Robot-Assisted Transaxillary Thyroidectomy

9

Gabriele Materazzi and Leonardo Rossi

9.1 Introduction

Thyroid surgery is one of the most common surgical procedures performed worldwide, and its frequency is reported to be growing exponentially as a result of an increasing use of neck ultrasonography and fine-needle aspiration biopsy (FNAB) associated with other environmental factors.

The conventional open approach for thyroidectomy was initially proposed by Theodore Kocher in the late 1800s and it has essentially remained unchanged until now. Open thyroidectomy has been the standard approach for more than a century due to its excellent surgical efficacy and low morbidity and mortality. However, the anterior neck scar is undesirable, in particular for young women or patients with a history of keloid who are very sensitive to cosmesis [1].

This cosmetic issue led to the development in the last decade of a large number of different remote-access approaches for removing the thyroid gland. Several routes have been proposed over the years including infraclavicular, axillary, postauricular, and bilateral axilla-breast approaches.

These techniques were introduced to offer patients a better cosmetic option and often reflected the different habits and expectations of patients from different geographic regions and cultures. Although initially met with skepticism due to technical challenges, concerns about oncological safety and cost and the introduction of new complications, some remote-access techniques have become increasingly popular among the community of endocrine surgeons [1].

G. Materazzi (✉) · L. Rossi
Department of Endocrine Surgery, University Hospital of Pisa, Pisa, Italy
e-mail: gmaterazzi@yahoo.com; rossi.leonardo.phd@gmail.com

M. Testini, A. Gurrado (eds.), *Thyroid Surgery*, Updates in Surgery,
https://doi.org/10.1007/978-3-031-31146-8_9

9.1.1 Background

Gasless transaxillary endoscopic thyroidectomy was first proposed in November 2001 in South Korea at the Yonsei University College of Medicine, Seoul, to satisfy the desire to avoid a neck scar [2]. However, endoscopic thyroidectomy showed several drawbacks, such as a two-dimensional view, difficulty in instrument handling, restricted vision, and fulcrum effect. The introduction of surgical robots was thought to overcome the limitations of endoscopic surgery and provide technical improvements: the magnified vision, the three-dimensional view, the tremor filtering system, and the endo-wrist technology along with the multi-articulations of the arms (7 degrees of freedom) allow a finer dissection and decrease interference between the robotic arms and the camera [3].

Robot-assisted transaxillary thyroidectomy (RATT), popularized by Chung et al. who published their experience with thousands of cases in 2018, became widely used in countries in the Far East, although its success in Europe and the United States came more slowly [4]. The negative connotation of a horizontal neck scar, which is thought to denote death in Asian culture, may have played a role in the rapid spread of this technique. Differences in body mass index (BMI), anthropometric characteristics, and greater size of goiters and cancers, combined with the elevated costs of the procedure and the need for training, have hindered the diffusion of this approach in the United States and Europe. To date, although RATT has shown promising results in feasibility, safety, and patient satisfaction, in the Western world it plays only a niche role in treating selected patients with appropriate pathology in high-volume centers [5].

9.1.2 Indications and Contraindications

The indications for RATT vary among the centers, but nowadays substantially both benign disease and well-differentiated low-risk thyroid carcinomas can be approached with this technique. Besides the characteristics of the thyroid, the patient's body habitus must also be assessed preoperatively as it can influence the decision to proceed with a robotic approach. Moreover, since proper positioning is an essential part of the procedure, certain conditions that may limit neck or arm mobility should also be considered preoperatively.

The guidelines recommended to restrict RATT to patients affected by well-circumscribed nodule <3 cm and with thyroid lobe <5–6 cm in the largest dimension [6]. Moreover, previous neck or breast surgery are usually considered contraindications, as are neck radiotherapy, pacemaker implant, shoulder arthrosis, previous shoulder surgery and substernal extension. Severe thyroiditis and Graves' disease may represent relative contraindications, especially at the beginning of the learning curve. With increasing experience, however, the indications have been progressively expanded and some institutions have performed RATT even in more advanced cases [4]. It is important to keep in mind that the best candidates for surgeons at the beginning of their robotic experience are young female patients with small thyroid glands without thyroiditis, small body habitus (BMI <30), long neck, and scheduled for thyroid lobectomy.

