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Technical Particularities of the Robot-Assisted Trans-Axillary Thyroidectomy

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Rezumat

Particularităţi tehnice ale tiroidectomiei transaxilare asistate robotic

În chirurgia tiroidiană au fost descrise şi puse în practică multiple tehnici operatorii minim invazive. Cu toate că aceste tipuri de intervenţii chirurgicale s-au dovedit sigure şi cu rezultate bune, practicarea lor rămâne limitată de o serie de dezavantaje tehnice. Tehnologia robotică a fost dezvoltată pe de o parte pentru a depăşi limitele chirurgiei endoscopice. Recent, pe baza avantajelor acestei noi tehnologii, asistarea robotică a intervenţiei endoscopice a fost introdusă şi în chirurgia tiroidiana. Experienţa noastră în abordul transaxilar asistat robotic al patologiei chirurgicale tiroidiene începe în noiembrie 2010, când practicăm prima lobectomie totală unilaterală. Din noiembrie 2010 până în martie 2012, am practicat 50 de tiroidectomii transaxilare asistate robotic. Scopul acestei lucrări este de a prezenta detaliile şi particularităţile tehnice ale acestei proceduri chirurgicale bazându-ne pe experienţa acumulată până la această oră.

Cuvinte cheie: asistare robotică, minim invaziv, chirurgie tiroidiană, abord transaxilar

Abstract

Numerous minimally invasive techniques for thyroid surgery have been described in recent years. Technical disadvantages have led to low practicability, although these techniques proved to be safe and to deliver good results. The robotic system was developed to overcome the limits of endoscopic surgery. Recently, based on the advantages of this new technology, robot assisted endoscopic surgery was introduced for minimally invasive thyroid surgery as well. Our experience with robot-assisted transaxillary thyroid surgery begins in November 2010 when we have practiced our first unilateral total lobectomy. From November 2010 to March 2012, 50 patients underwent robot-assisted endoscopic thyroid surgery using the transaxillary approach. The aim of this study is to present the technical details and particularities of this procedure, based on our experience.

Key words: robot-assisted, minimally invasive, thyroid surgery, transaxillary approach

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Introduction

Thyroid pathology is more frequent in females, with an increasing occurrence at younger age (Lee et al., 2011) (1).

Besides the success of the surgery, patients are gradually becoming more focused on postoperative evolution, including pain, duration of hospitalization and reintegration into normal activity, life quality conditioned by post-surgical sequelae and esthetic aspect of the scar.

In the past two decades these premises led to the development of several minimally invasive techniques for the surgical approach of the thyroid and parathyroid glands. These include open surgery through micro incisions, video assisted interventions and endoscopic thyroidectomy (Linos and Chung, 2012) (2).

In 1996, Gagner et al. (3) reports the first subtotal endoscopic parathyroidectomy, and in 1997, Hüscher, the first endoscopic thyroidectomy (4).

Miccoli, in 1999, introduced a minimally invasive, video-assisted thyroidectomy, through an anterior cervical incision, without gas insufflation (5). Furthermore, Japanese authors described endoscopic techniques via incisions far from the cervical region: anterior thoracic or combined axillary with anterior thoracic approach practiced by Ikeda (6), combined axillary and bi-areolar (ABBA) presented by Shimazu (7), bilateral axillary and areolar approach (BABA) by Choe et al. (8). For each technique, operating space was maintained by CO_2 insufflation.

Technical disadvantages led to the necessity of developing an increased number of minimally invasive techniques, these requiring and being available only in highly specialized surgical centers. The operations are difficult to perform and the learning curve is quite long (Lee et al., 2011) (9). Difficulty of the endoscopic approach is rendered on the one hand by the required instruments, borrowed from laparoscopic surgery and by the limited degree of freedom for movements, on the other; therefore dissection of delicate anatomic structures is executed with difficulty: recurrent laryngeal nerve (RLN), parathyroid glands (PT), dissection in the region of the Berry ligament. Images are bi-dimensional and unstable, the telescope being manipulated by the co-surgeon (9). Maintaining the surgical field open with CO_2 insufflation can lead to a series of complications: extended subcutaneous emphysema, hypercapnia, respiratory acidosis and gas embolism. Introduction of robotized technology was intended especially to reduce the limitations of classical endoscopic techniques. There are already several innovative technologies available, some being marketed, like the da Vinci Surgical System, some still under development and fine-tuning, one even developed in our country (Pisla et al., 2011) (10).

