Robotic Thyroidectomy: Operative Technique Using a Transaxillary Endoscopic Approach Without \( \text{CO}_2 \) Insufflation

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In recent years, several new techniques in thyroid surgery have been developed to improve visualization, reduce risk of complications, and shorten the length of neck incisions.\textsuperscript{1–4} In the United States, minimally invasive approaches have been shown to be feasible and safe, and are becoming more widely adopted by surgeons.\textsuperscript{5,6}

More recently, there have been several reports from Asia of endoscopic transaxillary approaches to the thyroid.\textsuperscript{7–15} Among these is a large series of patients, reported by a group from Seoul, Korea,\textsuperscript{16,17} who have undergone transaxillary robotic thyroidectomy incorporating the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA, USA). This approach eliminates the need for any cervical incisions, which increases patient satisfaction relative even to the small incisions used in minimally invasive video-assisted techniques.\textsuperscript{12} Although patient satisfaction alone may not justify the use of new technology, there may be other issues to consider.

From the surgeon’s perspective, the application of the da Vinci Surgical System to thyroid surgery may provide several advantages. The three-dimensional environment

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created with binocular 30° optics may improve visualization. Wristed instrumentation and 540° rotation increase the surgeon’s operative dexterity. With these advantages, robotic assistance may facilitate the endoscopic approach to the thyroid with no increased risk of injury to the parathyroids, and optimize recurrent and superior laryngeal nerve preservation.

Open thyroidectomy is a safe, effective, and time-honored approach. For this reason, many people may be skeptical of the value of using the robot for thyroid surgery. The same skepticism heralded the advent of robotic-assisted prostatectomy when this technique was introduced just 5 years ago. In the United States, 70% to 80% of radical prostatectomies are now performed using the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA, USA).

This article introduces the da Vinci Surgical System, describes the technique of robotic thyroidectomy with specific considerations for North American patients, and suggests a training paradigm for surgeons interested in adopting this technique.

DA VINCI SURGICAL SYSTEM

The da Vinci Surgical System, introduced in 1999 by Intuitive Surgical, is a surgical robotic system that has been widely adopted for urologic and gynecologic surgery. The system is composed of 3 components: a surgeon’s console, a patient cart, and a video tower.

The surgeon’s console allows the surgeon to have a three-dimensional high-definition view of the surgical field using a 0° or 30° stereo endoscope. This setup allows for magnification and enhanced visualization. In addition to controlling the endoscope, the console also allows the surgeon to control up to 3 additional instruments. Most instruments have 7° of freedom, allowing them to be maneuvered into locations that a surgeon normally cannot reach with conventional instruments. In addition, the motions can be scaled and any tremor is filtered out. Perhaps the most important advance is that the surgeon can operate with 2 hands in a large working space. Thus, fundamental and time-honored surgical principles of traction and countertraction, comprehensive exposure, and controlling the wound can be implemented in this robotic-assisted endoscopic approach. One limitation to the system is that the instruments do not provide tactile (haptic) feedback to the surgeon, as the surgeon would normally have when performing endoscopic surgery.

The patient cart is the portion of the system that docks to the patient and has the instruments and stereo endoscope attached to it. This portion is prepared with sterile drapes and typically a technician or nurse will attend to it during surgery.

TECHNIQUE

Like any surgical procedure, a robotic thyroidectomy requires preparation followed by a series of steps for successful completion. The essential steps of the procedure include patient positioning, marking the patient, creation of a surgical working space, docking the robot, performing a lobectomy or total thyroidectomy using the robotic instruments, and closing the wounds.

Room Setup

These cases require a significant amount of equipment to be present in the room, and therefore it is important for the surgeon to determine the best way to organize the room before the procedure. The shape and size of the specific operating room (OR) are aspects that typically cannot be modified and may provide limitations on where equipment can be placed. The positioning of the equipment may also need to be changed
depending on whether the surgical incision is being performed on the left side or right side of the patient. Ideally, the operating table will be oriented so that the anesthesia provider is at the head of the table and has access to the patient’s airway, head, and neck. The patient cart portion of the robotic surgical system should be covered with sterile drapes and positioned on the contralateral side of the operating table. Initially, it will need to be away from the table, as an assistant will need to stand on the contralateral side to help create the working space and to place the retractor. An assistant or technician will be on the ipsilateral side with the instrument table. The video cart portion of the robotic system or an additional video monitor should be placed so that the assistant on the ipsilateral side can visualize it during the procedure and provide assistance. The surgeon’s console portion of the robotic surgical system is typically located in the OR.

