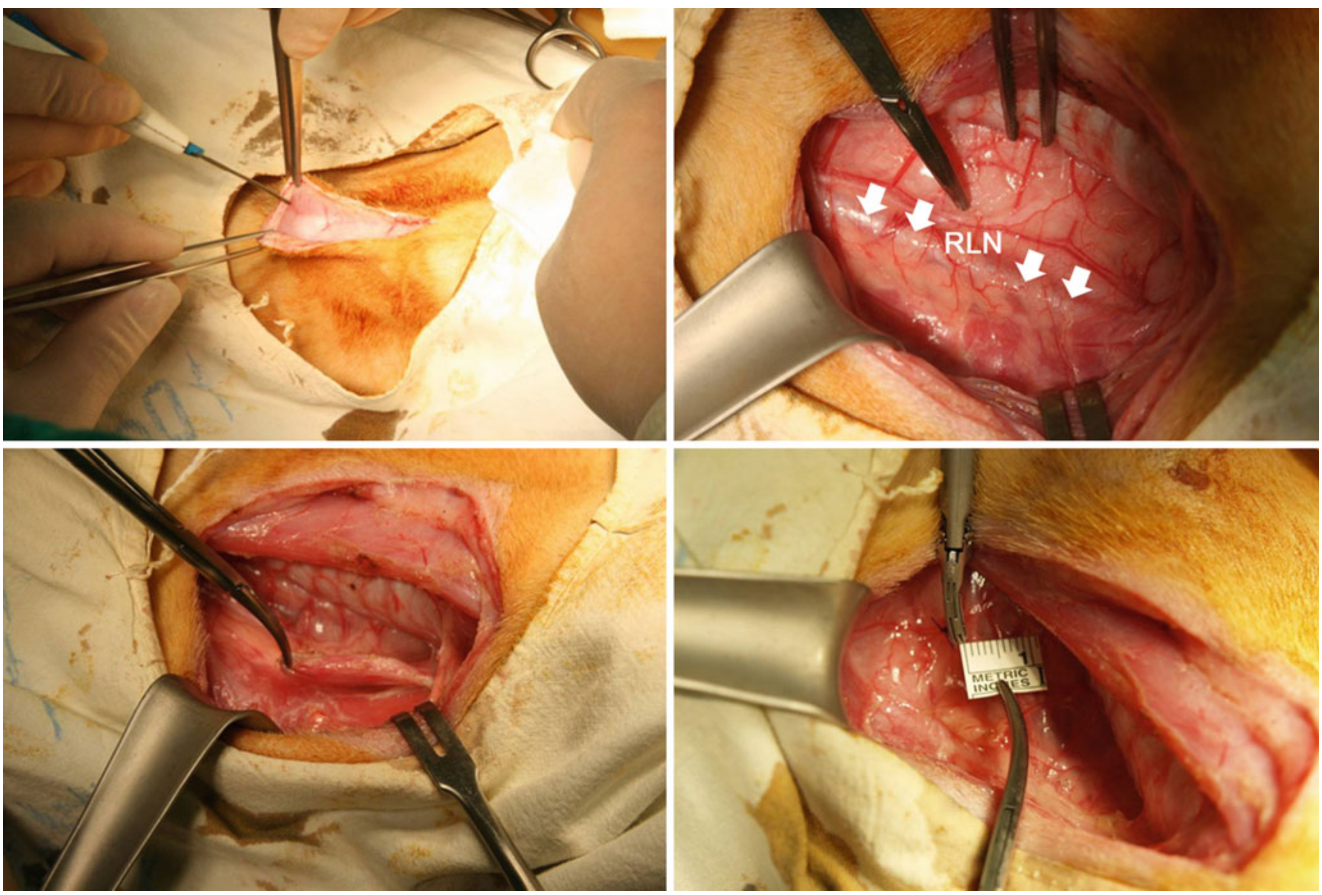


Fig. 6.5 Operation and identification of the recurrent laryngeal nerve in a canine model

