41 Robotic Transaxillary Thyroidectomy: A Modified Protocol for the Western Medical Community

Sang-Wook Kang, Emad Kandil, and Woong Youn Chung

Robotic transaxillary thyroidectomy is currently of great interest, particularly in Asia, Europe, and North and South America. Considerable research has shown that it is safe and that its outcome is at least equivalent, if not superior, to open thyroidectomy. It has been slow to gain widespread acceptance in clinical practice, however, perhaps because of reservations about its general applicability to all patient populations, uncertainty about the instruments involved, and questions about the willingness of insurance companies to fund the procedure. This chapter provides detailed information on the method and summarizes important modifications that may pave the way for its widespread adoption.

Robotic surgery has advanced greatly over the past decade, although its implementation has not kept pace, perhaps because of the limited availability of the technology or the hesitation of surgeons to adopt it. Another consideration is that coverage of the costs by patients' insurance companies is uncertain and varies according to the type and complexity of the procedure [1–3]. This general scenario describes the current state of robotic thyroidectomies, the topic of this chapter.

The thyroid gland is surrounded by critical nerves, organs, and vessels, so it is of primary importance to remove the thyroid without damage to the adjacent structures. Traditionally, removal has been accomplished with an open method that requires an incision in the skin of the neck that is approximately 4–6 cm long. The drawbacks of this method are a conspicuous scar and discomfort.

In recent years, minimally invasive approaches to thyroidectomies, including video-assisted surgery and a variety of endoscopic methods using remote site incisions, have been adopted in order to avoid the unsightly neck scars [4–8]. In 2007, these extracervical endoscopic thyroidectomies were successfully combined with dexterous robotic surgical systems. The facilitation of these surgeries with robotics was safe, and the surgical outcomes were comparable or even superior to those of conventional surgery. The results also had excellent cosmesis [9–11].

Transaxillary thyroidectomy, one of the endoscopic thyroidectomy methods that adopts an extracervical approach, is the focus of attention in this chapter. This method employs a lateral approach to the thyroid gland, and the operation view is quite similar to the open method. Consequently, it is easy for the surgeon to locate and preserve the recurrent laryngeal nerve (RLN) and parathyroid gland, to divide the superior thyroidal vessels securely, and to perform complete central compartment neck lymph node dissection, should there be a malignancy [8, 9, 11–17]. Since the first robotic thyroidectomy, numerous studies have shown that transaxillary robotic thyroidectomies are safe and practical and have outcomes that compare well with those of the conventional open method [9–17].

Transaxillary thyroidectomy requires incision of the skin of the armpit area and an additional subcutaneous tunnel to the thyroid gland, a wide dissection that cannot be considered minimally invasive. Nonetheless, many researchers conclude that it is superior to the open procedure with respect to many postoperative factors: patients experience less discomfort, less modification of their voices and sensory functions, and better cosmesis. An additional consideration is that the transaxillary procedure offers excellent ergonomics to the surgeon [18, 19].

This chapter introduces a detailed method for transaxillary robotic thyroidectomy, including some minor modifications that should enhance its applicability to Western medicine.

Surgical Indications for Transaxillary Robotic Thyroidectomy

Candidates for transaxillary robotic thyroidectomy should be diagnosed with surgical disease. The diagnosis should be histologically confirmed by ultrasonography-guided fine-needle aspiration biopsy. Staging neck ultrasonography and a neck CT scan can be used to evaluate preoperative clinical stages.

S.-W. Kang, MD (✉) · W. Y. Chung
Department of Surgery, Yonsei University College of Medicine, Seoul, South Korea
e-mail: oralvanco@yuhs.ac

E. Kandil
Department of Endocrine Surgery, Tulane University School of Medicine, New Orleans, LA, USA

Y. Fong et al. (eds.), *The SAGES Atlas of Robotic Surgery*, https://doi.org/10.1007/978-3-319-91045-1_41

Transaxillary thyroidectomy can limit the surgeon's working field. There is no preformed space for working on the neck area, and the newly developed access route to the thyroid gland can be a major space restriction. Hence, the volume of thyroid gland, the tumor size, and the tumor location should be evaluated and considered before the surgery is planned. Patients with conditions that result in an enlarged thyroid, including multinodular goiter, thyroiditis, and Graves' disease, are not good candidates for the surgery, as the enlarged gland can limit the working space and result in easy tearing of the tissue and bleeding.

The ideal candidate for transaxillary robotic thyroidectomy is one who has a follicular neoplasm with a tumor no larger than 5 cm. When the tumor is malignant, it is safest to limit the procedure to cases with well-differentiated thyroid carcinomas composed of tumors of 2 cm or less that have no definite extrathyroidal tumor invasion (T1 lesions). Finally, patients with malignant lesions in the dorsal thyroid, especially adjacent to the tracheoesophageal groove, are at risk for injury to the trachea, esophagus, or RLN during surgery and are not good candidates.

As robotic surgical experience accumulates, it seems likely that it will be possible to employ the technique in most cases, including advanced ones.

The following criteria for transaxillary robotic thyroidectomy are currently used for thyroid malignancy in high-volume centers:

- Surgery is *indicated* only when the thyroid carcinoma is well-differentiated.
- Surgery is *indicated* usually when the primary tumor is less than 4 cm.
- Surgery is *acceptable* when there is minimal invasion by the tumor into the anterior thyroid capsule and strap muscle.
- Surgery is *contraindicated* when there is definite tumor invasion to an adjacent organ such as the RLN, esophagus, major vessels, or trachea.
- Surgery is *contraindicated* when any coexisting substernal or retropharyngeal lymph node is involved by the cancer.
- Surgery is *contraindicated* when there is any evidence for perinodal infiltration of the lymph node to an adjacent organ: the internal jugular vein, common carotid artery, vagus nerve, or RLN.

Table 41.1 Special equipment needed for robotic thyroidectomy

Procedure	Instruments or materials
Patient position	Arm board Soft pillow
Creation of skin flap	Electrocautery with regular and extended-sized tip Vascular Debakey or Russian forceps (extended length) Army-navy retractor × 2 Breast lighted retractor × 2
Maintenance of working space	Chung's external retractor system (Fig. 41.2a) Or Modified retractor system (Fig. 41.2b)
Robotic procedure	5-mm Maryland dissector 8-mm ProGrasp™ forceps 5-mm harmonic® curved shears Dual-channel 30° endoscope Endoscopic rolled gauzes Endoscopic suction irrigator

Preparations

Special Instruments

The patient's arm on the lesion side will be fixed over the patient's head with an arm board that can be attached to the operating table. The neck will be extended with a soft pillow. As listed on Table 41.1, several devices will be needed during the creation of working space: electrocautery that has both a regular and a long tip, a vascular Debakey or Russian extended length forceps, two Army-Navy retractors, and breast lighted retractors (Fig. 41.1). The working space will be maintained with an external retractor system consisting of Chung's retractors or another modified type of retractor for robotic thyroidectomy (Fig. 41.2). For the robotic procedures, either the da Vinci® S or Si system (Intuitive Surgical, Sunnyvale, CA, USA) should be acquired, as well as three other robotic instruments: a 5-mm Maryland dissector, an 8-mm ProGrasp™ forceps (Intuitive Surgical), and 5-mm Harmonic® curved shears (Intuitive Surgical). A dual-channel camera (30°, used in the down view position) also will be needed. Harmonic® curved shears are the preferred energy device.

