Transaxillary Gasless Robotic Thyroidectomy

A Single Surgeon’s Experience in North America

Emad Kandil, MD; Samy Abdelghani, BSE; Salem I. Noureldine, MD; Paul Friedlander, MD; Mohamed Abdel Khalek, MD; Charles F. Bellows, MD; Douglas Slakey, MD

Objective: To describe a robotic technique for transaxillary gasless thyroidectomy with the addition of intraoperative peripheral nerve monitoring in the surgical management of thyroid disease.

Design: Prospective study.

Setting: Academic institution.

Patients: Fifty patients underwent robotic transaxillary thyroidectomy from September 1, 2009, to August 31, 2010. All the patients underwent preoperative and postoperative direct laryngoscopy. The patients’ demographic information, operative times, complications, postoperative hospital stay, and the surgeon’s learning curve were evaluated.

Main Outcome Measures: Feasibility of the robotic approach, patient and gland characteristics, operative time, and complications.

Results: Thirty-nine females and 11 males with a mean age of 48.2 (age range, 13-76) years were included in the study. A total of 37 surgical procedures were lobectomies, and 13 were total or near-total thyroidectomies. The mean nodule size (range) was 24.9 (10-72) mm. The mean operative time (range) was 122.5 (81-280) minutes, mean docking time (range) was 10.1 (6-15) minutes, and mean console time (range) was 55.5 (10-140) minutes. Mean blood loss (range) was 25 (10-100) mL. There were no conversions to conventional open surgery. One patient developed transient radial nerve neuropathy that resolved spontaneously. There were no other postoperative complications. In addition, there was no evidence of vocal cord palsy or paresis on postoperative laryngoscopy. All the patients were discharged home within 24 hours. Subjectively, the cosmetic results were considered excellent owing to the hidden anatomical location of the incision site.

Conclusions: We have demonstrated the technique to be feasible, safe, and applicable for patients with thyroid disease. We believe that the use of robotic technology for endoscopic thyroid surgical procedures could overcome the limitations of conventional endoscopic surgical procedures in the surgical management of thyroid disease. To our knowledge, this is the first reported large series using this novel technique in the United States.


Surgical management of thyroid diseases has changed considerably during the last 2 decades. Beginning with open approaches and progressing to multiple types of minimally invasive surgery, these evolving surgical approaches have resulted in better cosmetic results, shorter hospitalizations, and faster patient recovery.1,2 There has been a trend toward minimally invasive approaches for thyroidectomy across the globe.3-7 These approaches range from videoscopic techniques through a small cervical midline incision all the way to removal of the thyroid gland through the axilla.8-10 Several approaches for endoscopic thyroidectomy have been described, including the anterior chest approach,8 the breast approach,9 and the transaxillary approach.10 Most of these surgical approaches require the use of gas insufflation in the neck.11

The progression of techniques continues. Recently, robotic thyroidectomy with a gasless transaxillary technique has been approved by the Food and Drug Administration. This approach is intended to be scarless and result in less pain and a faster return to functional activities.11 The gasless method has no risk of complications, such as hypercapnia, respiratory acidosis, tachycardia, subcuteaneous emphysema, and air embolism as seen in gas insufflation approaches.8

This article aims to introduce our authors’ experience of robot-assisted thyroid surgery and to demonstrate its appli-
cability in the surgical management of thyroid disease. Our major objective was to demonstrate feasibility of this technique in the US population.

METHODS

We conducted a prospective, controlled, pilot study involving patients with thyroid disease treated between September 1, 2009, and August 31, 2010. The patient exclusion criteria included the following: (1) history of previous neck surgery; (2) advanced Graves disease with thyromegaly; (3) a malignancy with definite extrathyroidal tumor invasion, neck node metastases, or distant metastasis; and (4) a lesion located in the thyroid dorsal area (especially adjacent to the tracheoesophageal groove) owing to possible injury to the trachea, esophagus, or recurrent laryngeal nerve (RLN). Patients were enrolled using approved selection criteria after full institutional review board approval.

