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Gasless Transaxillary Robot-Assisted Neck Dissection: A Preclinical Feasibility Study in Four Cadavers

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Purpose: We hypothesized that comprehensive neck dissection could be achieved via a gasless transaxillary approach using a robotic system. We intended to evaluate the accessibility of level I, IIB and VA nodes with transaxillary robot-assisted neck dissection of four cadavers. **Materials and Methods:** Transaxillary robotic neck dissection was performed in four cadavers through a 7-cm longitudinal incision at the anterior axilla and a 0.8-cm-sized incision in the chest wall. **Results:** We successfully performed neck dissection from level II to V in all four cadavers. However, dissection of levels IIB and VA, which lie on the cephalic portion of the spinal accessory nerve, was difficult. Vital structures, including the internal jugular vein, carotid artery, vagus nerve, phrenic nerve, superior thyroid artery and hypoglossal nerve, were successfully identified and preserved. **Conclusion:** Our results demonstrate the feasibility of robot-assisted neck dissection using a transaxillary approach. We suggest that gasless, transaxillary robotic neck dissection is a promising technique for treating nodal metastasis in thyroid cancers or in selected squamous cell carcinomas of the head and neck. However, some modification of the approach might be needed when performing comprehensive neck dissections of all levels of the neck.

Key Words: Trans-axillary, robotic, neck dissection, cadaver, squamous cell carcinoma, endoscope

INTRODUCTION

Technological advances such as the introduction of the endoscope and surgical robotic system have brought great change to surgery. Such progress has led to minimally invasive surgery and allowed for a better postoperative cosmetic status for patients without compromising oncologic principles.[1,2] The 3-dimensional magnified surgical view provided by the da Vinci robotic system (Intuitive Surgical, Mountain View, CA, USA) allows surgeons to overcome the limitations of conventional endoscopic surgery, such as 2-dimensional views, lack of a third arm or a limited range of motion of instruments. Furthermore, multi-articulated instruments and downscaling systems provides an opportunity to perform more minute and precise dissections and to more successfully preserve vital structures.

In the field of head and neck surgery, there have been several studies about trans-oral robotic surgery (TORS), in which upper aero-digestive tract tumors are removed using the robotic surgical system.[3-5] Our team has also reported at length the feasibility of TORS in various head and neck squamous cell carcinoma (HNSCC) cases.[6,7] In addition, at our institution, robotic endoscopic thyroidectomy via trans-axillary approach has been performed in over 3,000 patients by Chung's research team.[8,9] The transaxillary approach provides enough surgical view to perform not only thyroid-ectomies but also dissections of the lateral compartment of the neck, as Chung has shown in his report on the feasibility of transaxillary robotic neck dissections (ND) in differentiated thyroid cancer patients with nodal metastasis.[10]

However, as of yet, studies regarding robotic neck dissection in HNSCC have not been performed. The need for this separate study is important because the comprehensiveness of ND in thyroid cancer and HNSCC might be somewhat different. The prognosis of patients with HNSCC is much poorer than those of thyroid cancer patients, and survival rates sharply decrease when patients have nodal metastasis in HNSCC. The control of neck disease in HNSCC is widely accepted as more important than in differentiated thyroid cancer. In Chung's study, instead of modified radical ND, they usually only performed selective neck dissection of levels IIA, III, IV, and VB.[10] Hence, for cases of HNSCC, we needed to verify the feasibility of robot-assisted transaxillary comprehensive ND of all neck levels, including level I, IIB and VA.

Therefore, we aimed to investigate whether a comprehensive ND for HNSCC could also be performed with this approach using the da Vinci robotic system. We intended to assess whether Level I, IIB and VA nodes can be dissected using a robot assisted endoscopic approach for HNSCC with nodal metastases in four cadavers.

Fig. 1. Position and neck incision. With a cadaver placed in the supine position, the neck was slightly extended, and the dissection-side arm was abducted 45° and fixed; a 7 cm longitudinal skin incision along the anterior axillary line was made, and a second skin incision (0.8 cm long) was made on the medial side of the anterior chest wall.