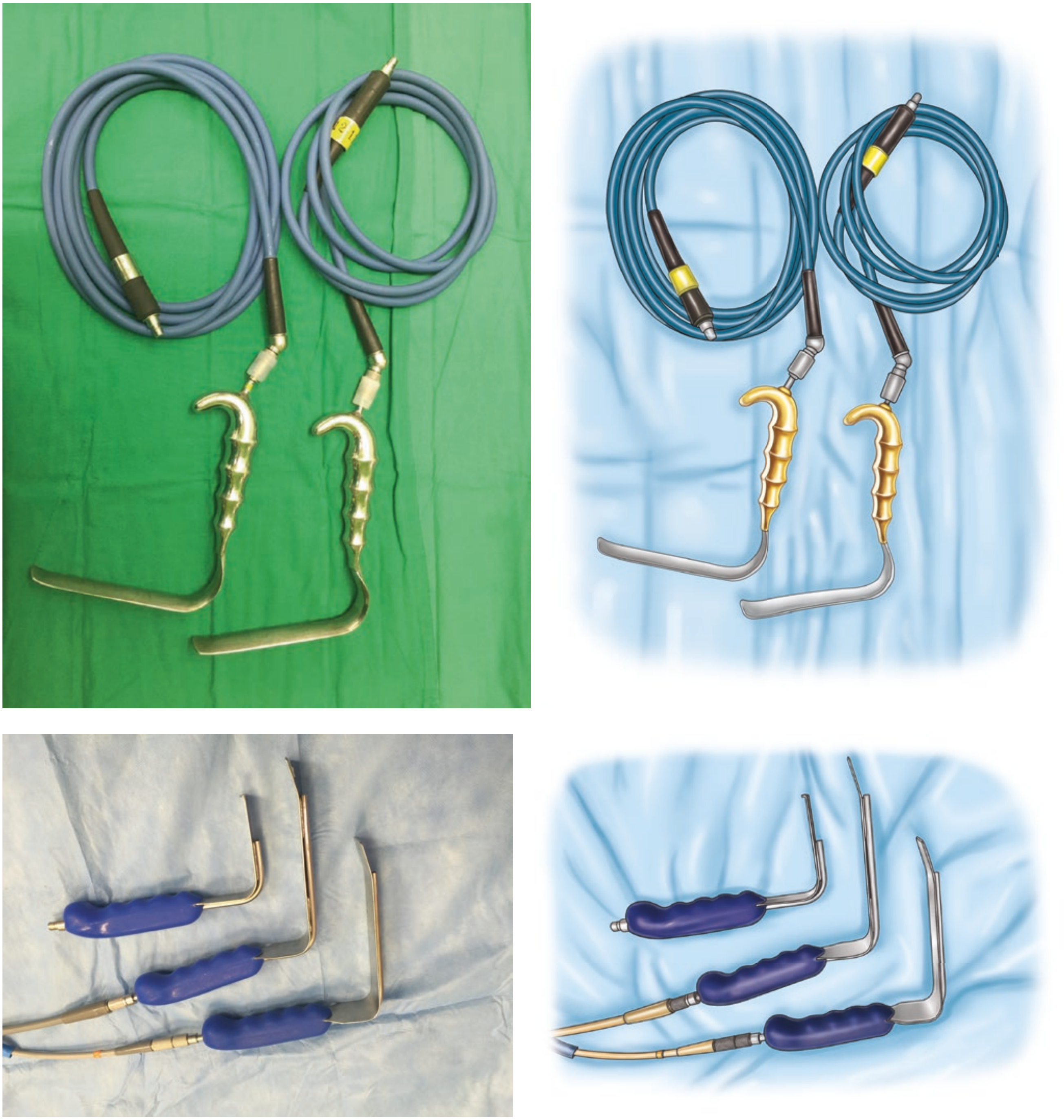

Fig. 41.1 Breast lighted retractor

Fig. 41.2 External retractor system. (**a**) Original Chung's retractor (BR Holdings, Seoul, Korea). Modified special retractor set (**b**) and blade (**c**) for big and obese patients (Marina Medical, Sunrise, FL, USA)

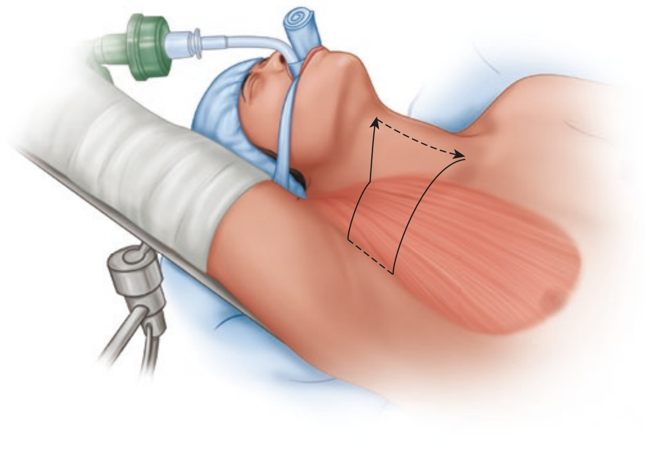

Fig. 41.3 Original patient positioning

Patient Position

The patient is placed in a supine position under general anesthesia, with the neck slightly extended with a soft pillow inserted under the shoulder. The lesion-side arm is raised and fixed to provide the shortest distance from the axilla to the anterior neck, shown in Fig. 41.3. If the patient is obese or has limited shoulder motion, the arm position is slightly modified (Fig. 41.4) by raising the lesion-side arm, bending it at the elbow, and placing the forearm just over the forehead without straightening the elbow. In this position, the arm can be placed and fixed using the soft pillow and pads without arm boards. This position also carries a low risk of stretching injury to the brachial plexus.