Because this was the initial surgical experience with this technique, operative times were divided into 2 groups: early (first 20 cases) and late (the next 30 cases), and the operative times were further analyzed to evaluate the total operative time, robot docking time, and console time. Time data from the early and late groups were compared using SAS (version 9.2; SAS Institute, Inc) using an independent t test to determine if significant improvement was achieved in the different time elements of the procedures.

All the patients were intubated with a NIMS EMG endotracheal tube (Medtronic Xomed) to allow intraoperative monitoring of RLN function. Appropriate placement of the NIMS EMG endotracheal tube was confirmed by direct laryngoscopy and by visualization of the electromyographic wave form on the NIMS monitor.

The arm ipsilateral to the lesion (ipsilateral to the larger lobe of the thyroid in cases of total or subtotal thyroidectomy) was positioned cephalad and flexed above the head as described by Ikeda et al\textsuperscript{11} and shown in Figure 1. This optimized exposure of the axilla and created a short distance from the axillary skin to the thyroid gland, through which dissection would be performed. The thyroid was identified by palpation and a vertical line was drawn from the midline of the thyroid to the sternal notch, demarcating the medial boundary of dissection. We also routinely used intraoperative ultrasonography to identify lesions and to examine the relationship of the internal jugular vein to the thyroid gland in the anteroposterior plane. As the thyroid is approached from a lateral perspective, if most of the gland is located anterior to the level of the internal jugular vein, the exposure and subsequent dissection are technically easier than if the internal jugular vein is larger in caliber and more anterior; therefore, we are more careful with dissection over the carotid sheath. In addition, the large caliber of the vein can possibly obstruct the view of the tracheoesophageal groove. Obtaining an ultrasonogram in the operating room is a standard procedure that we perform before thyroid operations. The patient incurs no cost for the ultrasonogram. A transverse line was then drawn from the sternal notch to the ipsilateral axilla, denoting the inferior limit of the surgical incision, and an oblique line was drawn from the thyrohyoid membrane 60° from midline to the axilla to mark the superior limit of the incision. The intersection of the oblique mark with the anterior axillary line marked the superior limit of the axillary incision. The intersection of the transverse mark with the anterior axillary line defined the inferior limit of the axillary incision. A mark for a third-arm incision was made in holding area 4 cm lateral to the areola, in the medial fold of the breast, approximately 2 cm from midline (Figure 2).

A 4-cm axillary incision was then made, and a monopolar electrocautery was used to continue dissection down to the pectoralis fascia. A myocutaneous flap was raised in a subplatysmal plane in the direction of the thyroid until the sternal and clavicular heads of the sternocleidomastoid were visualized. A wound protector was placed to protect the axillary wound edges from any heat generated by the electrocautery or the Harmonic scalpel (Ethicon). The modified Chung thyroid retractor (Marina Medical) was placed around the strap muscles and secured to the table mount lift. The triangular window between the sternal and clavicular heads was entered using the Harmonic scalpel, allowing identification of the carotid sheath.

Next the da Vinci S robot was docked from the side of the bed contralateral to the operative field. A 12-mm camera was used, which approached through the axillary incision. The 2 axillary arms were equipped with Maryland forceps (Intuitive
Surgical) and a Harmonic scalpel. The chest wall arm was equipped with a 5-mm ProGrasp (Intuitive Surgical). The ProGrasp was used to retract the thyroid lobe, allowing for meticulous dissection of the thyroid vessels under direct vision (Figure 3). The external branch of the superior laryngeal and the recurrent laryngeal nerves was visualized and preserved in all the cases. Nerve stimulation was performed via a probe introduced into the field via the axillary incision.

The Harmonic scalpel was used to divide the isthmus. The ipsilateral thyroid lobectomy and isthmectomy specimens were removed via the axillary incision, and hemostasis was ensured using a Valsalva maneuver to 40 mm Hg. Using the same technique, we continued the operation through the same access site to remove the contralateral lobe of the thyroid. A Jackson-Pratt drain was then placed in the thyroid bed, protruding from the axillary incision.

