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WILEY
Hybrid Supracricoid Partial Laryngectomy With Cricohyoidoepiglottopexy via Transoral Robotic Surgery

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**Objectives/Hypothesis:** To describe a hybrid supracricoid partial laryngectomy with cricohyoidoepiglottopexy (hybrid SCPL-CHEP) combining limited transcervical and transoral robotic approaches.

**Study Design:** Preclinical cadaveric study.

**Methods:** Using six human cadavers in a series of three preclinical laboratories (July 2016–February 2018), we developed a novel hybrid technique for SCPL-CHEP. A flexible single-port robotic surgical system was utilized for the transoral aspects of the procedure.

**Results:** Detailed procedural steps are defined: 1) transoral: mucosal incisions under direct visualization of the laryngopharynx (tumor resection); 2) transcervical: incision and mobilization of the larynx and pexis; and 3) transoral: mucosal closure. Hybrid SCPL-CHEP was technically feasible and allowed for complete transoral mucosal reconstruction. We discuss potential clinical significance of adding this TORS approach to conventional open SCPL-CHEP.

**Conclusions:** This hybrid technique for SCPL-CHEP provides two main advantages over the standard technique: direct visualization during tumor resection prior to laryngotomy and full closure of the laryngopharynx defect. These technical refinements might facilitate postoperative recovery and in turn make this larynx preservation procedure more accessible to patients and surgeons. A clinical trial evaluating the efficacy of hybrid SCPL-CHEP appears warranted to validate these observations.

**Key Words:** Laryngeal cancer, supracricoid partial laryngectomy, larynx preservation surgery, transoral robotic surgery.

**Level of Evidence:** NA

**INTRODUCTION**

Supracricoid partial laryngectomy (SCPL) with cricohyoidoepiglottopexy (CHEP), or cricohyoidoepiglottoplasty (CHP), is an important laryngeal preservation surgery performed through a standard open approach and used for selected early and intermediate-stage (T1–T3) carcinomas.1–3 This procedure removes three-quarters of the larynx, including the bilateral vocal folds, and spares the cricoid and one or two arytenoids. SCPL fulfills the principal requirements of conservation laryngeal surgery: 1) locoregional disease control, 2) transoral respiration without permanent tracheostoma, and 3) vocal and swallowing function without a prosthesis or tube. In terms of oncologic outcomes for previously untreated patients, SCPL-CHEP might be superior to other partial laryngectomies.4,5

In the recent era of head and neck surgery, minimally invasive surgery has become more widely utilized within the multidisciplinary treatment paradigm for head and neck cancer.6 Primarily focusing on oropharyngeal carcinoma, several approaches in transoral endoscopic head and neck surgery, including transoral laser microsurgery7 and transoral robotic surgery (TORS),8 underscore the increasing role of surgery for these patients. Yet, in the largest series of patients treated with TORS, only 5.9% of patients underwent TORS for laryngeal cancer.9 All of these patients had supraglottic cancer, and none had glottic cancer. The promise of TORS, with improved visualization and multi-instrument surgery in a confined space, seems to fall short for patients with laryngeal cancer.

In the spirit of the tradition of conservation laryngeal surgery, we explored new ways in which transoral surgery might be applied to conventional supracricoid partial laryngectomy. Two aspects of SCPL-CHEP appeared amenable to further development. First, in any open laryngeal procedure from supraglottic laryngectomy to total laryngectomy (TL), the surgeon must enter the airway blindly and make the first mucosal incision without visualizing the tumor. Second, wound reconstruction and closure to optimize voice and swallowing are technically challenging.10 Both of these aspects might be improved through the transoral techniques.

Herein, we present our preclinical experience in the development of hybrid SCPL-CHEP, which is based on the well-established partial laryngectomy SCPL procedure. We demonstrate the feasibility of hybrid SCPL-CHEP, provide...
detailed procedural steps, and discuss the potential clinical significance of adding the TORS approach to conventional open SCPL-CHEP.