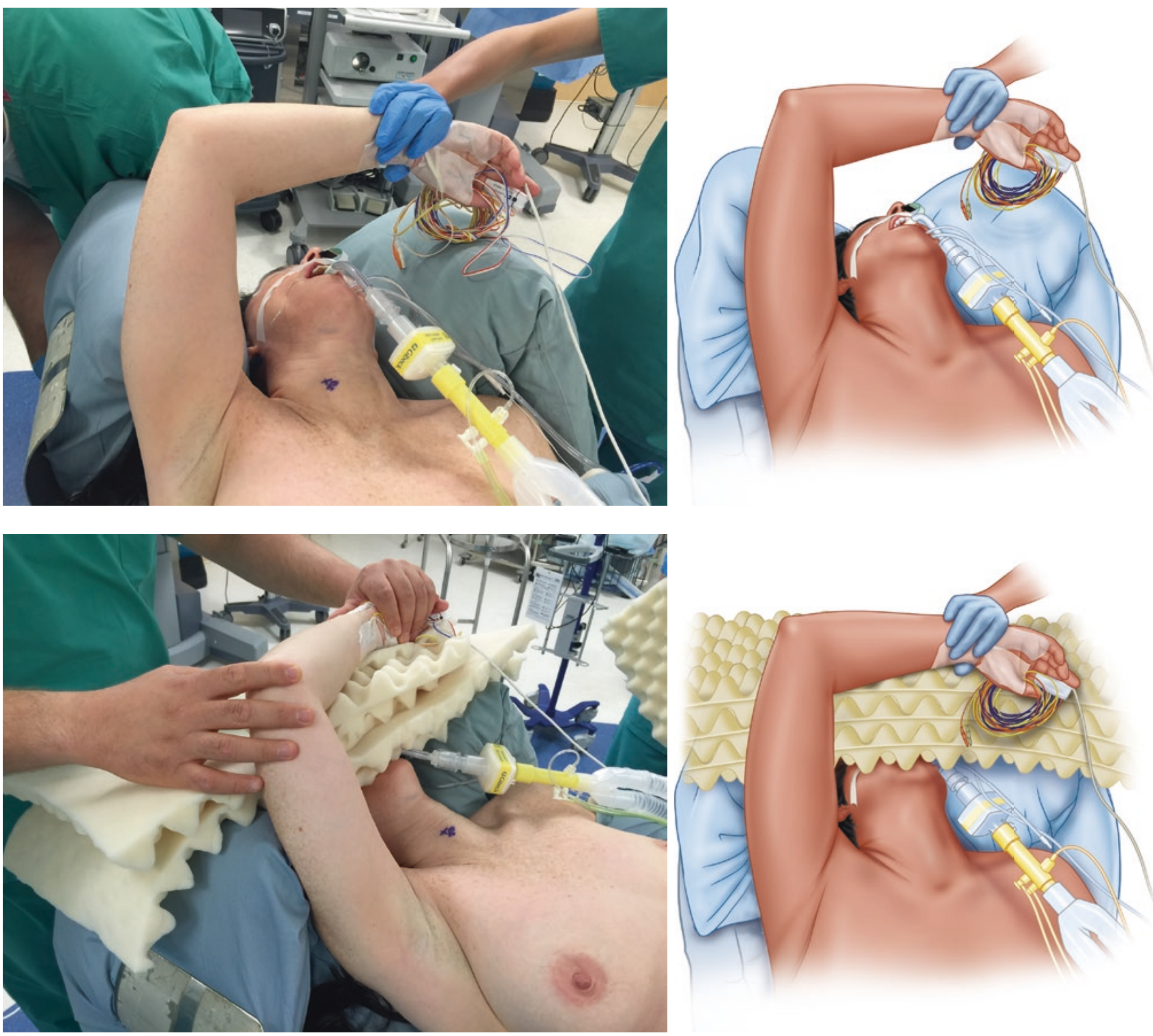

Fig. 41.4 Modified patient position for obese patients or patients with stiff shoulder joints

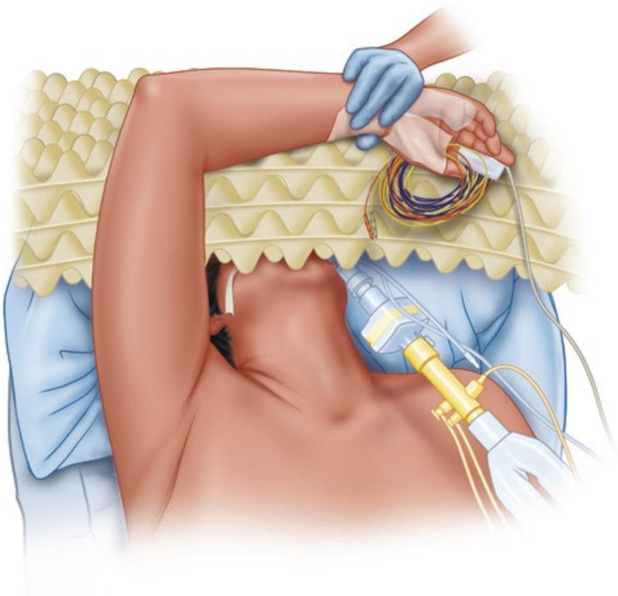

Fig. 41.4 (continued)

Surgical Techniques

Protocol for Development of Working Space

A curvilinear skin incision about 5–6 cm in length is made in the axilla along the anterior axillary fold. A subcutaneous skin flap is made over the anterior surface of the pectoralis major muscle from the axilla to the clavicle and the sternal notch. After crossing the clavicle, an adequate subplatysmal skin flap is created. It is recommended that an adequate extent of subplatysmal flap should also be made in the posterior neck area. The flap is dissected medially to the medial border of the sternocleidomastoid (SCM) muscle under direct vision. At this point, the dissection continues through the avascular space between the sternal and clavicular heads of the SCM muscle. The breast lighted retractor is the best choice for viewing the inside of the flap; some of the other tools are too short. Upon opening the avascular space between the heads of the SCM muscle, the superior belly of the omohyoid muscle and the internal jugular vein (IJV) usually can be identified. These are carefully detached from the lateral aspect of the thyroid gland, exposing the full lateral aspect of the gland. The strap muscle is detached from the anterior surface of the thyroid gland and lifted until the contralateral lobe of the thyroid gland is exposed (Fig. 41.5). Next, the blades of the external retractor system are inserted through the skin incision in the axilla and maneuvered to lift up the skin flap, the sternal head of the SCM muscle, and the strap muscles together, serving to maintain the working field for the robotic procedure (Fig. 41.6).

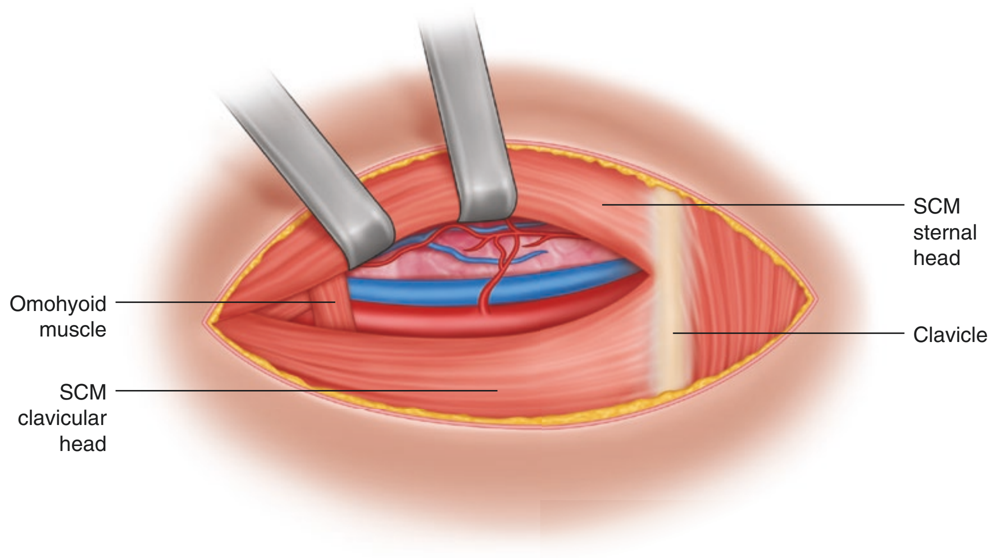

Fig. 41.5 The route of transaxillary approach (the space between two branches of sternocleidomastoid [SCM] muscle)