6.4.2 Materials and Methods

After approval by the Institutional Animal Care and Use Committee (Institutional Animal Care and Use Committee of Clinical Research Institute, Seoul National University Hospital, 07156, 06-2006-210-9), nine male dogs weighing 17–21.5 kg were divided into three groups on the basis of distance from the RLN to the application of HS (i.e., 1, 2, and 3 mm). Animals were pretreated with 3–5 mg/kg zolazepam intramuscularly and 25 mg/kg cefazolin. Vocal cords were examined by direct laryngoscopy, followed by intubation and anesthesia (i.e., 1–3 % isoflurane). A 10-cm skin incision was made in the midline of the neck, and the left thyroid and RLN were identified. After performing left thyroid lobectomy, HS (Harmonic Ace 36P; Johnson & Johnson Medical, Cincinnati, OH, USA) were applied 1 (group 1), 2 (group 2), or 3 (group 3) mm from the RLN. HS were applied for 10 s using a low power level (70-μm vibration) (Fig. 6.6). The RLN was marked with a nonabsorbable suture to facilitate subsequent harvesting of the nerve, and the wound was closed. To eliminate variability, all procedures were performed by the same experienced surgeon. Aseptic techniques were used throughout the procedure. After surgery, 0.4 mL/kg meloxicam was given intramuscularly to control pain.

One week after surgery, the animals were once again pretreated with 3–5 mg/kg zolazepam, and vocal cords were examined by laryngoscopy. Two weeks after surgery, animals were reexamined by opening the neck and harvesting the left RLN. The RLN from each group was fixed in formalin for histologic examination. Thereafter, the right thyroid and RLN were identified, and HS were applied as described above (Fig. 6.6). The right RLN from each group was harvested and placed in formalin. Animals were then sacrificed humanely.

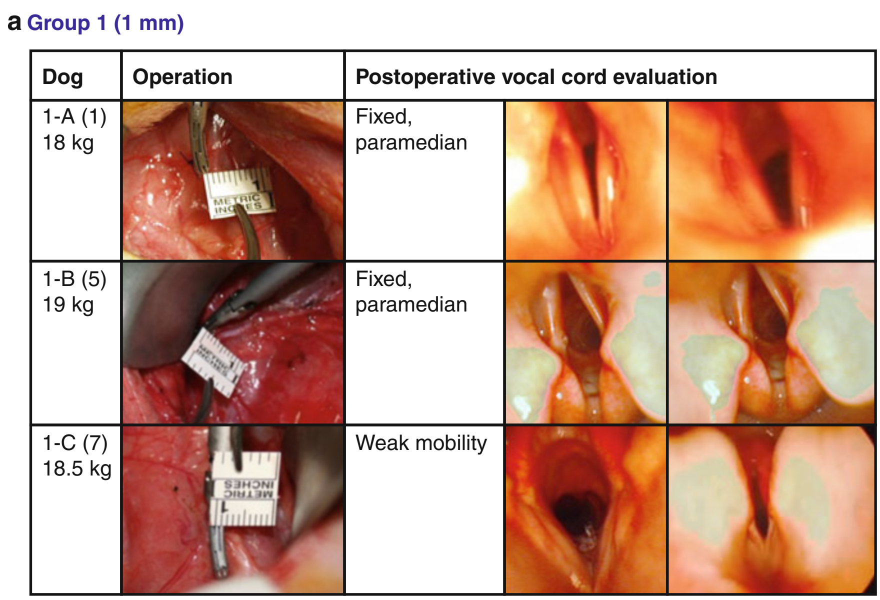
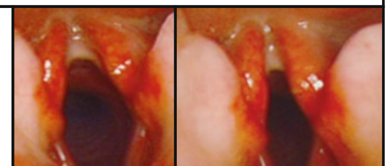
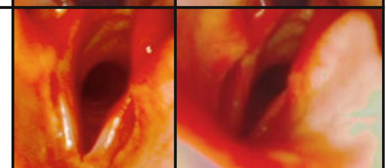
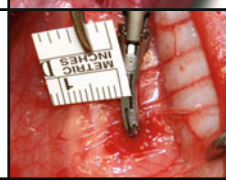
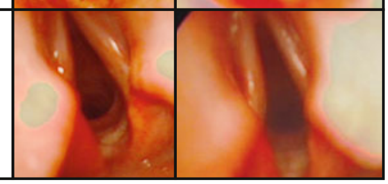


