Transventricular Chondroplastic Laryngotomy—A New Surgical Technique for the Endolarynx

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Summary: Current surgical techniques for laryngeal exposure pose distinct limitations. To address these issues, this article describes a novel surgical technique. Our technique, termed Transventricular Chondroplastic Laryngotomy, allows for extensive and direct external access to the endolarynx. This procedure is described in both a cadaver and animal models. Three pigs were submitted to thyroid cartilage window opening without touching the laryngeal ventricle, and seven animals were submitted to the full procedure, opening a thyroid cartilage window with wide ventricular opening. The animals were sacrificed 20 days following the procedure. Prior to sacrifice, all animals underwent laryngoscopic examination and following euthanasia, the larynx and cervical regions were examined grossly, in addition to histologically. This surgery allowed for extensive exposure of the ipsilateral vocal fold and the contralateral hemilarynx, through the laryngeal ventricle, and thus enabled bi-instrumental handling of the vestibular fold, laryngeal ventricle, and from the anterior commissure to the arytenoids, bilaterally. No postoperative complications were observed. Access to the ventricle was easily and directly achieved through the thyroarytenoid muscle. We hypothesize that transventricular chondroplastic laryngotomy will emerge as the surgical technique of choice in patients presenting with difficult exposure and/or traditional surgical instruments are not feasible. Future transventricular chondroplastic laryngotomy clinical applications of the procedure are discussed including the resection of lesions and more complex reconstruction of vocal folds.

Key Words: Larynx–Surgery–Laryngeal ventricle–Porcine model–Vocal folds.

INTRODUCTION

Access to the larynx is typically described via two routes: (1) external approaches, such as thyrotomy, thyroplasties, and laryngectomies, and (2) transoral, endoscopic microlaryngoscopic approaches. External approaches may affect the anterior commissure and usually require tracheotomy.1–5 In contrast, manipulation of laryngeal structures, as well management of sutures, flaps, and bleeding vessels, is challenging even using more advanced transoral techniques.6 These limitations may reduce the effectiveness of the particular operative outcome. Furthermore, we hypothesize that both techniques are less than ideal.

The literature is sparse regarding the incidence of difficult exposure in microlaryngoscopy and its effects on surgical outcomes. In addition, endoscopic approaches may not be possible in some patients,7–11 making surgical exposure challenging. In contrast, external approaches may result in damage to the anterior insertion of the vocal folds as in thyrotomy. Tracheotomy may be required.

As an alternative to the traditional techniques, article contains preliminary information regarding a novel laryngeal approach, referred to as Transventricular Chondroplastic Laryngotomy (TCL). TCL permits wide exposure to the endolarynx and allows for complete laryngeal reconstitution. This procedure is ideal for complete resection, adequate reconstruction, restoration of optimal function and is based on sound surgical principles. The anterior commissure remains intact allowing for easier and more direct access to the endolarynx. In addition, high-powered magnification may be useful, but is not typically required, depending on larynx dimensions and specific lesions or intervention planned to be done through this access.

TCL involves access to the endolarynx through the thyroid cartilage using a large window through which the lateral portion of the interior aspect of the laryngeal ventricle is accessed (Figures 1–6). Through this opening, it is possible to directly manipulate the vocal folds and ventricular folds uni- or bilaterally, in addition to the ventricle, anterior commissure and arytenoid complexes.

Our review of the literature revealed several reports of similar procedures12–25 involving dissection and exposure of the larynx. Shapshay et al26 and Rebeiz et al27 described a “window partial laryngectomy” technique using endoscopic laser resection of laryngeal tumors via a cartilage window, requiring muscle flap reconstruction. In addition, laryngotomy, as described by Netterville et al28 and Coleman et al,29 for the removal of Teflon (DuPont, Wilmington, DE) is similar to TCL, but stopped short of opening the ventricle. Instead, a wide window through the thyroid lamina was opened, including the inferior edge. Interestingly, the authors suggested that the sole utility of this procedure was Teflon removal.

Gray et al30 introduced the minithyrotomy for increased precision of fat implantation into the vocal fold through a submucosal tunnel, guided by microlaryngoscopy without opening a cartilage window or the ventricle. Thome et al31 described a lateral thyrotomy approach to the paraglottic space for laryngocele resection. Most recently, Billante et al32 used this same access for Teflon removal, preserving lamina propria and introducing an extrinsic muscle flap or Silastic (Dow Corning, Midland, MI) implant. In all cases, the authors describe their
procedures for a specific use, not for broad surgical exposure with the potential for multiple procedures.

MATERIALS AND METHODS

Our preliminary experimentation with TCL was performed on excised human larynges and on a single cadaver. Images from this preliminary work are shown in Figures 7–9. Investigation then proceeded to an animal model.