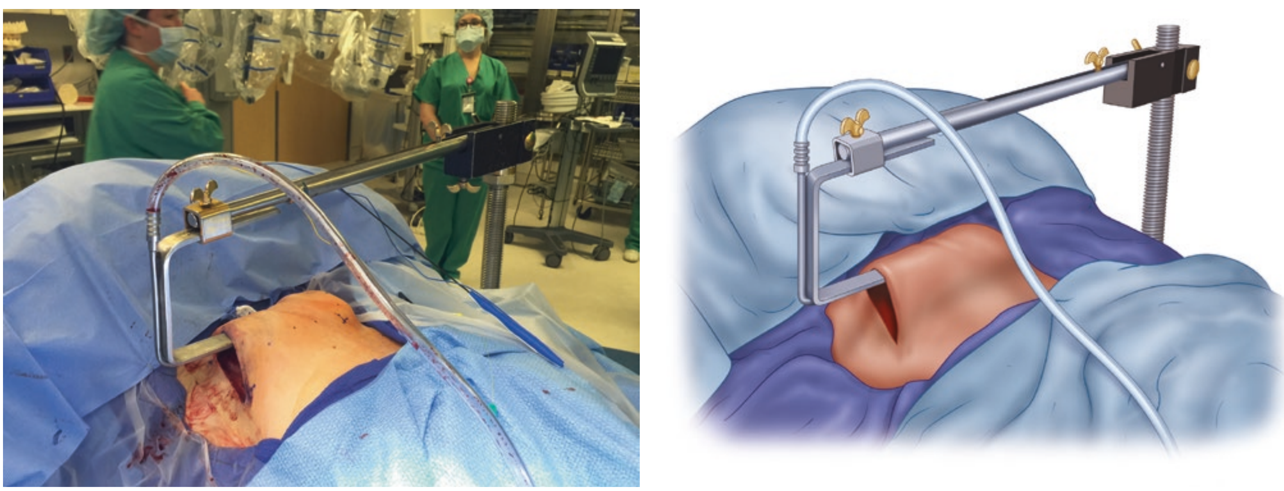

Fig. 41.6 The blades of the external retractor system elevate the skin flap, sternal head of the SCM muscle, and strap muscles together to maintain the working field for the robotic procedure

Protocol for Docking and Instrumentation

All the robotic arms are inserted through the axillary incision. Interference between the robotic arms can be a problem, and the guidelines in this protocol should prevent this interference. The critical issues are correct placement of the ProGrasp™ forceps, the ideal angles of the robotic arms, and maintenance of the correct interarm distances.

The patient cart is placed on the lateral aspect of the patient, opposite to the route of approach. The robotic column is located near the operating table so that the robotic camera is in a straight line with the axis of the external retractor (Fig. 41.7). For an approach from the right side, a 12-mm trocar for the camera and a 30° dual-channel endoscope are located in the center of the axillary incision. The camera is inserted in the upward direction: its external third joint is in the lowest part

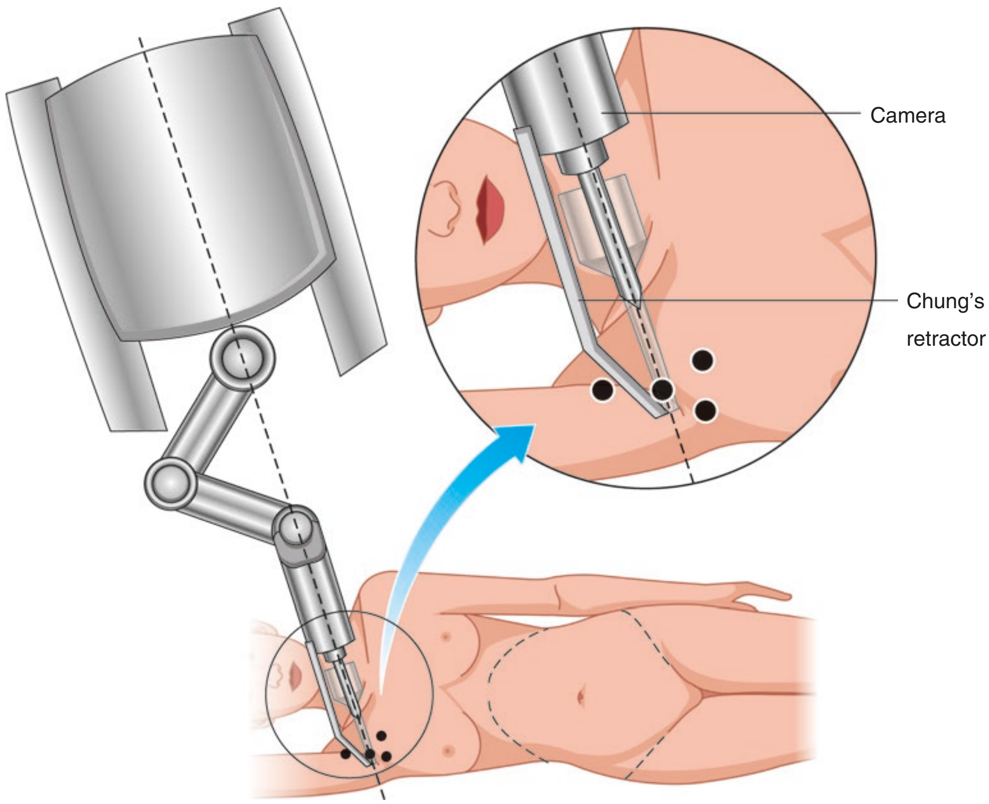

Fig. 41.7 Adjustment of the operating table for optimum efficiency. The robotic camera should be in a straight line between the robotic column and the surgical approach route (the direction of retractor insertion)

(floor) of the incision entrance, with its tip directed upward. An 8-mm trocar for the ProGrasp™ forceps is then positioned to the right of the camera, parallel with the suction tube of the retractor blade. At this point, the ProGrasp™ forceps are located as close as possible to the ceiling of the working space (the retractor blade). The 5-mm trocar of a Maryland dissector is then positioned on the left of the camera, also at the left edge of the incision, and the 5-mm trocar for the Harmonic® curved shears at the right side of the camera, at the right edge of the incision. Instruments should be as far apart as possible and inserted upward, in the same direction that the camera is inserted (Fig. 41.8).