Current state of knowledge

Robotic surgery is continuously developing in several fields: heart and mediastinal surgery, urological - mainly prostate surgery, or abdominal surgery – locally advanced gastric cancer etc. (Vasilescu and Procopiuc, 2012) (11). The advantages of this resource-demanding technique become obvious when complex interventions should be executed in restrained space (Oliveira et al., 2012) (12). This was the starting point for the use of robots in cervical surgery, especially for thyroid and parathyroid glands. In 2007, Professor Chung – Yonsei University, Seul, South Korea – introduced the robot-assisted transaxillary thyroidectomy, without CO_2 insufflation (Kang et al., 2009) (13). Data obtained from continuously increasing groups are being published since 2009. Mostly the malignant pathology of the thyroid was considered – well differentiated carcinomas – the intervention being composed besides of a total exeresis of the gland, of central compartment lymphadenectomy as well (13). At this point, the South Korean experience is by far the widest, sustained by multicentric studies (1).

Experience is limited for both the United States and especially for Europe, where Caucasian patients are prevalent. There are only a few publications, and the number of patients cured with the use of the technique is low, the pathology being preponderantly benign. Post-surgical results referred to one center of robotic surgery are limited to a few cases (Boccara et al., 2011) (14). In the United States, in April 2012, Kandil et al. published the results of 100 cases of robotic transaxillary thyroidectomies (15).

In the Vth Surgical Clinic of the Cluj-Napoca Municipal Clinical Hospital the Da Vinci ȘI platform was acquired in 2009, and in November 2010, the first robotic transaxillary total lobectomy was performed. The experience of the robotic surgery team reached 50 cases in March 2012.

Operating technique

The operating technique is presented in the first procedure guide by Professor Chung, 2011 (16). It starts with an incision in the axilla on the side of the lesion and dissection continues in the fascial layer of the pectoralis major (PM), up to the clavicle, under the platisma muscle, then entering through the space formed by the sternal and clavicular insertion of the sternocleidomastoideus muscle (SCM), continued under the subhyoid muscles to the thyroid loggia. Working space is maintained with the help of a special, autostatic retractor, without gas insufflation. Robotic instruments of arms 1 and 2, and the telescope are introduced trough the axilla, the instrument of arm 3 through an 8 mm incision, executed on the same side, with a pre-pectoral and latero-sternal position. Then the console time begins, constituting the actual thyroidectomy.

As the number of interventions increased, our technique suffered slight changes in order to better fit the needs of a different target population, as it was described in the vast majority of literature data. This 50 patient row of interventions led to a modified, adapted protocol.

Patient positioning

The patient is placed on the operating table in dorsal decubitus, producing a slight extension of the cervical region. A more pronounced extension, similar to the position in open surgery through cervicotomy, lowers under the horizontal the cranial extremity of the dissection space, between the sternal and clavicular insertions of the SCM, reducing working space and producing a difficult or impossible access over the superior thyroid pedicle. More reduced extension or lack of it narrows the working field, the inferior pole of the lobe descends near the clavicle, and the supraclavicular or near clavicular dissection becomes impossible.

Positioning the upper limb from the incision side is a delicate problem (14). The risk of neuropraxia of the brachial plexus through vicious positioning is real (1) and presented in most of the published articles in the field (Kang et al., 2009) (17).