MATERIALS AND METHODS

Six fresh-frozen human cadavers were used to study a hybrid technique of SCPL-CHEP in a series of three laboratories (July 2016–February 2018) designed to simulate normal operating room conditions. The laboratory experiments were performed at Intuitive Surgical (Sunnyvale, CA) using a flexible, next-generation, single-port robotic surgical system (da Vinci Sp; Intuitive Surgical). The cadavers were placed in the supine position without a shoulder roll with the head in slight atlanto-occipital extension. The tongue was withdrawn to provide better access to the laryngopharynx. Oral access was achieved with the Feyh-Kastenbauer Weinstein-O’Malley (FK-WO) oropharyngeal retractor (Olympus-Gyrus ACMI-ENT, Bartlett, TN). Hybrid SCPL-CHEP was conducted following the surgical sequence: 1) transoral: mucosal incisions under direct visualization of the laryngopharynx for tumor resection; 2) transcervical: incision and mobilization of the larynx and pexis; and 3) transoral: mucosal closure.

RESULTS

Detailed surgical procedures of hybrid SCPL-CHEP are defined as follows with the critical steps summarized in Table I. A schematic drawing of the surgical allocations of hybrid SCPL-CHEP is displayed in Figure 1.

The procedure begins with a tracheotomy fenestrated at the third tracheal ring. Prior to the creation of a tracheostoma, a deep cervico-mediastinal tracheal release was done through the tracheal wound. An endotracheal tube is placed in the tracheostoma, and is changed to a tracheostomy canula at the end of the procedure. Prior to moving to the transoral mucosal incision, a needle marker is passed at thyroid notch through the epiglottis petiole to serve as a landmark for the transoral mucosal incision.

Transoral

In the transoral sequence, mucosal incisions are made under direct visualization of the laryngopharynx for tumor resection. The FK-WO retractor is positioned in the oral cavity with its curved tongue blade end at the vallecula to retract the tongue base. The single-port, 25-mm cannula of da Vinci Sp is oriented along the somatic midline with an articulating camera and three EndoWrist instruments (Maryland forceps, monopolar cautery spatula, and grasping forceps) placed in the oropharynx. The cannula tip is positioned at 5 to 15 cm from the upper lip to allocate the instruments to be deployed within the pharynx to allow full dexterity in the larynx. The camera port should be positioned at the bottom column of the cannula (camera down position), so that the camera head can be maneuvered for an optimal vision of the laryngopharynx. The fenestrated grasping forceps is used for retraction of the suprahypothyroid larynx, epiglottis, and tongue base, whereas the remaining two Endowrist surgical arms are utilized for performing the following surgical tasks.

The horizontal mucosal incision is initiated at the level of landmark needle to transect the petiole (Fig. 2a). Across the aryepiglottic folds, incisions continue along the...
superior border of the thyroid laminae and curve to reach the anterior arytenoids and the vocal processes (Fig. 2b). Superior laryngeal nerves are identified and preserved, but the superior laryngeal arteries are clipped by the bedside assistant. The nerves and arteries might also be managed via the following transcervical approach.

**Transcervical**

With the transcervical approach, incision and mobilization of the larynx, pexis, and closure are performed. A 6-cm horizontal skin incision at the level of cricoid is created, followed by elevating superior and inferior subplatysmal skin flaps. When neck dissection is required, it can be done by extending the ends of the initial 6-cm horizontal incision vertically along the anterior border of the sternocleidomastoid muscle (H-shaped incision). At the cervical linea alba, sternohyoid and sternothyroid muscles are identified and retracted laterally to explore the pretracheal tissues including thyroid gland. Thyroid isthmusectomy is performed, and both lobes are freed up from the tracheal wall to facilitate better neolaryngotracheal elevation during the pexy. Caution is paid not to connect the inferior sub platysmal dissection and the tracheostomal compartment. Communication between both compartments might result in increased risk of postoperative wound infection and emphysema.