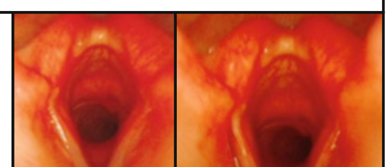
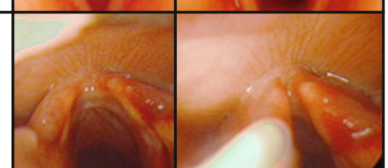
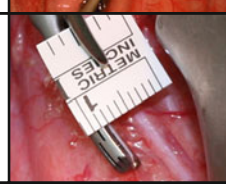
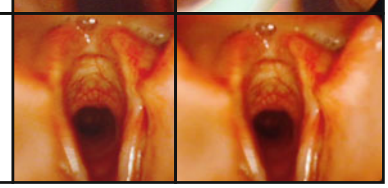
Fig. 6.6 Application of Harmonic® shears and laryngoscopic evaluation of vocal cords 1 week after surgery. (**a**) Group 1 for 1mm distance, (**b**) Group 2 for 2mm distance, and (**c**) Group 3 for 3mm distance

Fig. 6.6 (continued)

b Group 2 (2 mm)

Dog	Operation	Postoperative vocal cord evaluation	
2-A (3) 20.5 kg		Good mobility	
2-B (6) 17 kg		Fixed, paramedian	
2-C (9) 19 kg		Good mobility	

c Group 3 (3 mm)

	Operation	Postoperative vocal cord evaluation	
3-A (2) 20 kg		Good mobility	
3-B (4) 21.5 kg		Good mobility	
3-C (8) 21.5 kg		Good mobility	

6.4.3 Results

6.4.3.1 Functional Results

All animals demonstrated normal vocal cord movement prior to the initial operation. In group 1, fixed vocal cords and decreased vocal cord movement were observed in two and one animals, respectively, 1 week after surgery. In group 2, fixed vocal cords were observed in one animal. In group 3, there was no abnormality in vocal cord movement ($p = 0.020$).

6.4.3.2 Histologic Results

Eight left RLNs from all three groups were examined for subacute damage 2 weeks after the initial operation. Morphological changes, including swelling, vacuolar changes, and myelin and axonal loss, were observed in RLNs harvested from animals displaying abnormal vocal cord function. To assess acute damage, nine right RLNs from all three groups were histologically examined. Five of eight animals in group 1 exhibited morphological changes, including swelling, vacuolar changes, and myelin and axonal loss, while only one of seven animals in group 2 showed similar changes. Group 3 displayed no morphological changes.