Protocol for Robotic Total Thyroidectomy with Central Compartment Neck Dissection

The Harmonic® curved shears are used for ligations of vessels and hemostasis. With traction of the upper pole of the thyroid gland in the medio-inferior direction by the ProGrasp™ forceps, the superior thyroid artery and veins are individually divided (Fig. 41.9). The upper pole of the thyroid gland is pulled steadily for countertraction with the ProGrasp™ forceps. Frequent repositioning allows optimal exposure of the superior parathyroid gland and Zuckerkandl's tubercle of the thyroid gland. The thyroid

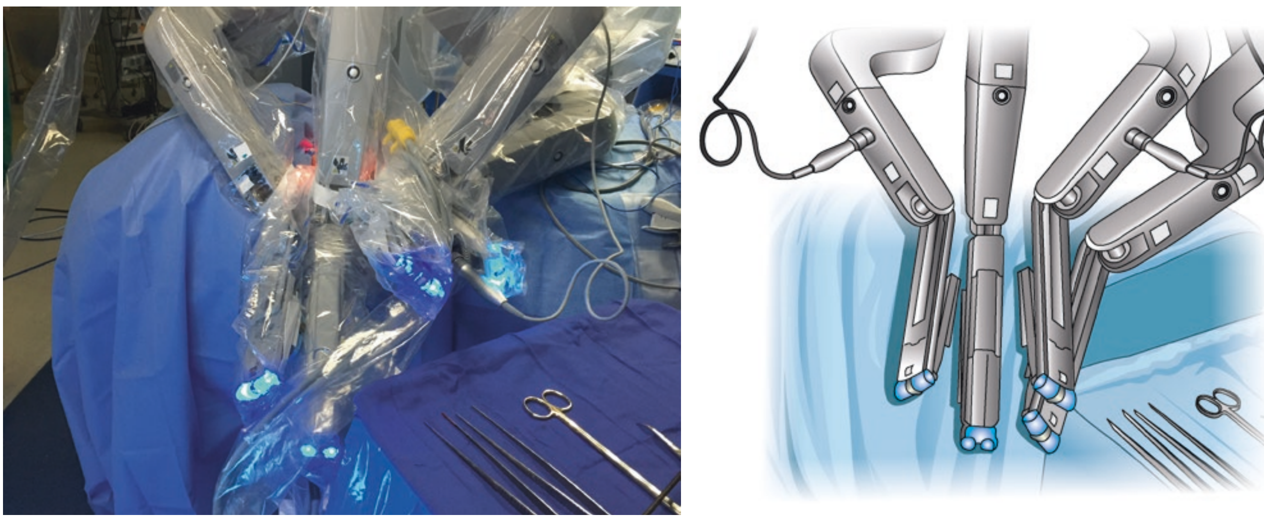

Fig. 41.8 Placement of robotic instruments. The camera should be placed down in the center of the skin incision in an advanced upward direction. Two instruments should be introduced through the caudal side, with the camera as the center. The ProGrasp™ forceps should be inserted and secured to the highest part of the working space, close to the retractor blade (caudal side of the retractor). The Maryland dissector and Harmonic® curved shears should be located on both ends of the skin incision, as far apart as possible

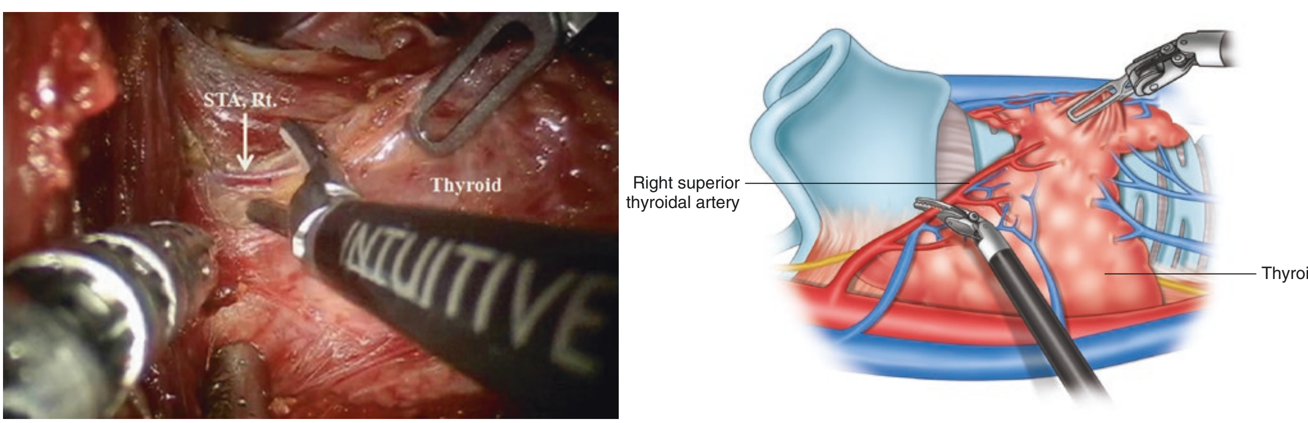

Fig. 41.9 The ligation of superior thyroidal vessels. With medio-inferior traction of the thyroid gland, the pedicles of superior thyroidal vessels are exposed and can be individually divided

gland is peeled from the cricothyroid muscle; this method allows the identification and preservation of the superior parathyroid gland (Fig. 41.10). The upper pole dissection is continued until the superior part of Zuckerkandl's tubercle is exposed, using great care around the RLN insertion site. The next step follows upper pole mobilization but is not attempted until the RLN is identified and traced along its whole path (Fig. 41.11). After this, the central compartment lymph node is dissected, preserving the critical structures. This step involves complete detachment of the thyroid gland and central lymph nodes from the trachea. In the Berry ligament region, great caution is required to prevent direct or indirect thermal injury to the RLN by the Harmonic® curved shears. After right lobectomy of the thyroid gland, contralateral lobectomy of the thyroid is performed by subcapsular dissection, taking care to preserve

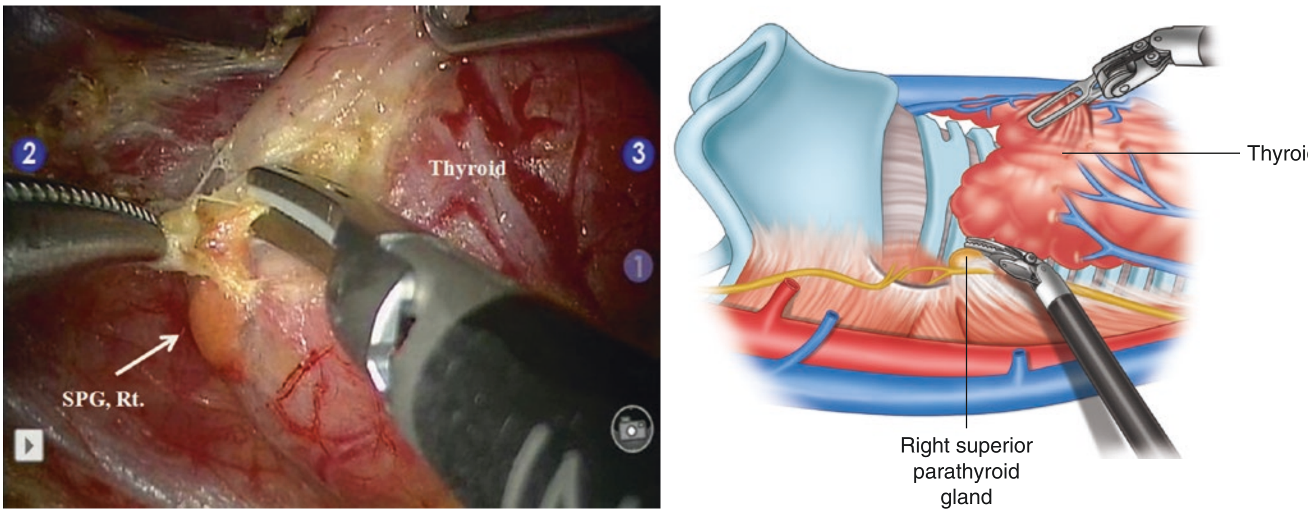

Fig. 41.10 Identification of the superior parathyroid gland. The superior parathyroid gland is identified and preserved by detaching the thyroid gland from the cricothyroid muscle