Under the sternohyoid muscles, sternothyroid and thyrohyoid muscles are identified and transected at the oblique line of thyroid cartilage to further expose the thyroid and cricoid cartilages. The thyropharyngeal (inferior constrictor) muscles are dissected off from the thyroid laminae, whereas cricopharyngeal muscles are left untouched. By rotating the entire larynx, the cricothyroid joints are disarticulated with care not to injure the recurrent laryngeal nerves, which run 1 to 2 mm behind the joints.

Through the subplatysmal tunnel, cervical and laryngopharyngeal wounds are connected. Superior horns and thyroid laminae are carefully detached from pyriform sinuses. Dissection generally continues on the non–tumor-bearing side of the hemilarynx, as the laryngopharynx is opened into the transcervical exposure.
DISCUSSION

With a flexible, next-generation robotic surgical system, the hybrid SCPL-CHEP was technically feasible in the preclinical cadaveric laboratory. This approach might provide enhancements of the classic time-honored approach through direct visualization of tumor before laryngotomy and during tumor resection. Moreover, combined transoral and transcervical techniques might enhance the reconstructive aspects of the technique through transoral mucosal reconstruction.

This work builds upon growing experience with novel flexible robotic systems that are changing the way we approach head and neck cancer. In 2016, the single port da Vinci Sp was first evaluated in a preclinical cadaveric study of transoral lateral oropharyngectomy. Additional preclinical experiences with this platform have been reported for the nasopharynx, hypopharynx, and tongue base. In 2017, da Vinci Sp was utilized for the first phase I clinical trial in Hong Kong to operate on a series of six patients with oropharyngeal and supraglottic diseases with positive early results.

In 2013, TORS TL was reported as an off-label extended application of the da Vinci Si system. Most of the TORS total laryngopharyngeal surgeries have involved combined transcervical and TORS approaches. An early report described transoral robotic supracricoid partial laryngectomy with cartilaginous framework preservation, a cartilage-preserving approach was described, and cricohyoidepiglottopexy (CHEP) was not performed. Recently, a technique for TORS SCPL-CHEP was described using the da Vinci Si system. In their article, Morisod et al. performed an external dissection of the larynx through the tracheostomy incision, and then using transoral robotic resection, the specimen was delivered through the mouth. Similar to the surgical maneuvers proposed here, this team described transoral hypopharyngeal reconstruction with suturing. They performed CHEP by utilizing a stab incision at the hyoid and transoral passage of suture under the cricoid. The pexis knots were tied externally to complete the impaction. Though da Vinci Si system is reported to be capable of performing TORS SCPL-CHEP, the single-port Sp system, which was designed for deeper transoral access, might offer surgeons improved maneuverability or even access to the supraglottis in cases that would be difficult with the Si system.

Our hybrid SCPL-CHEP procedure begins with tracheotomy to avoid transoral interference with the endotracheal tube. We believe that a chief advantage of the proposed hybrid SCPL is to permit cervicomedial tracheal release, which permits better neo-laryngotracheal mobility during pexis. We hypothesize that this release reduces tension on the closure and thus reduces the risk for postoperative rupture of the pexis. For hybrid SCPL-CHEP, the mucosal incisions can be made with the tumor under direct visualization. This might offer a significant advantage over conventional open SCPL procedures where the mucosal incisions are made after transcervically, and the first incision to open the larynx is blind. The use of the intraluminal landmark to indicate the lower resection margin at the petiole was helpful to avoid creating an excessively short epiglottis, which might result in inverted epiglottis.

Whereas mucosal cuts under direct visualization could lead to improved resection margins, such a theory would need to be evaluated in clinical context. In our proposed approach, the mucosal incision is initiated at the landmark needle at the petiole, and continues along the superior border of the thyroid laminae, transecting aryepiglottic folds and posterior false cords to reach vocal processes. If hybrid SCPL-CHP is planned, the initial mucosal incision is made at the median glosso-epiglottic fold at the vallecula and extending postilaterally to cross the bilateral glosso-epiglottic folds.
The advantage of transoral mucosal cuts might not apply to surgeons experienced in laryngeal conservation procedures. The second advantage, mucosal closure, might be a refinement that even improves outcomes for these experienced surgeons.