RESULTS

Between September 2009 and September 2010, fifty patients underwent robotic-assisted transaxillary thyroidectomy. Thirty-nine were females and 11 were males with a mean age of 48.2 years (age range, 13-76 years). Thirty-seven surgical procedures were lobectomies, and 13 were total or near-total thyroidectomies. The mean nodule size (range) was 24.9 (10-72) mm. The mean operative time (range) was 122.5 (81-280) minutes, the mean docking time (range) was 10.1 (6-15) minutes, and the mean console time (range) was 55.5 (10-140) minutes. The mean blood loss (range) was 25 (10-100) mL. Only 2 patients who underwent total thyroidectomy (4%) were found to have hypocalcemia. One patient was found to be at a level of 7.4 mg/dL and the other at a level of 8.3 mg/dL (reference range, 8.4-10.4 mg/dL). However, they were asymptomatic. Both patients were normocalcemic by 2 weeks postoperatively after oral calcium supplementation at home. There were no conversions to conventional open surgery. One patient developed a transient radial nerve neuropathy that resolved spontaneously. There were no other perioperative or postoperative complications. All the patients tolerated the procedure well and were discharged home the next day. All the patients underwent postoperative laryngoscopy within 1 week of the surgical procedure, and no evidence of vocal cord palsy or paresis was found. Subjectively, the cosmetic results were considered excellent owing to the hidden anatomical location of the incision site (Figure 4).

In an effort to evaluate the learning curve, the cases were divided into early and late experience groups. The early experience group was defined as the first 20 cases; the late experience group was composed of the next 30 cases. In the early experience group, the mean robot docking time (SD) was 10.8 (1.9) minutes, compared with 9.7 (1.1) minutes in the late group (P=.01). The mean console time (SD) was 54.4 (28.4) minutes in the early experience group compared with 56.4 (36.5) minutes in the late experience group. The mean total operative time (SD) was 120.6 (36.0) minutes in the early experience group compared with 123.9 (60.4) minutes in the late experience group. The mean docking time (SD) for the hemithyroidectomies performed in the early experience group was 10.7 (2.0) minutes compared with a mean docking time of 9.5 (1.1) minutes for the late experience group (P=.04). Mean console time (SD) was 55.7 (29.7) minutes in the early experience group and 54.2 (37.3) minutes in the late experience group of hemithyroidectomies performed (P=.89). The mean total operative time (SD) for hemithyroidectomies performed in the early experience group was 122.6 (37.5) minutes compared with a mean total operative time (SD) of 122.4 (71.2) minutes for the late experience group (P=.99) (Table). No significant improvement was achieved in the key elements of the surgical procedure. We only found significant improvement in the robot docking time.

COMMENT

New technologies have defined the pace of medical progress in the recent years, but the biggest challenge associated with them is assessing their safety, efficacy, and...
value. It has been more than 15 years since Gagner et al.16 introduced the first endoscopic neck surgery, and significant advances in both endoscopic equipment and technique have been reported. The impetus behind this expanding body of work is the desire to avoid a conspicuous cervical scar. While such a scar is well tolerated by many patients, local pain, paraesthesia, dysesthesias, numbness, contractures, hypertrophy of the scar, and keloid formation have all been described as adverse sequelae of open thyroidectomy. Relocating the surgical scar to a less visible location is the goal of current endoscopic procedures. The transaxillary approach described here leaves incisions that are well concealed in the axillary fold when the arm is at rest. Figure 4 and Figure 5 show scars immediately after the surgery and 4 weeks later, respectively. Moreover, the transaxillary endoscopic thyroidectomy provides a natural operative view, similar to that found in open surgery, and easier manipulation of the upper and lower poles of the thyroid compared to the inferior approach. Identification of the RLN and the parathyroid gland is also made relatively simple with this method.14 New alternative robotic approaches are being used in thyroid surgery. Terris et al.15 recently described the feasibility of the robotic facelift thyroidectomy technique in 14 patients; however, additional clinical experience is warranted to further validate this technique.