Our protocol is the following: the subject is positioned on the table with the upper limb on the incision side in extension, abduction, parallel to the cephalic extremity, slightly supine, so that the distance between the axilla and cervical region becomes minimal. After positioning and holding it for at least 5 minutes, questioning of the patient follows, regarding new occurrence of aches, paraesthesias, and, if needed, limb position is adjusted. The angle between the limb and the surface of the table is indicated by the South Korean authors to be of 25 degrees. In reality, the recommendation is realizable only for young, non-obese patients; with older, overweighed or obese patients, with different degrees of freedom of the scapulo-humeral joint, an angle of only around 45 degrees is obtained. Anaesthesia and oro-tracheal intubation takes place only after the final positioning. Optimizing the placement of the upper limb and objective evaluation of its effects before narcosis and assessment of the functions of the brachial plexus during surgery is realized by continuous neurophysiologic monitoring throughout the whole length of the surgery, namely somato-sensory evoked potentials obtained with the stimulation of a peripheral nerve of the limb, most frequently the median.

Approach

The approach is transaxillary, with a vertical incision, parallel with the external margin of the PM. Important anatomical landmarks are: the thyroid cartilage, suprasternal fossa, sterno-clavicular joint, external margin of the PM (*Fig. 1*).

Position and dimensions of the incision are debatable. In order to realize the intervention, the distance between the axis of the Chung autostatic retractor (CAR) and posterior margin of the working space should reach at least 4 cm. Elasticity of the skin and subcutaneous tissue and position of the incision related to the margin of the PM muscle should be considered for this. If the incision is positioned more postero-laterally from the margin of the PM, the possibility to observe the scar in orthostatic position with the patient's arm in a natural position is low, so the esthetic results are very good. If the skin elasticity is reduced and the incision is positioned more posterior, a wider skin incision is required. The more posterior positioning of the incision, the higher is the risk for ischemic post-surgical skin necrosis through the tension produced by the CAR. Objective appreciation of the incision might be performed through clinical evaluation of tissue elasticity (*Fig. 2, 3*).

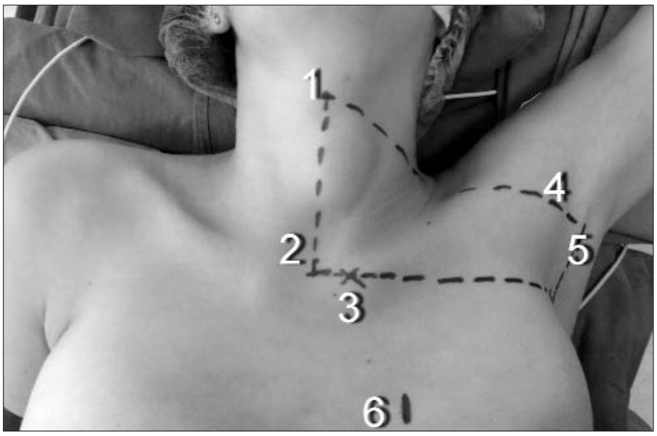
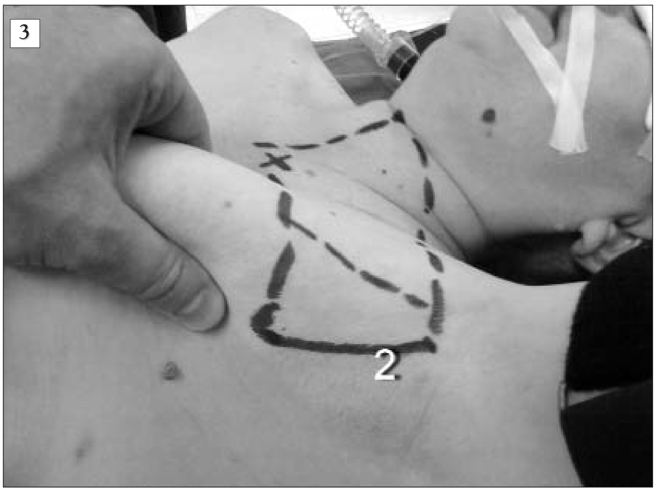


Figure 1. *Anatomical landmarks: 1. thyroid cartilage; 2. suprasternal fossa; 3. sterno-clavicular joint; 4. margin of PM; 5. incision line; 6. arm 3 port 8 mm incision*



Figures 2,3. *Pre-surgical evaluation of tissue elasticity: 1. margin of PM; 2. incision line*

The most difficult cases to dissect and mobilize are underweighted young men, requiring placing the incision on the margin of the PM. Generally it is possible to install robotic arms using an incision of around 4-5 cm.