**Patient Positioning**

The patient is positioned in a supine position on a small shoulder roll. The patient’s ipsilateral arm is placed in an arm board extended cephalad to expose the axilla. The arm should not be secured in place until after the patient’s incision is marked. The patient’s contralateral arm is tucked adjacent to the patient’s body. It is crucial to place adequate padding around bony prominences on the arm, under the neck, shoulder, and small of the back. Good positioning is essential for exposure in this procedure, so patients with limited range of shoulder or cervical motion require careful positioning and, in severe cases, may not be candidates for this procedure. In addition, morbidly obese patients may pose significant challenges regarding positioning, dissection, and placement of the retractor needed to keep the working space open.

**Marking the Patient**

A vertical line is marked from the sternal notch to the hyoid in the midline. A 5- to 6-cm line is marked in the axilla at the posterior aspect of the pectoralis muscle (Fig. 1). The

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![Fig. 1. Skin markings showing the incision within medial axillary fold and location of robotic instrumentation. (Courtesy of Marina Medical Instruments, Inc, Sunrise, FL; with permission.)](image)
arm is placed into its natural position to confirm that the incision marked will be hidden in the axilla postoperatively. The arm can then be secured in place. A line is then drawn from the superior aspect of the axillary incision line to the superior aspect of the midline marking, and from the inferior aspect of the axillary incision line to the inferior aspect of the midline marking. These lines define the limits of the dissection.

A small incision on the ipsilateral chest is marked for the placement of the fourth robotic arm. Kang and Chung\textsuperscript{16} recommend placement of an 8-mm incision, located 2 cm superior to the right nipple and 6 to 8 cm medial of the right nipple (between the breast and sternum). However, because of differences in body mass index, stature, or breast size in the North American population, the location of this incision may need to be modified to ensure that port placement will allow the instrument to reach the working space.

\textbf{Placement of the Nerve Monitor}

Before preparing the patient, the laryngeal nerve monitor grounding electrode is inserted. The electrode can be placed slightly off the midline to the contralateral side, inserted into the field, and secured with a clear sterile adhesive dressing before starting the procedure.

\textbf{Creation of the Working Space}

An incision is made along the line marked in the axilla and carried down to the level of the pectoralis muscle. Dissection is performed with electrocautery above the pectoralis major muscle to create a space using serially longer retractors to elevate the skin, subcutaneous tissue, and platysma by the contralateral assistant. Lighted breast retractors or a headlight can be used to see within this space. It is helpful to have suction to evacuate the smoke. The skin markings provide a guide to the extent of the subplatysmal dissection. The dissection is continued over the clavicle to identify the space between the clavicular and sternal head of the sternocleidomastoid muscle. This space is opened superiorly, the omohyoid is retracted superficially and postero-laterally or divided, and the sternohyoid and sternothyroid muscles are elevated off the thyroid gland. The modified Chung thyroid retractor with table mount lift (Marina Medical, Sunrise, FL, USA) is placed under the strap muscles and secured to the table mount lift (Fig. 2). The lift is used to ensure an adequate working space with ample visualization of the thyroid, and should be at least 4 cm in height at the opening. The anesthesiologist should ensure that the patient has adequate padding around the neck and shoulders after the retractor is secured.

An 8-mm paramedian vertical incision is then made on the chest wall. A tract is created using hemostats and then a blunt-tipped trocar is placed and tunneled into the working space. This trocar will be used to place the third arm of the robot and later the ProGrasp instrument.

\textbf{Docking the Robot}

Once the space has been created and the retractor is in place, the patient cart of the da Vinci Surgical System is moved to a position adjacent to the table and the arms are oriented to insert the instruments. A 30° down stereoscopic endoscope, 8-mm Harmonic curved shears, and a 5-mm Maryland dissector are placed in the ports that enter through the axillary incision. The Harmonic curved shears are placed in the position that would correspond with the surgeon’s dominant hand. The angles with which these instruments are placed are essential to prevent conflict within the wound. The camera, which is in the middle, should be low outside the wound and high inside the wound. In this way it is oriented with a view down on the thyroid and
out of the way of the instruments. The instruments should enter high in the wound and be angled to a low position, so that they are under the camera.

An 8-mm ProGrasp forceps is placed in the port that enters through the chest incision, and is typically used to retract the thyroid and other tissues during the procedure.

**Removing the Ipsilateral Thyroid Lobe**

The superior pole of the ipsilateral thyroid lobe is retracted with the ProGrasp forceps and the superior thyroid pole is dissected from the cricothyroid muscle and other surrounding tissues. It is then transected with the Harmonic shears. The inferior aspect of the thyroid is also dissected from the trachea using the Harmonic shears. The thyroid is then retracted medially and ventrally, away from the trachea and paratracheal groove, using the ProGrasp forceps. In so doing, the recurrent laryngeal nerve and both parathyroids are identified and preserved. The thyroid lobe is then dissected off the trachea to the midline and divided using the Harmonic shears.