The mean nodule size of the resected specimens in our patients ranged from 10 to 72 mm. Despite this, the surgical procedures were successfully carried out in all the cases without conversion to the open approach, implying that the size of the thyroid would not be a limiting factor to this approach. We were able to clearly view the RLN and the parathyroid glands on both sides, and there was no evidence of damage to either of these structures in any of the surgical procedures. Furthermore, the mean intraoperative blood loss in our series was smaller than that of reported endoscopic thyroidectomies2,17,18 or the conventional open total thyroidectomies.19,20 We observed no postoperative hematomas.

In the effort to determine the learning curve in our cohort, we could not define an end point at which there was minimal variation or a steady state of performance of overall operative times; this is mainly due to the very small sample size. In addition, an academic institution like ours has several fellows and residents who were being taught while these procedures were being performed. We are observing improvement in the operative time with our current experience, and it is a point of follow-up in future studies as more patients are added to the analysis.

An additional advantage of the surgical robot is the excellent quality of optics, with true 3-dimensional visualization. An intraoperative image of the surgeon's view is shown in Figure 6. Improved visualization has been described as a major benefit by many authors experienced in endoscopic cervical surgery.21 Using the 3-dimensional vision, excellent range of motion, and tremor reduction features intrinsic to the surgical robot, the procedures were swift, precise, and created no unnecessary trauma to the surrounding structures.

Minimal access surgery of the head and neck using a robotically assisted approach is feasible and safe. The addition of the robot to operations in difficult-to-reach anatomical areas makes the surgery easier to perform and will ultimately save time once the learning curve of the setup and approach is surpassed. Our experience with the transaxillary gasless robotic thyroidectomy described herein suggests that patient satisfaction in the United States will be high. To our knowledge, this is the first reported large series of use of this technique in the United States.

<table>
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<th>Experience Group</th>
<th>Early, min (n = 20)</th>
<th>Late, min (n = 30)</th>
<th>P Value</th>
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<td>Docking time</td>
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<td>Console time</td>
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<td>Total operative time</td>
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<td>Hemithyroidectomy</td>
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<td>Console time</td>
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<td>.89</td>
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<tr>
<td></td>
<td>Total operative time</td>
<td>122.6 (37.5)</td>
<td>122.4 (71.2)</td>
</tr>
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</table>

Figure 5. Axillary incision 4 weeks postoperatively.

Figure 6. Intraoperative view of the recurrent laryngeal nerve (RLN). TE indicates tracheoesophageal.
We have demonstrated this technique to be feasible, safe, and applicable for patients with thyroid disease. We believe that the use of robotic technology for endoscopic thyroid surgical procedures could overcome the limitations of conventional endoscopic surgical procedures in the surgical management of thyroid disease.

Submitted for Publication: March 23, 2011; final revision received September 20, 2011; accepted November 8, 2011.

Correspondence: Emad Kandil, MD, Department of Surgery, Tulane University School of Medicine, 1430 Tulane Ave, SL-22, New Orleans, LA 70112 (ekandil@tulane.edu).

Author Contributions: Drs Kandil, Noureldine, Friedlander, Abdel Khalek, and Slakey and Mr Abdelghani had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Kandil, Bellows, and Slakey. Acquisition of data: Abdelghani, Noureldine, and Abdel Khalek. Analysis and interpretation of data: Noureldine and Friedlander. Drafting of the manuscript: Abdelghani and Abdel Khalek. Critical revision of the manuscript for important intellectual content: Kandil, Noureldine, Friedlander, Bellows, and Slakey. Administrative, technical, and material support: Kandil and Bellows. Study supervision: Friedlander and Slakey.

Financial Disclosure: None reported.

Previous Presentation: This study was presented at the American Head and Neck Society 2011 Annual Meeting; April 27, 2011; Chicago, Illinois.

REFERENCES