9.1.3 Instruments

For the console time of the procedure, the da Vinci S, Si, or Xi system (Intuitive Surgical Inc., Sunnyvale, CA, USA) can be used along with a 30° endoscope, a 5-mm Maryland dissector (Intuitive Surgical Inc., Sunnyvale, CA, USA) and a 5-mm harmonic curved shear (Intuitive Surgical Inc., Sunnyvale, CA, USA). Three trocars can be inserted through the single axillary incision: two 5-mm trocars and one 12-mm trocar. During the procedure a 5-mm laparoscopic suction and irrigation device can be used by the first assistant to retract structures such as the sternocleidomastoid muscle (SCM) or the trachea [7]. Some institutions use an additional robotic arm with an 8-mm ProGrasp forceps (Intuitive Surgical Inc., Sunnyvale, CA, USA).

9.2 Surgical Procedure

9.2.1 Patient Position

The axillary access is chosen according to the side of the thyroid lobe to be removed in the case of lobectomy, or to the side of the largest nodule in the case of a total thyroidectomy. The procedure is performed under general endotracheal anesthesia. The patient is placed supine with the neck slightly extended. The arm on the side of the access is extended cephalad and flexed at the elbow, and the wrist is positioned over the forehead, in the modified Ikeda arm position [8]. The arm is then padded and fixed to a frame. The position of the arm is checked before the incision in order to avoid any extreme position that may lead to a brachial plexus injury. The venous access is positioned in the contralateral arm, which is placed along the body.

9.2.2 The Remote Access: From the Axilla to the Thyroid

A 5–6 cm incision is performed along the posterior border of the anterior axillary pillar; it will remain completely hidden in the axillary fold. Mirroring Korean surgeons, at our institutions we create the working space under direct vision; however, other surgical teams do this by means of laparoscopic instruments under endoscopic vision with a 30° camera [9].

Dissection of the subcutaneous flap is performed by using a monopolar scalpel. The surgical space is maintained using a lighted retractor which elevates a subcutaneous flap above the pectoralis major muscle fascia, whose position is changed and adapted during the dissection. Subplatysmal dissection is performed after crossing the clavicle until the sternal and clavicular heads of the SCM are visualized. The

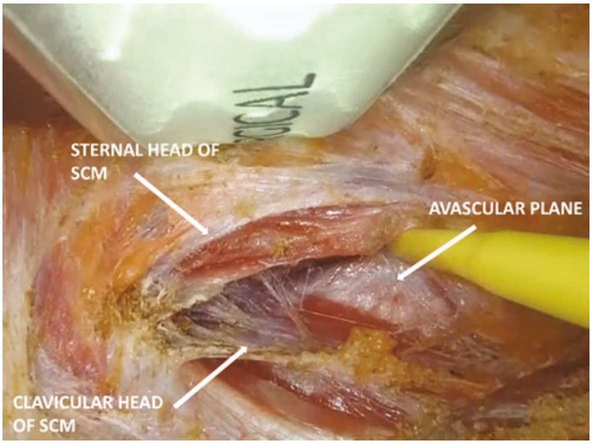

Fig. 9.1 Opening the avascular plane between the two heads of the sternocleidomastoid muscle (*SCM*)

dissection proceeds through the avascular plane between the two SCM heads (Fig. 9.1). Care must be paid to avoid skin burns and injury to major vessels. The strap muscles are identified and gently dissected, and the thyroid lobe is exposed. If a total thyroidectomy has been scheduled, the dissection proceeds beyond the midline on the contralateral strap muscles. Once the access is completed, a specific self-retaining robotic-thyroidectomy retractor is placed in order to maintain the surgical space during the console time [7]. It is mounted at the contralateral side of the bed and placed below the sternal bound of the SCM and strap muscles, crossing the midline, in order to maintain the working space. This retractor is connected to a suction tube to aspirate the smoke from the sealing devices used during the console time [10].

9.2.3 Docking Time

The robot is docked from the contralateral side of the table. We perform RATT by means of two instruments, the Maryland dissector and the harmonic shear, and a 30° robotic camera. We keep the fourth robotic arm folded, as this technique reduces the length of the incision and the encumbrance of the instruments; however, some institutions perform RATT by using an additional robotic arm with a ProGrasp forceps. The camera is inserted at the center of the incision in the upward direction. The Maryland dissector is placed at the caudal edge of the incision, and the harmonic shear at the cranial edge. The instruments should be as far apart as possible and inserted in the upward direction [10].