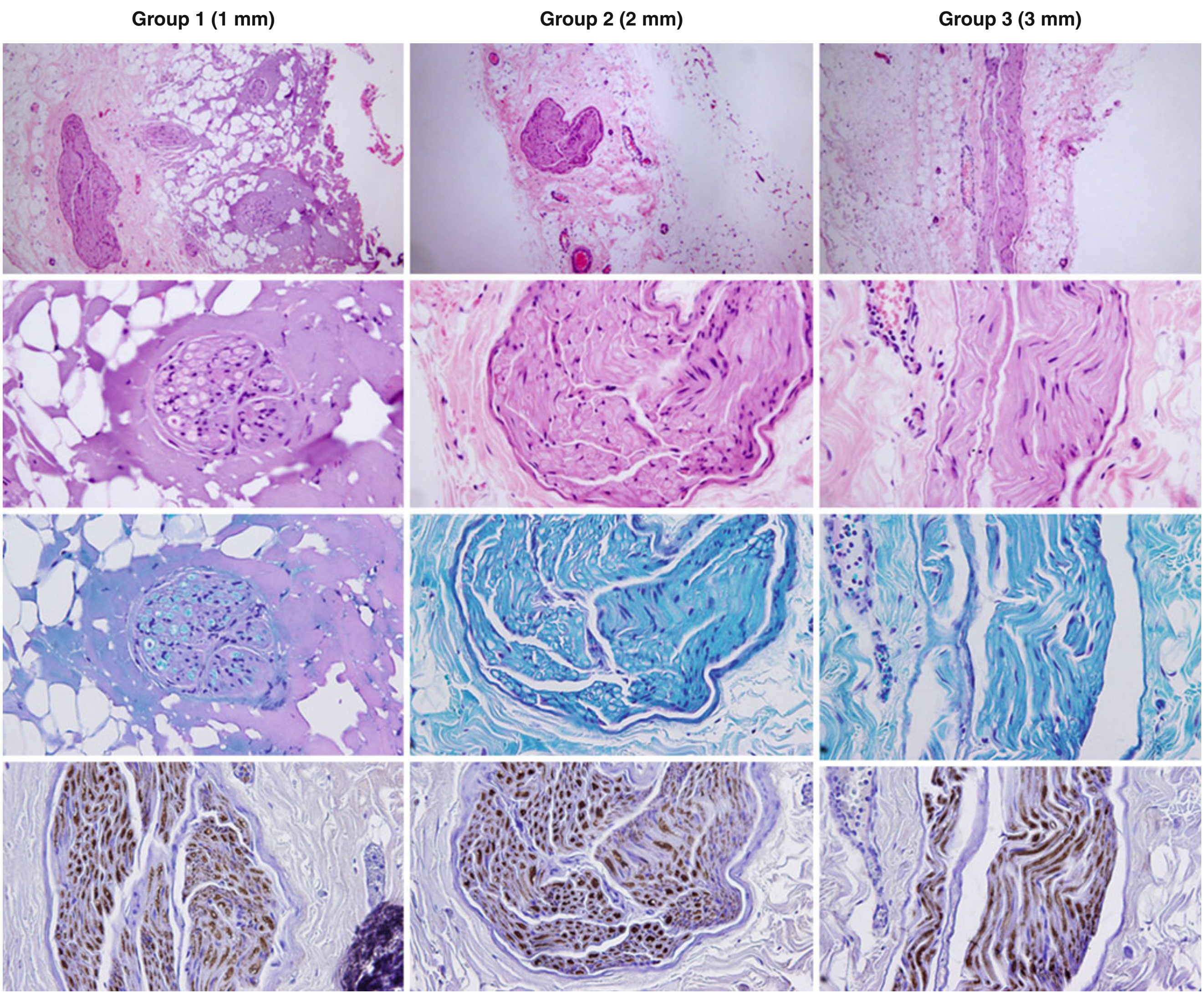


Fig. 6.7 Histologic results of the recurrent laryngeal nerve 2 weeks after surgery

Conclusions

On the basis of this study, we recommend the following clinical guidelines:

(1) Contact should not be made between the RLN and HS.
(2) A 10-s application at power level 3 is safe when applied at a RLN distance of 3 mm.
(3) Caution should be exercised with tip position.
(4) The shear jaws should be opened when the least thermal damage is needed.

As a conclusion, a distance of 3 mm between the RLN and the application of HS is safe in a canine model. This study would warrant further study to determine the clinically acceptable distance safety margin for the application of an energy device in the vicinity of the recurrent laryngeal nerve.

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Index

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