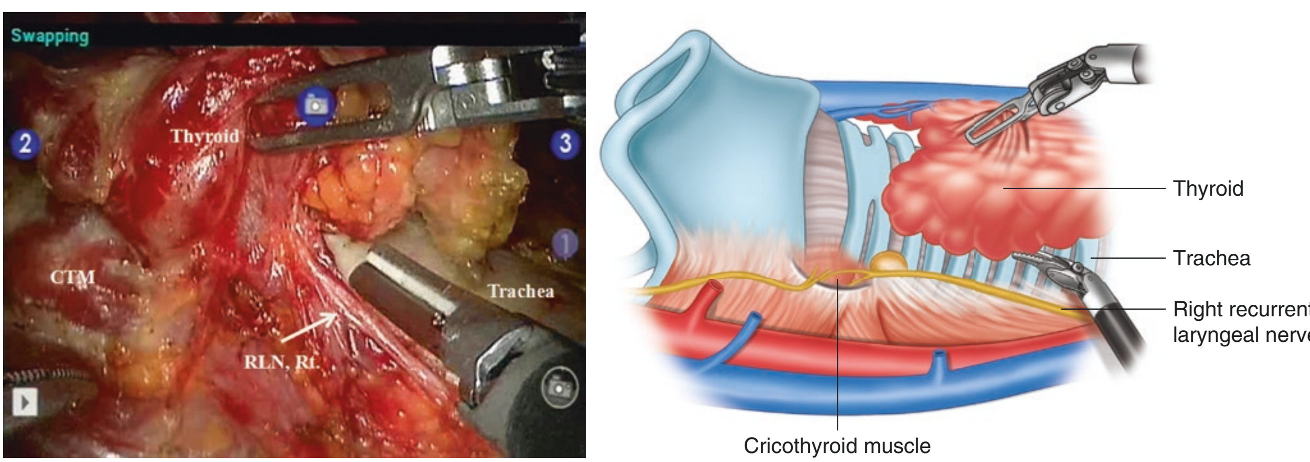

Fig. 41.11 Ipsilateral recurrent laryngeal nerve (RLN) identification. After tracing the whole running course of the RLN, the thyroid can be detached from the trachea completely

the parathyroid glands and the RLN (Figs. 41.12 and 41.13). In some cases (e.g., a male patient or one with a prominent trachea), it is possible to achieve better exposure of the contralateral tracheoesophageal groove by tilting the operating table to 10–15°, left side up.

After extraction of the specimen, irrigation is performed to clean the operative fields. Finally, a 3-mm closed-suction drain is inserted through a separate skin incision below the axillary skin incision, and the wound is closed cosmetically (Fig. 41.14).

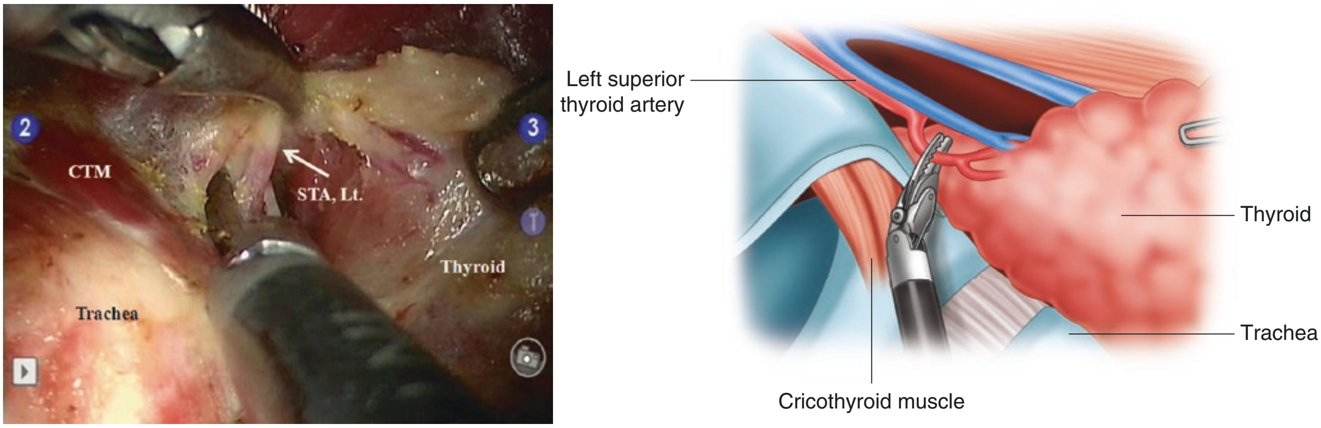

Fig. 41.12 Ligation of contralateral superior thyroidal vessels. With the inferolateral traction of the contralateral thyroid gland, the space of Reeves can be identified and the superior thyroidal vessels can be safely divided

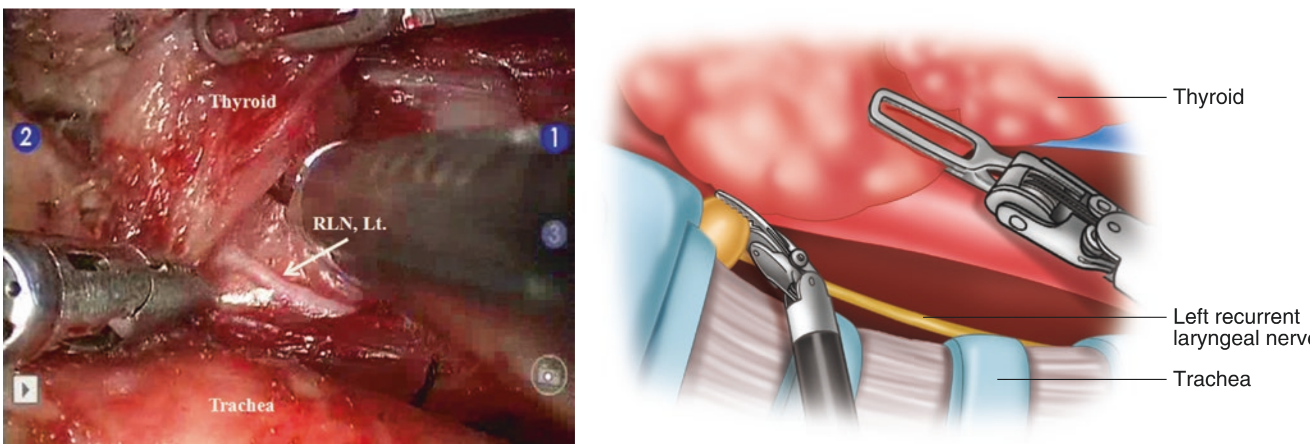

Fig. 41.13 Identification of the contralateral RLN. Contralateral thyroidectomy usually proceeds with the subcapsular dissection to preserve the parathyroid gland and RLN