MATERIALS AND METHODS

Cadavers

Four human cadavers were obtained from the Department of Anatomy of Yonsei University College of Medicine after approval by the Severance Robot and Minimally Invasive Surgical Training Center. Three of the cadavers were male and one was female. The cause of death were hepatocellular carcinoma in two cadavers, myocardial infarction in one, and uterine cancer in the remaining one. Dissection was done on the left side in three of the cadavers and the right side in the other. The choice of dissection side was made depending on the condition of the cadavers, and neck dissection was only performed on the selected side.

Flap elevation

With a cadaver placed in the supine position, the neck was slightly extended, and the dissection-side arm was abducted 45° and fixed (Fig. 1). A 7-cm longitudinal skin incision along the anterior axillary line was made and the skin flap was elevated under direct vision above the pectoralis major muscle to access the subplatysmal plane. After exposing the lateral border of the sternocleidomastoid muscle, we cut its clavicular head and retracted the muscle anteriorly and superiorly. Then, the dissection continued posteriorly along the anterior border of the trapezius muscle, and the spinal accessory nerve (SAN) was preserved after being identified at about 1 cm above Erb's point. Initially, we intended to elevate the skin flap up to the inferior border of the mandible, while preserving the marginal mandibular branch of the facial nerve. However, it was difficult to reach the mandible across the submandibular gland, and the external self retractor we used was too short to elevate and suspend the skin flap over level I. As a result, the flap was superiorly elevated up to the inferior border of the submandibular gland (SMG) and until the posterior belly of the digastric muscle was noted.

Docking of robotic system

To create a working space, we inserted an external retractor (Sejong Medical Corporation, Paju, Korea) through the skin incision in the axilla, which was raised using a lifting device. Four robotic arms were used during the dissection. Three arms including a dual channel endoscope, Harmonic curved shears and a Maryland dissector (the latter two designed by Intuitive Surgical) were inserted through the axillary port. The endoscope was placed in the center of the three robotic arms, accompanied with the Harmonic scalpel and Maryland dissector on both sides. Another 0.8-cm-sized skin incision for the fourth robotic arm was made on the anterior chest wall, 2 cm superior and 6-8 cm medial of the dissection-side nipple (Fig. 1). Prograsp forceps (Intuitive Surgical) were then inserted through this anterior chest port.

RESULTS

We successfully performed neck dissection from levels II to V in all four cadavers. After the flap elevation and docking of the robotic arms, dissection was initiated from level IV and V, and then progressed upwards. With the Prograsp forceps, we continuously retracted or rolled the surgical specimen. The dissection was performed with a Harmonic scalpel under the control of the dominant hand and a Maryland dissector under the non-dominant hand.

At level V, we carefully dissected fibrofatty tissue along the anterior border of the trapezius muscle, preserving the previously identified SAN during skin flap elevation (Fig. 2). The external jugular vein and omohyoid muscle were divided. The transverse cervical artery was identified and preserved (Fig. 3). Fibroadipose tissue at level IV was retracted upward, exposing the brachial plexus and the phrenic nerve (Fig. 3). At level IV, the thoracic duct or lymphatic duct was carefully identified and divided with the Harmonic scalpel. As the dissection continued superiorly, the cutaneous branches of the cervical plexus were divided and the carotid sheath was incised. The vagus nerve, common carotid artery and internal jugular vein were exposed. The superior thyroid artery was identified anterior to the carotid sheath and was preserved (Fig. 4).