A horizontal skin incision of 6 cm was adopted, which might be as much as one-third the size of the conventional T- or U-shaped incision. A 6-cm skin incision at the cricoid level seems to be appropriate to safely manage the extrinsic laryngeal muscles and the cricothyroid joints. Based on our previous trials, identification of the cricothyroid joints from the endolarynx was virtually impossible. Attempting to blindly dissect the cricothyroid joint with monopolar cautery transorally is likely to injure the recurrent laryngeal nerves, and possibly result in a paralyzed larynx. By tracing and advancing the transoral mucosal incision from the neck exposure, the laryngeal specimen can be removed and the CHEP completed. With this limited transcervical approach, the surgical invasiveness to cervical and laryngopharyngeal tissues is reduced compared with the conventional open SCPL approach.

Based on our experiences, the attempt to transorally dissect and release the superior horns of thyroid cartilage tended to result in mucosal trauma. Therefore, we recommend the superior horns to be managed via a transcervical approach. Although supraglottic mucosal incisions can be readily performed transorally, visualization deeper within the larynx is hindered by working space and instrument constraints. Because of this, the infraglottic resection of supracricoid larynx is likely best managed through the transcervical exposure.

Because hybrid SCPL-CHEP is generally indicated for early to intermediate glottic cancers (best for unfavorable T2 and well-selected T3), neck dissections might be necessary. When neck dissection is required in a hybrid approach, it can be done by extending the ends of the initial 6-cm horizontal incision vertically along the anterior border of sternocleidomastoid muscle (H-shaped incision); neck dissection can be performed concurrently or in a staged fashion.

With conventional open SCPL-CHEP, the central plexus of the cricoid and hyoid restores the airway, speech, and swallowing. However, a complete laryngeal mucosal closure is not possible. For most patients, the laryngopharyngeal border line between the pyriform sinus and reconstructed neo-larynx heals by secondary intention. As a result, pharyngocutaneous fistula is a rare complication of SCPL (0% in the largest French experience but 4% in the largest US experience in experienced hands. In this study, we propose that a more complete laryngopharyngeal mucosal closure might improve functional and oncologic outcomes. Extrapolating to future clinical trials, we postulate that this additional closure might accelerate postoperative healing and further refine functional recovery. However, a more careful study of this hybrid SCPL-CHEP technique in a prospective clinical trial would be necessary to validate these potential functional benefits.

In the face of declining use of SCPL, we feel our robotic modification might be a way to add the option of laryngeal conservation for more patients. By incorporating a hybrid robotic approach, we believe this surgery might become more accessible to head and neck surgeons who are surgically capable but not particularly versed in open SCPL techniques, thus reviving the clinical use of this time honored larynx preservation procedure.

The main limitations to this approach pertain to challenges with maneuvering the robotic system deep within the aerodigestive tract. For example, manipulations beyond the glottic level are still limited by collisions between the articulating camera and the instruments. The surgical working space decreases in size as one descends beyond the oropharynx and enters the supraglottic larynx, glottic larynx, and hypopharynx. These working spaces are much more narrow than the desirable working space for Sp instruments described as a ‘tennis ball size.’ Though Sp may offer advantages over the Si system, further miniaturization and improvements in the strength and dexterity of robotic instruments will be welcomed advances for TORS. Additional preclinical studies might be planned in the future. Among future steps, TORS neo-glottis reconstruction might be contemplated.

CONCLUSION

Hybrid SCPL-CHEP, by combining limited transcervical and transoral robotic approaches was technically feasible in the preclinical cadaveric laboratory setting and appears to provide further enhancements to the conventional open SCPL-CHEP approach. Whether this novel technique offers real benefits that translate into oncologic and functional outcomes would require further prospective clinical study.

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BIBLIOGRAPHY