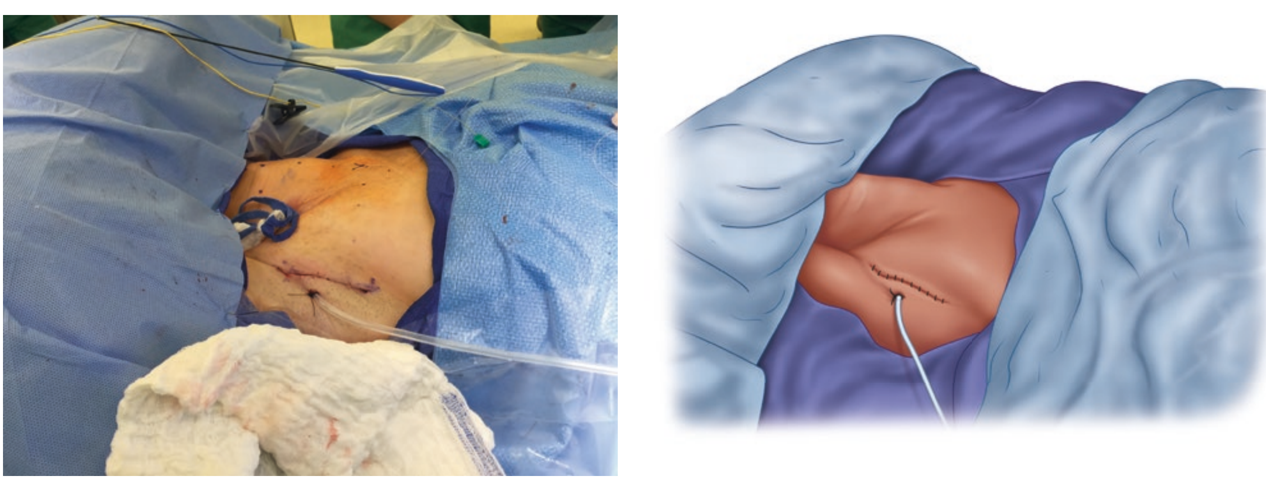

Fig. 41.14 Postoperative wound after drain insertion and skin closure

Postoperative Management

Postoperative pain can be controlled with the usual postoperative medication regimen. The period of drain placement after the operation usually depends on the patient's age, medication, and underlying disease; it can be safely removed without the risk of postoperative seroma if there is less than 50 mL of drainage per day. Discharge and the outpatient follow-up plan should be based on the surgeon's experience and preference.

Complications

The typical complications of any thyroidectomy, regardless of the surgical methods, are transient or permanent hypoparathyroidism, injury to the RLN or the superior laryngeal nerve, hemorrhage, seroma, and wound infection. The robotic approach carries some specific risk of complications such as injury to the skin flap (either thermal or from penetration), injury to the IJV or trachea, and ipsilateral arm paralysis. The injury to the skin flap or IJV may occur during the creation of the skin flap and is most likely when the surgeon is inexperienced with the approach. Tracheal injury is possible due to the lateral approach of this method and the possible reduction of the surgeon's tactile sensation by the robotic instruments. Injury to the tracheal wall is particularly likely around the Berry ligament if the operational field is not properly maintained and appropriate caution is not taken.

Transient ipsilateral arm paralysis can result from incorrect patient positioning, usually overtraction or overrotation of the shoulder joint, which can eventually overstretch the brachial plexus. This paralysis is usually transient, and arm movement will be recovered within several weeks. To avoid this inconvenient complication, especially for patients who have stiff joints, the surgeon can use an intraoperative neural monitoring system for real-time checking of the median and ulnar nerve (Fig. 41.15). This system also carries the benefit of allowing the surgeon to identify and avoid damage to the RLN and superior laryngeal nerve simultaneously by adding a nerve integrity monitor (NIM) endotracheal tube (Medtronic Xomed; Jacksonville, FL, USA).

Remaining Problems and the Future of Robotic Thyroidectomy

Despite its promise for cosmesis and postoperative outcome, robotic thyroidectomy has some limitations that must be overcome. Specifically, robotic transaxillary thyroidectomy is more invasive than the open conventional method because of the wide dissection from the axilla to the anterior neck, and it is also more time-consuming. The one-sided approach is a complicated avenue to the contralateral upper pole of the thyroid gland, particularly for the inexperienced surgeon. In contralateral upper pole dissection, all the instruments should cross over the trachea and approach the deep, narrow area as the trachea is depressed. Depression can be difficult in male patients with prominent trachea. Furthermore, the use of the non-articulating Harmonic® curved shears makes some areas of the deep and narrow working spaces inaccessible.

Although these limitations must be acknowledged, mechanical technology often evolves rapidly, and these limitations may soon be overcome. It seems likely that robotic instruments will become smaller and multifunctional in the near future, permitting precise and delicate procedures to be performed. Also on the horizon is the possibility of image-guided surgery, such as fusion of preoperative imaging techniques with the high-definition, three-dimensional images of the surgical field. For thyroid surgery, these techniques may permit surgeons to preserve important structures like the RLN and parathyroid glands with confidence and ease.