9.2.4 Console Time: Thyroidectomy

Overall, RATT follows the same steps of open thyroidectomy. The upper pole of the thyroid is freed by pulling the lobe downward and medially with the Maryland dissector. The upper vessels are identified and dissected with the harmonic shear close to the thyroid lobe in order to avoid injury to the external branch of the superior laryngeal nerve. If the working space is narrow, the isthmus can be divided at this time. The recurrent laryngeal nerve (RLN) and the ipsilateral parathyroid glands are identified (Fig. 9.2). The inferior thyroid artery is divided with the harmonic shear (the first assistant may apply an endoscopic clip). The RLN is followed from bottom to top, up to its entrance in the larynx. The thyroid lobe is removed following the tracheal plane and extracted by means of an endobag to avoid potential seeding along the surgical track. When a total thyroidectomy is scheduled, the contralateral lobe is approached through the same surgical access. The lobe is freed from the strap muscles and the upper pedicle is dissected with the harmonic shear. Once the thyroid lobe has gained mobility, it is pulled upward with the Maryland dissector to visualize the noble structures. Identification of the contralateral RLN and parathyroid glands is more difficult than the ipsilateral side and requires experience. The first assistant uses a laparoscopic suction device to exert gentle traction on the trachea in order to expose the RLN, which is followed upward (Fig. 9.3). The lobe is removed and extracted by means of an endobag [7].

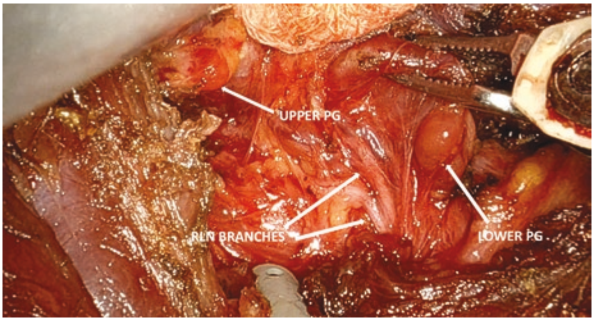

Fig. 9.2 Identification of the ipsilateral recurrent laryngeal nerve (*RLN*) and parathyroid glands (*PG*)

Fig. 9.3 Identification of the contralateral recurrent laryngeal nerve (*RLN*) and upper parathyroid gland (*PG*)

9.3 Controversies

9.3.1 Oncological Safety and Efficacy

When the selection criteria are accurately applied, RATT has proven safe for the treatment of differentiated thyroid carcinoma. Several systematic reviews and meta-analyses have reported comparable oncological efficacy between RATT and conventional thyroidectomy with virtually identical completeness and recurrence rate [11, 12].

Lee et al. assessed the safety of RATT in patients scheduled for total thyroidectomy with central neck dissection. The authors reported RATT as equivalent to the open approach in terms of number of retrieved lymph nodes, stimulated thyroglobulin levels acquired during whole-body scans and the ablation success rate. Moreover, the follow-up ultrasound examination documented no abnormal findings in either group [13]. The same group of authors evaluated the long-term follow-up of patients who underwent RATT: no statistically significant differences were documented compared to open thyroidectomy in terms of serum thyroglobulin and anti-thyroglobulin antibody levels, locoregional recurrence rate and disease-free survival [14].

Lastly, with increasing experience, the indications gradually expanded. Recently, Kim et al. described their experience of RATT with lateral neck dissection in 500 patients [15]. They reported satisfactory results in both primary operation for thyroid cancer (476 patients) and lateral neck dissection for recurrence (24 patients). Clearly, lateral neck dissection must be performed in high-volume institutions with surgeons experienced in robotic and endocrine surgery.

9.3.2 Conventional and Unconventional Complications

For the safe adoption of a novel technique, surgeons should ensure acceptable outcomes and minimize surgical complications. Several meta-analyses have reported a very similar rate of conventional complications (RLN palsy, postoperative hypocalcemia and bleeding) between robotic thyroidectomy and open thyroidectomy [12, 16]. The robotic platform provides optimal visualization of the RLN and parathyroid glands by means of a 3D magnified view and allows a gentle dissection thanks to the fine movements that potentially enable preservation of these noble structures.

