Feasibility and Clinical Outcomes of Transoral Robotic Surgery and Transoral Robot-Assisted Carbon Dioxide Laser for Hypopharyngeal Carcinoma

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Abstract: Transoral robotic surgery (TORS) has been used as a novel procedure for squamous cell carcinoma of the laryngopharyngeal cancers with encouraging outcomes. The safety, feasibility, and efficacy regarding this approach have previously been demonstrated. There are several studies proposing the benefit of combining TORS with carbon dioxide (CO2) laser in resecting upper aerodigestive tract tumors. We report a series of patients with hypopharyngeal carcinoma treated with primary TORS with or without the flexible carbon dioxide (CO2) laser. All TORS resections were completed without any intraoperative complication. None required conversion to an open procedure. Clinical outcomes in this preliminary analysis indicate that magnified view, 3D visualization with the wristed instruments and tremor reduction technology of robotic experience, allow en bloc resection of early stage hypopharyngeal cancers. TORS with CO2 laser is a promising, minimally invasive surgical alternative for the treatment of hypopharyngeal tumors with comparable oncologic outcomes.

Key Words: Hypopharyngeal cancer, transoral robotic surgery, transoral robot-assisted CO_2 laser

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The overall survival rate and prognosis of hypopharyngeal cancer are relatively poor despite aggressive surgery and chemoradiotherapy. Organ-preservation therapies have been popularized to treat hypopharyngeal cancer to avoid the morbidity and disfigurement associated with traditional open surgical approaches. However, the toxicity of these regimens often leads to organ dysfunction, permanent tracheostomy, feeding tube dependence, and poor quality of life outcomes.[1,2] Although conventional surgery carries significant morbidity, it remains one of the preferred therapeutic options especially in locally advanced cases. Nevertheless, there has been no consensus about the best treatment modality.[1] Recent studies demonstrated the feasibility of minimally invasive surgical approaches in the treatment of hypopharyngeal cancers, with a considerable decrease in morbidity rate.[2,3]

Transoral robotic surgery (TORS) facilitates the performance of highly complex surgeries in areas of the upper aerodigestive tract that are challenging to access and manipulate instruments within, such as the nasopharynx, oropharynx, hypopharynx, and larynx.[3–6] It allows for wristed instruments and tremor-reduction technology to provide surgeons with improved control of limited surgical fields. A three-dimensional magnified camera allows excellent visualization of the target anatomy and aids in precise resection. Patient-related benefits include shorter operative time and hospital stay, minimal bleeding, low complication rates, as well as excellent quality of life.[4,5]

The aim of this study was to analyze a series of hypopharyngeal cancers treated with primary TORS with and without the flexible carbon dioxide (CO_2) laser. Objectives included determining the following: (1) safety, (2) feasibility, and (3) efficacy of the technique.

MATERIALS AND METHODS

Institutional review board approval was obtained from the Ohio State University Office of Responsible Research Practices. All patients participating in the trial signed the standardized informed consent as per institutional guidelines.

Study Design and Setting

The study was designed as a prospective clinical trial at a tertiary care academic comprehensive cancer treatment center. Data were collected exclusively at the Ohio State University Wexner Medical Center from 2008 to 2013.

Data Collection

Data were obtained from a prospective TORS clinical trial database. All data were verified with a retrospective electronic medical records review to ensure accuracy. Data points collected include patient demographics, tumor variables, staging, treatment details, complications, and follow-up information.

Outcomes

The main outcome measure was the complication rate after TORS with/without CO_2 laser for hypopharyngeal cancers. Secondary outcomes included surgical success and specimen margin status.

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FIGURE 1. Initial incision was made around the hypopharyngeal lesion using the flexible CO_2 laser attached to the robotic needle driver.

FIGURE 3. The view of the surgical bed after the tumor resection.

Surgical success was defined by the ability to remove the tumor en bloc using TORS.

Surgical Technique

Transoral robotic surgery was performed with the patient under general anesthesia using the da Vinci SI Surgical System (Intuitive Surgical, Sunnyvale, CA). Transnasal intubation with a laser-safe endotracheal tube was used to keep the endotracheal tube posterior to the surgical field. Transoral exposure was established with a Feyh-Kastenbauer retractor (Gyrus ACMI, Southborough, MA). Visualization was achieved with a 30-degree upfacing binocular robotic camera. The working arms of the robot held a Maryland dissector and a Bovie monopolar cautery or a robotic needle driver. The needle driver held a flexible CO_2 laser (OmniGuide Surgical, Cambridge, MA).

The procedures began after a sufficient view of the tumor, and its margins were obtained (Fig. 1). Laser or cautery dissection proceeded from a superior to inferior direction, with the Maryland dissector used to provide countertension. A surgical fascial plane was achieved deep to pharyngeal constrictor muscles. The specimen was released from the lateral and posterior pharyngeal walls initially. En bloc resection was completed after excising the tumor from inferior and medial (laryngeal) attachments (Fig. 2). The surgical field was then inspected for any bleeding, and hemostasis was achieved with suction cautery (Fig. 3).

FIGURE 2. While the surgeon was resecting the tumor with robotic arms, an assistant surgeon was providing countertraction using an aspirator.

After the completion of TORS, immediate margin analysis was achieved with intraoperative frozen section biopsies. Concurrent bilateral selective lymph node dissection was performed in all patients after frozen section margins were sent off to the pathology unit.

RESULTS

Among 300 TORS patients, a total of 5 patients with squamous cell carcinoma of the hypopharynx underwent TORS hypopharyngectomy between 2011 and 2013. Table 1 summarizes the patient characteristics and clinical outcomes. All patients were alive at the time of data analysis, with a mean follow-up time of 12.8 months (range, 4–28 mo).