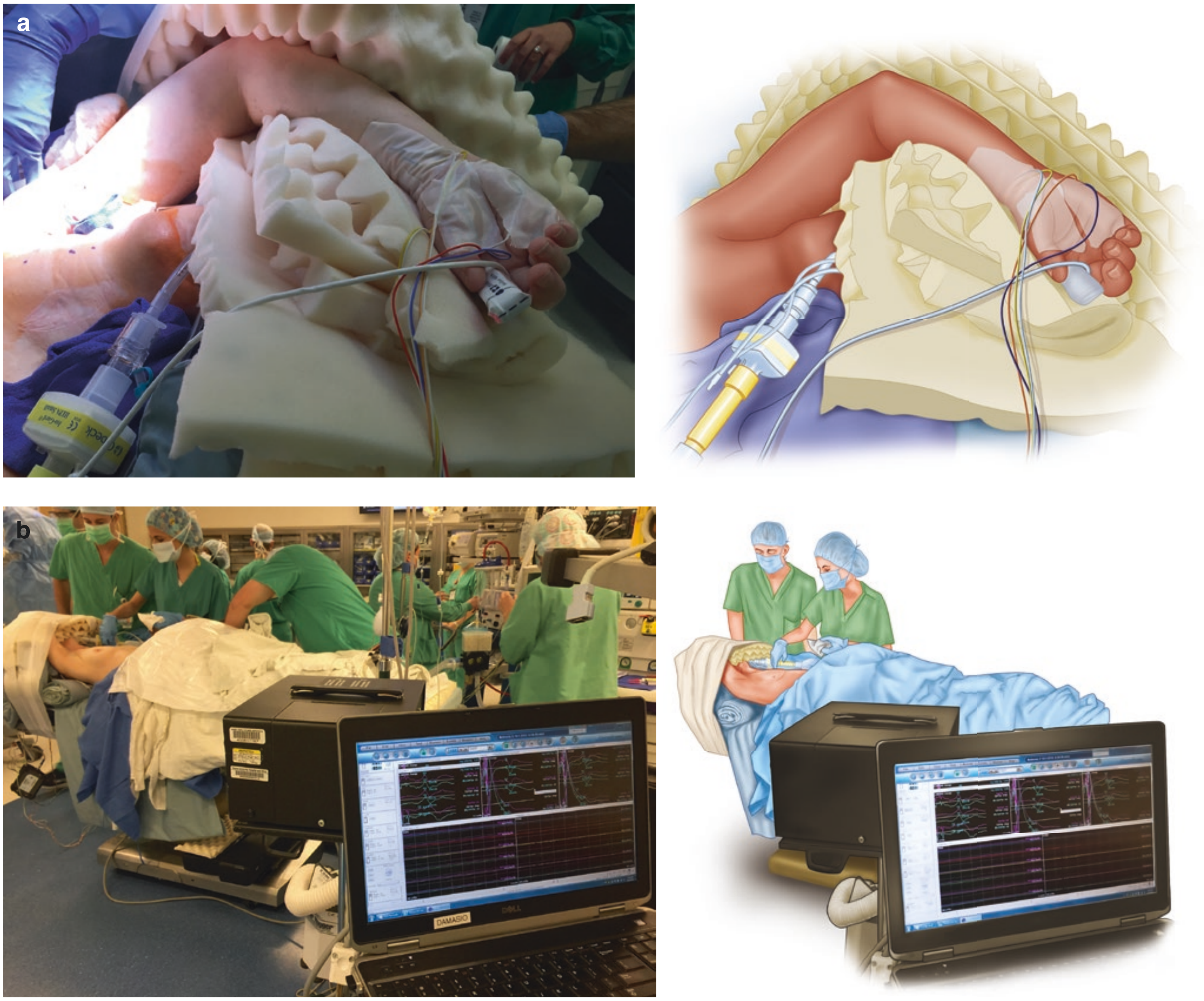

Fig. 41.15 (**a** and **b**) Real-time monitoring of median and ulnar nerves using somatosensory evoked potentials (SSEP) (Biotronic; Ann Arbor, MI, USA)

Conclusion

The application of robotic technology in the treatment of thyroid disease has been shown to be postoperatively superior to the conventional open procedure and to have acceptable surgical outcomes. We hope that the information in this chapter will serve to overcome some of the major obstacles to the adoption of robotic thyroidectomy in Western medicine.

The robotics instruments currently in use were not originally designed for thyroidectomies, and some are unsuitable for thyroid surgery. With the advance of robotic mechanics, more stabilized procedures of robotic thyroidectomy can be developed with improved safety and surgical outcome.

References

1. Rencuzogullari A, Gorgun E. Robotic rectal surgery. J Surg Oncol. 2015;112:326–31.
2. O'Malley DM, Smith B, Fowler JM. The role of robotic surgery in endometrial cancer. J Surg Oncol. 2015;112(7):761–8. https://doi.org/10.1002/jso.23988.
3. Ramirez D, Zargar H, Caputo P, Kaouk JH. Robotic-assisted laparoscopic prostatectomy: an update on functional and oncologic outcomes, techniques, and advancements in technology. J Surg Oncol. 2015;112(7):746–52. https://doi.org/10.1002/jso.24040.
4. Hüscher CS, Chiodini S, Napolitano C, Recher A. Endoscopic right thyroid lobectomy. Surg Endosc. 1997;11:877.
5. Ohgami M, Ishii S, Arisawa Y, Ohmori T, Noga K, Furukawa T, Kitajima M. Scarless endoscopic thyroidectomy: breast approach for better cosmesis. Surg Laparosc Endosc Percutan Tech. 2000;10:1–4.

6. Miccoli P, Berti P, Raffaelli M, Conte M, Materazzi G, Galleri D. Minimally invasive video-assisted thyroidectomy. Am J Surg. 2001;181:567–70.
7. Inabnet WB 3rd, Jacob BP, Gagner M. Minimally invasive endoscopic thyroidectomy by a cervical approach. Surg Endosc. 2003;17(11):1808.
8. Yoon JH, Park CH, Chung WY. Gasless endoscopic thyroidectomy via an axillary approach: experience of 30 cases. Surg Laparosc Endosc Percutan Tech. 2006;16:226–31.
9. Kang SW, Jeong JJ, Yun JS, Sung TY, Lee SC, Lee YS, et al. Robot-assisted endoscopic surgery for thyroid cancer: experience with the first 100 patients. Surg Endosc. 2009;23:2399–406.
10. Lee KE, Rao J, Youn YK. Endoscopic thyroidectomy with the da Vinci robot system using the bilateral axillary breast approach (BABA) technique; our initial experience. Surg Laparosc Endosc Percutan Tech. 2009;19:e71–5.
11. Kang SW, Lee SC, Lee SH, Lee KY, Jeong JJ, Lee YS, et al. Robotic thyroid surgery using a gasless, transaxillary approach and the da Vinci S system: the operative outcomes of 338 consecutive patients. Surgery. 2009;146:1048–55.
12. Kuppersmith RB, Salem A, Holsinger FC. Advanced approaches for thyroid surgery. Otolaryngol Head Neck Surg. 2009;141:340–2.
13. Lewis CM, Chung WY, Holsinger FC. Feasibility and surgical approach of transaxillary approach robotic thyroidectomy without CO_2 insufflation. Head Neck. 2010;32:121–6.
14. Holsinger FC, Sweeney AD, Jantharapattana K, Salem A, Weber RS, Chung WY, et al. The emergence of endoscopic head and neck surgery. Curr Oncol Rep. 2010;12:216–22.
15. Landry CS, Grubbs EG, Morris GS, Turner NS, Holsinger FC, Lee JE, Perrier ND. Robot assisted transaxillary surgery (RATS) for the removal of thyroid and parathyroid glands. Surgery. 2011;149:549–55.
16. Lee J, Chung WY. Robotic surgery for thyroid disease. Eur Thyroid J. 2013;2:93–101.
17. Kang SW, Lee SH, Ryu HR, Lee KY, Jeong JJ, Nam KH, et al. Initial experiences of robot-assisted modified radical neck dissection for the management of thyroid carcinoma with lateral neck node metastasis. Surgery. 2010;148:1214–21.
18. Lee J, Chung WY. Robotic thyroidectomy and neck dissection: past, present, and future. Cancer J. 2013;19:151–61.
19. Lee J, Kwon IS, Bae EH, Chung WY. Comparative analysis of oncological outcomes and quality of life after robotic versus conventional open thyroidectomy with modified radical neck dissection in patients with papillary thyroid carcinoma and lateral neck node metastases. J Clin Endocrinol Metab. 2013;98:2701–8.