Furthermore, the da Vinci robot system (Intuitive Surgical Inc., Sunnyvale, CA, USA) has recently been equipped with the Firefly system (Novadaq Technologies Inc., Mississauga, ON, CAN), which takes advantage of the indocyanine green (ICG) fluorescence of the parathyroid glands. This represents an emerging technique which helps surgeons to identify the parathyroid glands and to assess their blood supply at the end of the dissection (Fig. 9.4) [17]. Moreover, even during RATT it is possible to perform intraoperative nerve-monitoring, with both the intermittent or continuous setting, in order to evaluate RLN integrity (Fig. 9.5).

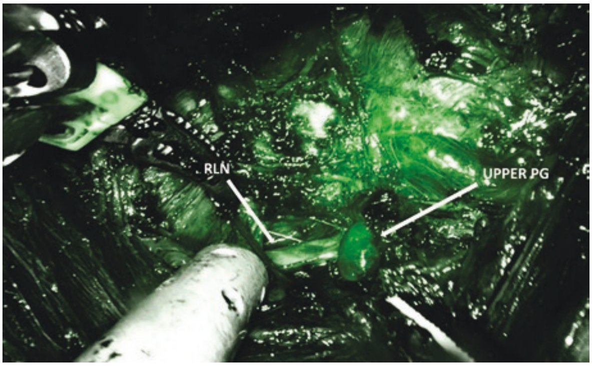

Fig. 9.4 Identification of the upper parathyroid gland (*PG*) with indocyanine green fluorescence (*RLN*, recurrent laryngeal nerve)

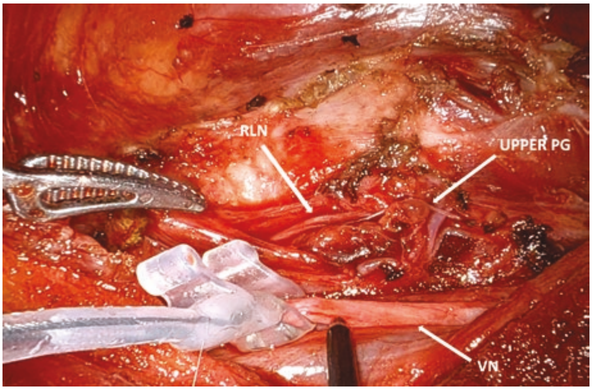

Fig. 9.5 Continuous intraoperative nerve monitoring during robot-assisted transaxillary thyroidectomy (*RLN* recurrent laryngeal nerve, *VN* vagus nerve, *PG* parathyroid gland)

Regarding hemostasis, the effectiveness of the harmonic shear helps in obtaining comparable results to open thyroidectomy. Moreover, the working space created during the access time allows the blood to drain into the vast subcutaneous pocket in the prepectoral region, reducing the risk of airway compression in the event of bleeding. Nonetheless, surgeons must pay attention to the active blade when using the ultrasonic shears because of the potential transfer of energy to the nearby RLN, parathyroid glands and trachea.

The introduction of unconventional complications, mainly related to the position of the patient on the operating bed and to the surgical access, initially hindered the spread of RATT in the Western world. These complications are mainly represented by brachial plexus palsy, surgical track seeding, seroma formation, great vessel injury and skin flap perforation. Brachial plexus injury is caused by extreme arm extension and usually occurs during the first 20 to 40 minutes of surgery [18]. To avoid this complication, caution has to be taken not to overextend the shoulder. Besides, nerve monitoring of the radial, median, and ulnar nerves using somatosensory evoked potential (Biotronic, Ann Arbor, MI) can be used to reduce the risk of stretching of any of these nerves [19]. Track seeding along the surgical access is another newly introduced complication, probably caused by cell exfoliation due to the repeated trauma inflicted by the endoscopic instruments: the routine use of an endobag to retrieve resected specimens may reduce the incidence of this complication. Other access-related complications are skin flap perforation and seroma formation; some studies have also reported injury to the great vessels. However, these complications are very rare and may also occur during open thyroidectomy.

Overall, although RATT harbors the potential risk of new, technique-related complications, these are very rare and the approach can be considered safe in experienced hands. However, surgeons must keep in mind the possibility that these complications may indeed occur and know how to prevent them [18].