The subcutaneous tissue is sectioned to reveal the margin of PM, trying to use the shortest approach without opening the axillary fascia. Dissection progresses in the fascial layer of

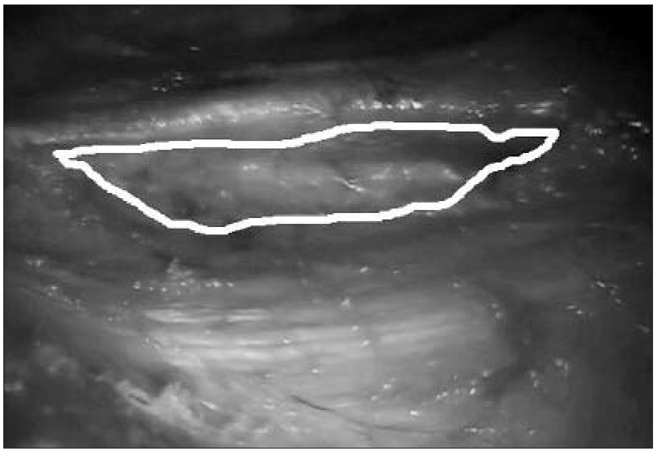


Figure 4. *Dissection space between insertions of SCM*

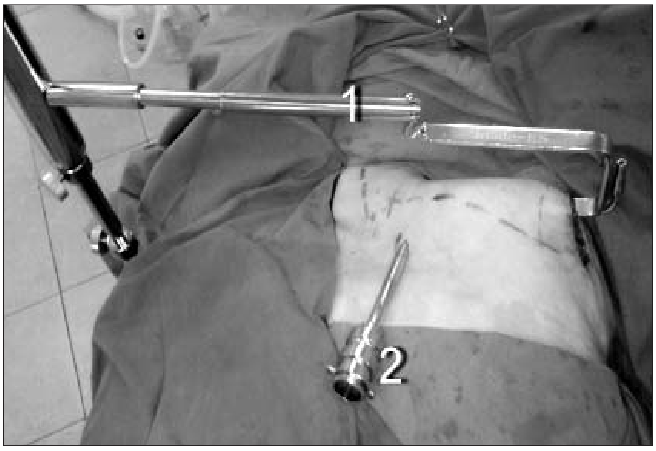


Figure 5. *Position of the CAR: 1. CAR; 2. arm 3 8 mm trocar*

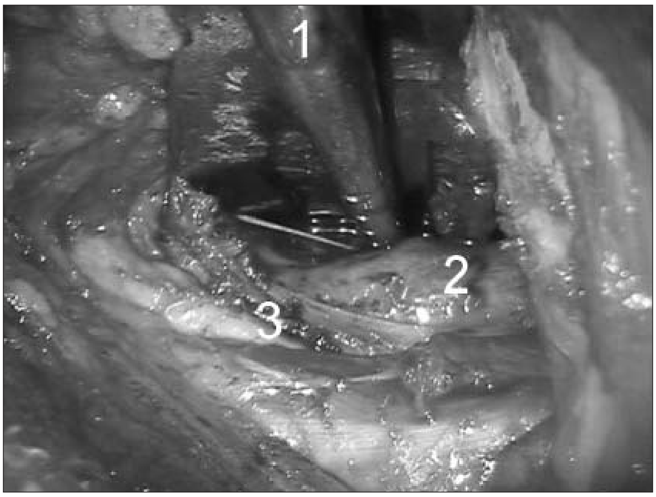


Figure 6. *Position of CAR: 1. CAR; 2. left thyroid lobe; 3. IJV*

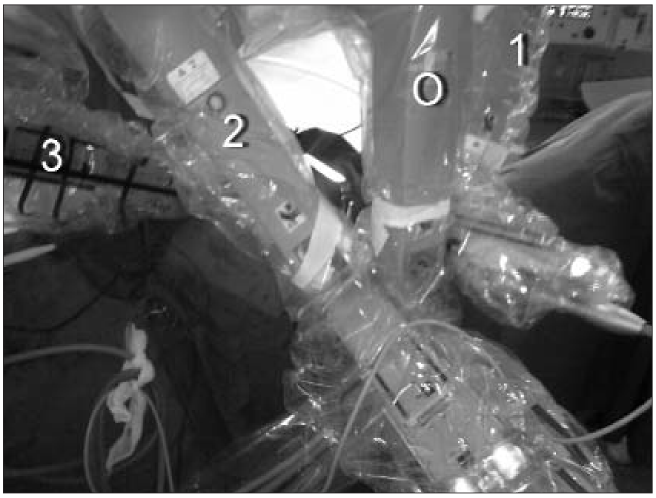


Figure 7. *Docking of the robot: 1,2,3 – arms; O – camera arm*

the PM, without problems of hemostasis, up to the sterno-clavicular joint and the internal third of the clavicle. After passing over the pectoral and subclavicular regions, dissection becomes more profound, reaching the superficial fascia of the neck, which houses the SCM muscle. Next step is to reveal the small supraclavicular fossa and SCM distal insertions. Usually the sternal insertion shows a fusiform shape, which ends as an easily recognizable tendinous structure, noticeable through the superficial fascia of the neck, on which, via an incision, dissection enters deeper between the insertions of the SCM (*Fig. 4*), reaching the level of the pretracheal fascia and subhyoid muscles (SH).

The vascular extension of the fascia is then dissected, revealing the internal jugular vein (IJV), and the SH muscles are elevated on a retractor. Position and diameter of the IJV is pre-surgically evaluated through ultrasound. More extended, spheroid tumors displace the IJV antero-laterally, increasing the risk of injury.

In the resulting space one can identify the lateral aspect of the thyroid lobe. The dissection progresses, led by the layer of the thyroid capsule, up to the antero-lateral surface of the contralateral lobe, even in case of unilateral lobectomy.

The CAR is then positioned and under visual and palpatory control, the musculo-cutaneous layers are lifted on the retractor, conferring enough space for the exeresis, but, concomitantly also controlling the tension of the elevated structures. (*Fig. 5, 6*).

Docking the robot

The robotic cart is placed contralaterally to the incision, in the axis of the CAR, forming an angle of approximately 45° with the axis of the table (*Fig. 7*).

Arms 1, 2 and the camera arm are positioned to allow their introduction through the axillary incision (*Fig. 8*).

The remote center (steady point of the trocar) is just inside the edge of the skin incision. The trocar of arm 3 will be introduced through a supplementary 8 mm incision, pre-pectoral and latero-sternal, on the same side. The latter incision is made after the CAR is in place; the arm is positioned according to the conformation of the patient, the thickness of fatty tissue, volume and position of the mammary gland. Risk

Figure 8. *Docking of the robot (operative procedure guide for robotic thyroidectomy – WY Chung 2009)*