Description of the procedure

A 2-cm square window is marked on the thyroid lamina at a distance of 3–5mm from the midline and lower border of the lamina. We’ve also found that this window may be larger depending on the size of the ala as well as the exposure required. The cartilage was easily cut with a blade (#15) in the posterior area and with the help of an electric drill in the anterior region. The window was opened, preserving the superior, external perichondrium as a hinge. A 30° rigid endoscope with light source was then used to visualize the endolarynx and illuminate the ventricle helping to identify its inferior and most lateral aspect. The ventricle is then opened with a curved blade from outside to inside. We used a customized self-retaining retractor, modified from the Love retractor, and the larynx lumen was widely exposed. We could see and manipulate the entire contralateral aspect of the larynx, including the vocal and ventricular folds and ventricle, from anterior commissure to arytenoid, from supraglottis to subglottis. Visualization of the ipsilateral aspect of the larynx is also easily obtained. Some novel instruments were required. We used a modified curved microscissor and, we also attempted to use several other microinstruments to determine the feasibility of such instrumentation in the surgical field.

Animal model

Once the procedure was perfected in the excised larynx model, we proceeded to an established porcine model. All procedures described were approved by the Animal Welfare Board of the Universidade Federal de São Paulo. This model was used to address the following experimental questions: (1) What would happen to the cartilage after making the window? (2) How would the ventricle respond after being opened, elevated and sutured? (3) What would be the effect on the ipsilateral hemilarynx? and (4) Would TCL effect laryngeal function? Furthermore, we specifically investigated the potential for contamination of the larynx with resultant infection, subcutaneous emphysema and/or fistula formation. We were also particularly concerned about the potential for adhesions and/or anatomic aberrations leading to diminished phonatory, respiratory, and/or sphincteric laryngeal functions.

To address these issues, we opened a thyroid lamina window without accessing the laryngeal lumen in three pigs and we created a window to access the endolarynx through the ventricle in seven animals. In all animals, a skin incision was made and dissected medially, without sectioning any extrinsic muscle.
The angle of the thyroarytenoid muscle in pigs is more vertical, proceeding from posterior to anterior, and it was easily identified with or without endoscopic light (Figure 10). An incision was made between the superior third and the inferior two thirds of the thyroarytenoid muscle, searching for the ventricle (Figure 11). As in the human larynx, the ventricle mucosal edges were elevated and the larynx lumen was exposed. We could see and manipulate the contralateral aspect of the larynx, especially the vocal and ventricular folds and ventricle, from anterior commissure to aryttenoid and from supraglottis to subglottis. Visualization of the ipsilateral larynx was obtained from a lateral viewpoint, superiorly to the vocal fold and inferiorly to the ventricular fold (Figure 12). We used Vicryl (Johnson & Johnson, New Brunswick, NJ) 6-0 to close the ventricle, Prolene (Johnson & Johnson) 4-0 for a single cartilage stitch, Vicryl 4-0 for the extrinsic muscles and nylon (DuPont) 2-0 for the skin.

All animals were monitored daily for activity (normal or lethargic); grunt (normal or altered); breathing (normal or difficult); cough (absent or present, following or unrelated to swallowing); food acceptance (complete, partial or refusal); weight (initial and final at euthanasia); wound healing (appropriate, edema, granulation and/or fistula) and for postoperative death. We sacrificed the animals on postoperative Day 20 following direct laryngoscopy under general anesthesia. We performed gross and microscopic analysis of the tissues of the

FIGURE 3. Dissecting through thyroarytenoid muscle to the inferior margin of the ventricle.

FIGURE 4. Ventricle opened; direct view of left hemilarynx.

FIGURE 5. Closing the ventricle; mucosa and thyroarytenoid muscle.
neck, from the skin to the endolarynx, including the cartilage window and the ventricle.

RESULTS

The cartilage window was created with ease and did not appear to cause trauma to the larynx. TCL provided excellent exposure to the thyroarytenoid muscle, with the open window hinging on the intact superior perichondrium. The ability to use the microscope and optical systems greatly enhanced visualization of the endolaryngeal structures.

No animal presented with any aberrant signs or significant deterioration of health in the postoperative period. The larynx appeared normal and laryngeal function appeared to be preserved; all the animals gained weight. There was no apparent damage to thyroid cartilage after making these windows, and the ventricles appeared normal after being opened and sutured; there was no evidence of dysfunction or anatomical alteration of the larynges after TCL. Two of the 10 pigs presented with very small superficial infections immediately under the scar on the neck.

DISCUSSION

Although several other authors have described lateral approaches to the larynx, we found no reports of accessing the larynx through the ventricle as a multipurpose surgical procedure. We believe this is a natural extension of previous efforts and present initial results of this procedure in both human cadaver and porcine models. Preliminarily, the procedure appears to be safe and effective at providing endolaryngeal exposure. TCL is not technically challenging and provides surgical flexibility; allowing supplementation with optical instruments and microscopes when needed. It is a less extensive operation than several external procedures now in use. Except for the small scar on the neck, the risk of infection and/or airway
obstruction appears minimal, but warrants further investigation. TCL allows for increased surgical precision, improved control of hemostasis, and vastly improved access for laryngeal reconstruction. We plan to begin to use it in very selective human cases, particularly in those patients with difficult exposure or when traditional instrumentation is not feasible. When considering possible future applications of TCL image magnification may be helpful. In addition, two people may be required for more complex reconstructions of vocal folds including flap rotations, treatment for unilateral or bilateral vocal fold paralysis, nerve resection for spasmodic dysphonia, injection augmentations, treatment of sulcus vocalis, resection of sinuechias and stenosis, and benign and malignant tumors.

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