9.4 Conclusion

RATT is a feasible and safe approach in properly selected cases even when applied to Western world patients. It provides an excellent cosmetic result by avoiding a visible neck scar, and it is associated with reduced neck discomfort and higher ergonomics. The rate of conventional complications of RATT is comparable to that of the open approach, whereas procedure-related complications are very rare. RATT has been proven safe even for the treatment of thyroid cancer, with identical outcomes to open thyroidectomy. Moreover, some encouraging results of robotic lateral neck dissection are emerging. However, it is critical to stress that it is strongly recommended to perform this approach in high-volume institutions with surgeons experienced in robotic and endocrine surgery and to strictly adhere to the selection criteria.

References

1. Rossi L, Materazzi G, Bakkar S, Miccoli P. Recent trends in surgical approach to thyroid cancer. Front Endocrinol (Lausanne). 2021;12:699805.
2. Kang SW, Jeong JJ, Yun JS, et al. Gasless endoscopic thyroidectomy using trans-axillary approach; surgical outcome of 581 patients. Endocr J. 2009;56(3):361–9.
3. Moorthy K, Munz Y, Dosis A, et al. Dexterity enhancement with robotic surgery. Surg Endosc. 2004;18(5):790–5.
4. Kim MJ, Nam KH, Lee SG, et al. Yonsei experience of 5000 gasless transaxillary robotic thyroidectomies. World J Surg. 2018;42(2):393–401.
5. Aidan P, Arora A, Lorincz B, et al. Robotic thyroid surgery: current perspectives and future considerations. ORL J Otorhinolaryngol Relat Spec. 2018;80(3–4):186–94.
6. Berber E, Bernet V, Fahey TJ 3rd, et al. American Thyroid Association statement on remote-access thyroid surgery. Thyroid. 2016;26(3):331–7.
7. Fregoli L, Rossi L, Papini P, Materazzi G. Robotic transaxillary thyroidectomy: state of the art. Gland Surg. 2020;9(Suppl 1):S61–4.
8. Ikeda Y, Takami H, Niimi M, et al. Endoscopic thyroidectomy and parathyroidectomy by the axillary approach. A preliminary report. Surg Endosc. 2002;16(1):92–5.
9. Piccoli M, Mullineris B, Gozzo D, et al. Evolution strategies in transaxillary robotic thyroidectomy: considerations on the first 449 cases performed. J Laparoendosc Adv Surg Tech A. 2019;29(4):433–40.

10. Alzahrani HA, Mohsin K, Ali DB, et al. Gasless trans-axillary robotic thyroidectomy: the technique and evidence. Gland Surg. 2017;6(3):236–42.
11. Wang YC, Liu K, Xiong JJ, Zhu JQ. Robotic thyroidectomy versus conventional open thyroidectomy for differentiated thyroid cancer: meta-analysis. J Laryngol Otol. 2015;129(6):558–67.
12. Pan JH, Zhou H, Zhao XX, et al. Robotic thyroidectomy versus conventional open thyroidectomy for thyroid cancer: a systematic review and meta-analysis. Surg Endosc. 2017;31(10):3985–4001.
13. Lee S, Lee CR, Lee SC, et al. Surgical completeness of robotic thyroidectomy: a prospective comparison with conventional open thyroidectomy in papillary thyroid carcinoma patients. Surg Endosc. 2014;28(4):1068–75.
14. Lee SG, Lee J, Kim MJ, et al. Long-term oncologic outcome of robotic versus open total thyroidectomy in PTC: a case-matched retrospective study. Surg Endosc. 2016;30(8):3474–9.
15. Kim JK, Lee CR, Kang SW, et al. Robotic transaxillary lateral neck dissection for thyroid cancer: learning experience from 500 cases. Surg Endosc. 2022;36(4):2436–44.
16. Shen H, Shan C, Qiu M. Systematic review and meta-analysis of transaxillary robotic thyroidectomy versus open thyroidectomy. Surg Laparosc Endosc Percutan Tech. 2014;24(3):199–206.
17. Muraveika L, Kose E, Berber E. Near-infrared fluorescence in robotic thyroidectomy. Gland Surg. 2020;9(Suppl 2):S147–52.
18. Rossi L, Buoni V, Fregoli L, et al. Postsurgical complications after robot-assisted transaxillary thyroidectomy: critical analysis of a large cohort of European patients. Updat Surg. 2022;74(2):511–7.
19. Davis SF, Abdel Khalek M, Giles J, et al. Detection and prevention of impending brachial plexus injury secondary to arm positioning using ulnar nerve somatosensory evoked potentials during transaxillary approach for thyroid lobectomy. Am J Electroneurodiagnostic Technol. 2011;51(4):274–9.