After level III dissection, the axis of the robotic arms was re-adjusted superiorly for level II dissection (Fig. 5). The inferior border of the SMG was dissected and the posterior belly of the digastric muscle was identified (Fig. 4). The dissection continued posteriorly, and the hypoglossal nerve was identified and preserved. The upper end of the internal jugular vein and the SAN were exposed under the posterior belly of the digastric muscle. The specimen was removed

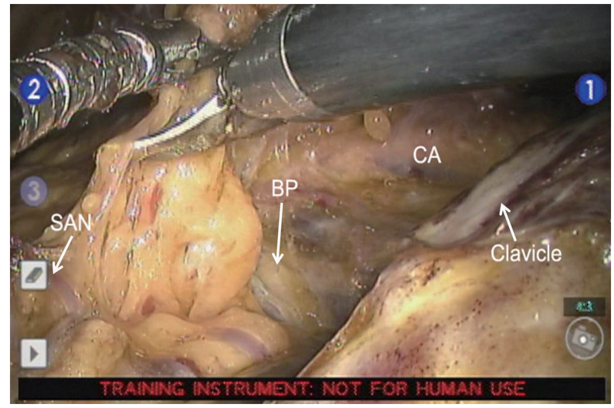

Fig. 2. Surgical view. SAN, spinal accessory nerve; BP, brachial plexus; CA, carotid artery.

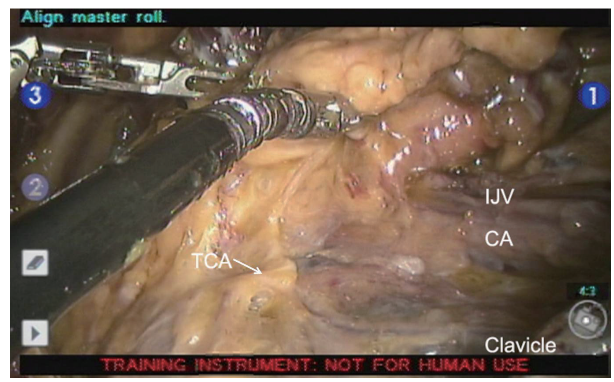

Fig. 3. Surgical view. TCA, transverse cervical artery; IJV, internal jugular vein, CA, carotid artery.

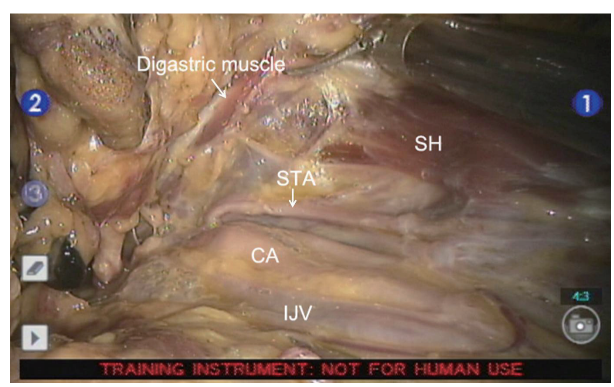

Fig. 4. Surgical view. STA, superior thyroid artery; digastric muscle, posterior belly of the digastric muscle; CA, carotid artery; IJV, internal jugular vein; SH, sternohyoid muscle.

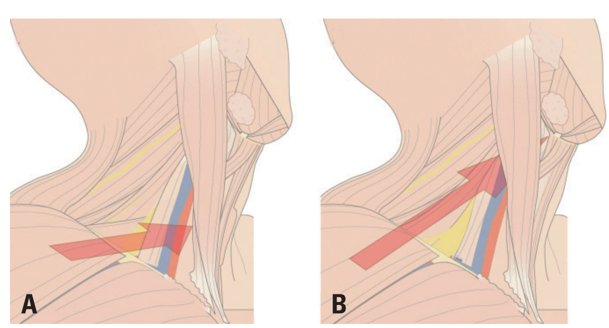

Fig. 5. The axis of robotic system (A) for level III, IV, V dissection; (B) for level II dissection.

through the axillary incision.

The side of dissection did not have any significant effect on the performance of ND. Dissection of levels IIB and VA, which lie on the cephalic portion of the SAN, was difficult on both sides, as full exposure and complete dissection was hard to obtain due to the angle of the robotic arm and endoscope.