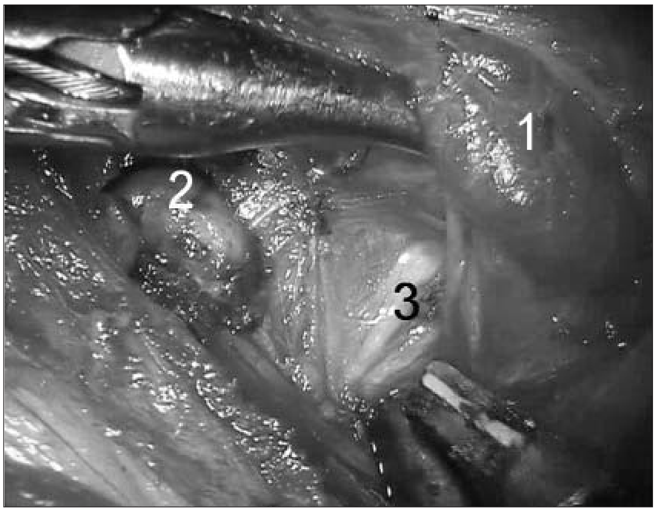


Figure 9. *Dissection of the posterior margin of the left thyroid lobe: 1. left thyroid lobe 2. left inferior PT 3. RLN*

of clavicle and rib fracture when arm 3 is moving requires increased attention in the case of this trocar.

Robotic instruments are presented in *Table 1*.

Console time

It represents the effective time of exeresis. Initially, by tractioning antero-caudally with the grasper, the superior pole is exposed. The superior pedicle is approached up to the level of first degree branches, for a safer hemostasis and to avoid the risk of injuring the external branch of the superior laryngeal nerve. Branches are sealed and sectioned with the Harmonic scissor.

Then the inferior pole is revealed by antero-cranial traction, followed by the section of divisions of the inferior pedicle at capsular level, exposure of the lateral margin by antero-medial tractioning, revealing and sectioning of the medial vein.

With the lateral aspect exposed in the same position, the dissection of the posterior margin starts, revealing the PT glands and the RLN. Dissection of PT should be executed carefully, to preserve vascularization (*Fig. 9*).

Landmarks for RLN are the same as for classic surgery: relation with the inferior thyroid artery and its divisions, Zuckerkandl's tubercle, Berry ligament, and the observation that the nerve never enters the thyroid parenchyma. RLN is isolated up to its entrance in the larynx.

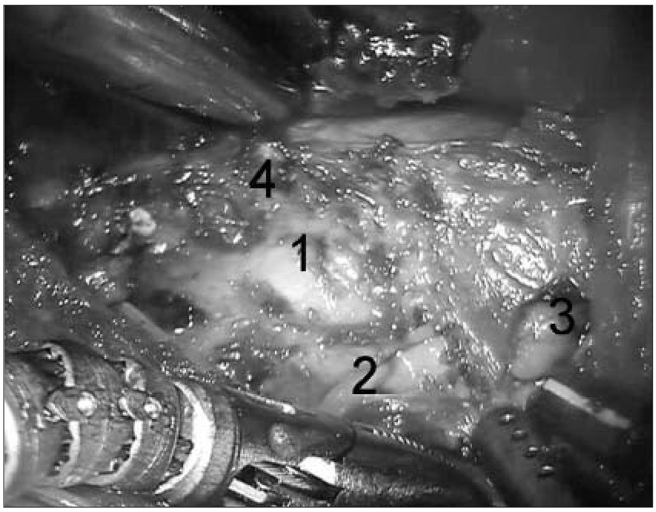


Figure 10. *View after left total lobectomy: 1. trachea; 2. RLN; 3. superior PT; 4. contralateral isthmic ending*

Dissection then follows the surface of the trachea, from posterior to anterior and from lateral to medial, with the sectioning of the Berry ligament and lifting of the lobe, to the level of the isthmus. After the isthmus is separated from the trachea, the lobe is repositioned in its loggia, and the isthmus is sectioned via an anterior approach, in a caudal to cranial manner. The thyroid lobe is then extracted through the

Table 1. *Devices and instruments required to perform robotic thyroidectomy*

Robotic Platform	da Vinci ȘI Surgical System robot - Intuitive Surgical, Inc., Sunnyvale, CA, USA
Recommended EndoWrist Instruments	Energy Instrument: Harmonic Curved Shears Dissector: Maryland Dissector (5 mm) Grasper: ProGrasp Forceps
Other instruments	30° down endoscope Thyroid retractor - Chung model Electro cautery pen (with short & long tips) Various elbow retractors Irrigator-aspirator cannula for laparoscopy

axillary incision (*Fig. 10*).