The primary tumor site was the pyriform sinus in 4 patients and lateral pharyngeal wall in the other. Two patients (40%) had T1, 2 (40%) had T2, and 1 (20%) had T3 disease. Extracapsular spread was present in 1 patient (20%) and lymphovascular invasion was identified in 2 patients (40%). Nodal status at final pathologic diagnosis was N0 in 4 patients (80%) and N2 (20%) in 1 patient. En bloc tumor resection with negative surgical margins was achieved in all 5 patients. None of the patients required tracheostomy at the time of the surgery.

All TORS resections were completed without any intraoperative complication. Soft oral diet was initiated after 24 hours of surgery in all patients. The mean hospital stay was 4.6 days (range, 4–5 d). During follow-up, 1 patient required temporary tracheostomy and parenteral gastrostomy (PEG) tube insertion because of partial airway obstruction and dysphagia. Two patients needed PEG tube transiently during radiation therapy. All patients returned to their daily activities without any swallowing and speech problems in 3 months.

DISCUSSION

Hypopharyngeal cancer comprises 3% to 5% of all upper aerodigestive tract cancers. Because most are diagnosed at an advanced stage, extensive surgical resection is typically needed. The result is postoperative dysphagia, dysphonia, and poor survival.[1] In an attempt to decrease morbidity and increase postoperative quality of life, organ-preservation strategies using chemotherapy and radiotherapy have been incorporated into hypopharyngeal cancer treatment.[7]

TABLE 1. Patient Characteristics and Clinical Outcomes

Pt	Age, y	Sex	Site of Tumor	TNM	Surgery	Surgical Margin	Adj Tx	Trach	PEG Tube
1	59	M	Lateral hypopharyngeal wall	T1N0M0	TORS-L	neg	RT	n/a	n/a
2	75	M	Pyriform sinus	T2N0M0	TORS-L	neg	n/a	n/a	n/a
3	56	M	Pyriform sinus	T1N0M0	TORS	neg	n/a	Transient	Transient
4	47	M	Pyriform sinus	T3N0M0	TORS	neg	RT	n/a	Transient
5	62	F	Pyriform sinus	T2N2M0	TORS	neg	RT+CT	n/a	Transient

Adj Tx, adjuvant treatment; CT, chemotherapy; F, female; M, male; n/a, no/any; neg, negative; Pt, patient; RT, radiotherapy; TNM, TNM classification; TORS-L, transoral robotic surgery with carbon dioxide laser; Trach, tracheostomy.

Although aggressive chemoradiotherapy may preserve the larynx, it does not eliminate the need for permanent tracheostomy or PEG tube placement in all patients. Despite preserving the organ, Hanna et al[8] found no significant differences between total laryngectomy and primary chemoradiation groups in speech and swallowing–related quality of life scores. Therefore, preservation of an organ does not always ensure preservation of function. Furthermore, survival rates have not been very encouraging. Beauvillain et al[7] observed 5-year overall survival and local control rates of 19% and 39%, respectively, after definitive chemoradiotherapy.

The trend toward minimally invasive organ- and function-preserving treatment regimens for oropharyngeal and laryngopharyngeal carcinomas has occurred in parallel with the evolution of new surgical technologies. A variety of minimally invasive surgical options are now available for the management of head and neck tumors including transoral CO_2 laser microsurgery. Transoral CO_2 laser microsurgery is a valid alternative to any other surgical or nonsurgical therapeutic regimen in the treatment of early and advanced hypopharyngeal cancer. In contrast to radical surgical procedures, transoral CO_2 laser microsurgery provides high rates of organ and function preservation with enhancing oncologic outcomes, minimizing the loss of healthy tissue and avoiding extensive reconstruction procedures.[2] The advances in technology resulted in the development of flexible, mechanically robust, biocompatible, low–optical loss fibers for CO_2 lasers that afford reliability and power handling capacity suitable for laser applications.[2,6]

Innovations and refinements in optic technology as well as the introduction of the da Vinci robot have steadily improved the view, reach, and, consequently, the effectiveness of minimally invasive TORS techniques. Endoscopic resection of early-stage hypopharyngeal cancer is less invasive and has the potential to improve patients' quality of life, minimizing swallowing, aspiration, and phonation problems. Current data support that TORS facilitates access to aerodigestive tract tumors via a minimally invasive approach, with comparable oncologic outcomes. Park et al[5] reported 23 cases of hypopharyngeal cancer treated with TORS. The procedure was completed successfully in all patients, with negative margins in 21 patients. Iseli et al[9] reported 15 cases of laryngeal (12) and hypopharyngeal (3) cancer, all completed successfully with negative margins of resection.

Currently, monopolar cautery is frequently used to cut or coagulate the tissues in the TORS process. A single incision made by unipolar cautery is wider and deeper compared with laser, and more thermal damage to the surrounding tissue occurs as well.[10] These characteristics are disadvantages of TORS for hypopharyngeal carcinoma, which requires more precise operation around the airway. However, laser has the advantages of more precise cuts with less thermal damage and a lymphatic sealing effect that prevents tumor cell spread. Moreover, postoperative tissue swelling is minimal in the laser cases.[2,6,10] CO_2 laser combined with the robotic arms of the da Vinci surgical system may produce less morbidity in hypopharyngeal resections than TORS with monopolar cautery.

The major limitations of this study are the small sample size and short follow-up time. Long-term follow-up with a larger cohort series of patients will be necessary to compare oncologic results of TORS hypopharyngectomy with other modalities.

CONCLUSIONS

Transoral robotic surgery with CO_2 is a promising, minimally invasive surgical alternative for the treatment of hypopharyngeal tumors with good functional and clinical outcomes in this preliminary analysis. Transoral robotic surgery is a safe and feasible procedure in the treatment of early-stage hypopharyngeal cancers.

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