DISCUSSION

Conventional neck dissection requires a long incision and leaves a prominent scar on the neck. There has been a lot of effort to reduce postoperative scars in head and neck surgery, such as minimally invasive video assisted thyroidectomy[11] and endoscopic thyroidectomy.[9,12] In addition, very recently, the introduction of the surgical robotic system, da Vinci, has spurred the development of new surgical techniques to minimize visible postoperative scars.[13] Among these various new surgical techniques, the transaxillary approach has the advantage of cosmesis. As the incidence of thyroid cancer is much higher in females and the proportion of young patients is increasing, endoscopic or robot-assisted transaxillary thyroidectomy is now accepted as a good alternative to conventional open thyroidectomy. Moreover, if we could remove the lateral neck nodes through the axillary port successfully, thyroid cancer patients with positive neck nodes could also be treated through this approach leaving no visible scars on their neck. Robotic neck dissection could be an alternative operative method, in low risk, well-differentiated thyroid cancer patients with lateral neck metastasis.

However, even though reducing the surgical extent of neck dissection in HNSCC has become an important aspect in surgery, HNSCC still necessitates a wider and more thorough removal of neck nodes than differentiated thyroid cancer. In this respect, the transaxillary approach has some limitations, which we need to overcome for appropriate neck treatment. First, dissection at level I was extremely difficult. During the cadaver dissection, we elevated the skin flap and tried to dissect level I; however, level I was too far from the axillary skin port to dissect efficiently with robotic arms under endoscopic view. Furthermore, vital neural structures such as the lingual nerve, the hypoglossal nerve beneath the mylohyoid muscle or the marginal mandibular branch of the facial nerve were difficult to identify and preserve. Second, level IIB, which lies outside of the spinal accessory nerve, was difficult to dissect completely because of a limited view. Third, in the presence of a prominent clavicle, the lower portion of level IV was difficult to dissect completely because the Harmonic shears have a limitation in bending motion.

On the other hand, the concept of super-selective neck dissection has been gradually accepted as a reasonable neck treatment for HNSCC patients. In the treatment of clinically node-negative HNSCC, limited neck levels have been removed for elective neck management and the possible exclusion of several sub-levels has also been reported.[14] For example, there are several reports that level I or IIB could be excluded in elective neck dissection or therapeutic neck dissection in selected larynx, hypopharynx or tonsillar cancer patients.[15-17] Using the robotic system via the transaxillary approach, surgeons could successfully dissect selected neck levels. Therefore, we presume that robotic neck dissection could be applied for neck treatment in selected HNSCC patients after validation of surgical or oncologic studies. In cases of thyroid cancer, there are not many cases where level I or IIB dissection is needed, as level I metastasis is hardly observed,[18] and the incidence of level IIB metastasis is reported to be low in some studies.[19]

In oral cavity cancer, in which level I dissection is mandatory, we postulate that several additional ports combined with the transaxillary approach would allow for the complete dissection of level I. For example, the floor of the mouth (FOM) could be a good additional route for level I dissection. As several authors have reported on trans-oral robot assisted FOM thyroidectomy,[20] level I can be accessed through the FOM. Primary tumors in the oral cavity could be removed simultaneously by lingual release or a pull-through approach. However, even with the FOM approach, level IIB dissection still remains a pitfall of the transaxillary approach.

Another plausible additional route is a retroauricular approach, which some surgeons have used for endoscopic submandibular gland excision.[21] By combining the retroauricular approach, we might be able to dissect not only level I but also level IIB. Hence, we are currently investigating the feasibility of a transaxillary and retroauricular approach for comprehensive neck dissection in human cadavers, and we are planning a follow-up report.

In conclusion, our results demonstrate the limited feasibility of robot-assisted endoscopic neck dissection using a gasless, transaxillary approach. We suggest that robotic neck dissection using the transaxillary approach might be applied for treating nodal metastasis only in selected squamous cell carcinomas of the head and neck, which do not require level I or IIB dissection. Some modification of the approach might be needed when performing the comprehensive ND of all levels of the neck.

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