**Removing the Contralateral Lobe**

Kang and colleagues\(^{17}\) have demonstrated the technique and advocated for total thyroidectomy via a single transaxillary incision. If a total thyroidectomy is to be performed, the contralateral superior pole is retracted using the ProGrasp forceps and transected using the Harmonic shears. A subcapsular dissection is performed between the deep aspect of the thyroid and the trachea using the Maryland forceps and Harmonic shears. However, exposure of the nerve in the contralateral paratracheal groove is technically more challenging because of limited visualization. Dr Chung (personal communication) recommends that the robotic-assisted endoscopic surgeon demonstrate significant competency with a robotic thyroidectomy before attempting total thyroidectomy via unilateral transaxillary incision.
Closure

After hemostasis is obtained, a closed suction drain is placed, and the incisions are closed by the surgeon’s preferred method.

Postoperative Care

Patients are treated postoperatively by the surgeon’s usual protocols for managing drains, hypocalcemia, and inpatient observation. Because the working space created is much larger than in conventional thyroid surgery, the risk of postoperative airway compression from a hematoma is low, and therefore it is plausible that these patients could be discharged on the same day.

SUGGESTED TRAINING PARADIGM

For surgeons currently in practice there is no definitive training algorithm for incorporating robot-assisted techniques into their surgical practice. For experienced thyroid surgeons, using the da Vinci Surgical System to perform thyroid surgery represents the application of a new tool to anatomy already well understood to perform an existing surgical procedure. This situation is not dissimilar from the progression from open techniques to the application of the endoscope to sinus surgery. However, many of the surgeons in Asia now embracing robotic-assisted approaches in thyroid surgery have a long experience of nonrobotic totally endoscopic thyroidectomy. A learning curve undoubtedly exists but has yet to be defined.

During mentorship and training for robotic surgery, the surgeon should consult with their local hospital credential committee to understand requirements and to follow recommendations on how to acquire and validate privileges for specific new procedures. Because the da Vinci Surgical System is complex and the surgeon is ultimately responsible for its operation, it is essential that surgeons undergo thorough training before performing this procedure on patients.

In addition to learning how to use the robot and its instruments, it is recommended that surgeons become familiar with the use and tissue effects of the Harmonic shears before using the robot. At present, the Harmonic shears are the primary cutting and coagulation instrument used in the procedure. One blade oscillates at 55,000 Hz and although the other is insulated, which partially protects surrounding soft tissues and neurovascular structures from thermal injury and neuropraxia. However, because the Harmonic oscillation requires a unique mechanical architecture, the 540° wristed instrumentation found in other da Vinci instruments is lacking. This omission creates certain limitations for its use. Alternatives include the Maryland forceps with bipolar cautery.

Critical activities to learning this technique include:

- da Vinci Surgical System Training. All surgeons must undergo online and hands-on robotic training as recommended by Intuitive Surgical. This training will allow surgeons to understand the components, functions, and controls of the robotic surgical system.
- Live case observation. Surgeons should consider observing robotic thyroidectomy in a live setting with an experienced surgeon. This process will be helpful in visualizing the room setup, patient positioning, the surgical approach, OR staff use, and positioning of the robot.
- Video case observation. Obtaining a video of the robotic portion of the procedure to study the steps involved before performing the procedure is helpful. Surgeons should also record their own cases and review the videos after completing the operation to look for opportunities for improvement.
- Cadaver dissection. In the laboratory, surgeons can practice positioning the patient, marking the patient, performing the surgical approach, docking the robot, and removing the thyroid using the robot in a fresh cadaver model. One suggested method would be to perform the transaxillary dissection and approach on one side, then use the robot to perform a thyroid lobectomy. After completing the lobectomy, the robot could be removed from the field; then the contralateral transaxillary dissection and approach can be repeated. After performing the second approach, the robot could be redocked on the ipsilateral side so that a total thyroidectomy can be performed. This method will enhance the surgeon’s ability to understand the transaxillary approach as well as the technique for ipsilateral lobectomy and contralateral lobectomy.

- Proctored cases. Surgeons could benefit from, and hospitals may require, having an experienced robotic surgeon proctor cases, particularly if the surgeon does not have live experience using the robot in other settings.

SUMMARY

Based on the experience of the group in Korea, our case observation in Korea, and the performance of this procedure on cadavers and patients, this technique seems to be safe and feasible. However, there are many unanswered questions including the benefits of the application of this technology relative to its costs, and whether the technology will provide additional benefits to patients and surgeons, particularly as new innovations are added to the system.

REFERENCES