The contralateral lobe is reached differently. Using the grasper, the sectioned isthmic ending is tractioned towards the anterior and contralateral aspect. Dissection follows the trachea, separating, if possible, up to the posterior margin, then on the antero-lateral aspect, to provide an extended release from muscle adherences.

The inferior pole then becomes the traction point and divisions of the inferior pedicle are sealed and sectioned. The capsule leads dissection, until it reaches the posterior margin and discovers the contralateral RLN. Then it progresses cranially, leaving the nerve posteriorly. A more difficult incision, that of the Berry ligament, is then performed and the superior pole is approached. Sectioning branches of the superior pedicle finishes the operation.

In every intervention a real help was conferred by the use of an aspirator cannula borrowed from laparoscopic surgery. By introducing it through the axillar incision, it evacuates the smoke or eventual hemorrhages, and also helps in different moments of the operation during dissection, as a revealing and retracting instrument, handled by the co-surgeon.

We always use a unique tube as well, exteriorized in a posterior contra-incision of the axillary entrance, for the drainage of the thyroid loggia.

Incidents. Complications

Taking into account the particularities of robot assisted trans-axillary thyroidectomy, there are a series of possible intraoperative complications.

The upper limb from the side of the incision could suffer postoperative dysfunctionalities due to positioning on the operating table. Although neurapraxia is a rare complication, 0.2-1%, still it is presented in most studies (1,14,15,17); and even if it is transitory, it could be really irritating, requiring for some of the cases' long rehabilitation therapies. Among our patients, we met one such complication, which was then corrected in over three months of physical therapy. Monitoring the functionality of the brachial plexus during the operation represents a solution to avoid this complication.

Advantages of robotic surgery as well as its technical particularities (13,17,18) led to the idea of implementing this novel technology for thyroid pathology, where the whole operation takes place in a restrained space, neighboured by important anatomical structures, which, if injured, could produce severe complications.

Conversion ratio to classic thyroidectomy is reduced if selection criteria of patients are rigorously applied, the main reason being hemorrhage (15). Among the 50 robot assisted operations we had one conversion to cervicotomy. The conversion was necessary for a tangential lesion of the IJV by the harmonic scissor, during the dissection of a nodule which pushed the IJV antero-laterally in a patient with Basedow disease treated with anti-thyroidal medication.

Postoperative complication rate resembles the rate noted during the classic approach. Hypocalcaemia and transient paresis of vocal cords through surgical trauma of RLN is mentioned with a low incidence in most of the published studies (1,17,18).

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Figures 11,12. *Post-surgical aspect, 3 months after robotic thyroidectomy. The axillary scar is completely covered by the patient's arm in a natural position*

Lateral approach of the lobe and stable tri-dimensional high definition imaging are evident advantages of the robotic assistance of the intervention. The absence of physiological tremor, and, moreover, the motion scaling, with the possibility of zooming the image facilitates the fine and precise movements specific to microsurgery for the dissection and protection of delicate anatomical structures (2,9,13,17,18).

Our experience, in accordance with the South Korean data seems to confirm that robotic assistance in thyroid surgery using the axillary approach is an intervention with very good results, comparable with open surgery using cervicotomy (19), and confers also an unequalled esthetic aspect (*Fig. 11, 12*).

Conclusion

European and American studies are very few and discuss a reduced number of cases. Although the technique has already been published by South Korean authors, still, intimate particularities of the operation are not detailed, lacking data referring mainly to Caucasians, with different anthropometric parameters like height, BMI or length of the clavicle, which might lead to a more difficult approach.

Adapting the technique to local patient - and facility-related particularities led our robotic surgery team to encouraging results, on a row of 50 patients with thyroid pathology, results that are comparable to those of the above-mentioned studies. As a consequence, we further consider the use of the robotic technique in this field, the intervention being safe and feasible.

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