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Anesthesia and ventilation options for flex robotic assisted laryngopharyngeal surgery☆,☆☆,☆☆☆

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ABSTRACT

Background: Transoral treatment of benign and malignant lesions of laryngopharynx has limitations in exposure and access, partially due to the endotracheal tube (ETT). With a proper airway control to tailor ventilation and maximize exposure, transoral Flex robotic surgery (FLEX), using its 3D camera and instruments, can expand its ability. Choosing the right ETT, including a novel concept of using jet ventilation (JV) in FLEX, and placement technique can allow augmentation of the advantages that robotic surgery offers.

Methods: Chart review of FLEX assisted procedures was performed. Attention was given to demographics, all events of airway manipulation and ventilation type, procedures performed and outcomes including adverse effects.

Results: Fifty-two patients underwent eighty procedures. The airway was manipulated sixty-four times to include 8 JV. All possible FLEX instruments including CO2 laser were used. Three novel possible indications for transoral robotic surgery including the feasibility of JV in FLEX procedures were shown.

Conclusions: Lesions of the tongue base, hypopharynx, larynx and trachea have the possibility to be managed with adequate exposure with minimal obstruction from ETT. Robotic HD camera permits both the surgeon and anesthesiologist to observe surgery and safely monitor the airway. An algorithm was developed for selecting ideal ventilation method for different procedures. The FLEX and the utilization of JV allows flexibility of two instruments without obstruction.

1. Introduction

Robot assisted surgery in the head and neck has steadily gained popularity since its introduction. Transoral robotic surgery (TORS) has been used to treat a variety of benign and malignant conditions. TORS is currently used for tongue base surgery for OSA indication and a variety of procedures for squamous carcinoma. Nearly all knowledge and technical feasibility gained were performed with the da Vinci Si robot, which comprises of several independent rigid arms, with one of them being the camera [1]. The current instrument arm, which has a diameter of 5–6 mm, together with the 8.5 mm camera head and rigidity of instruments commonly used today in TORS can make a transoral robotic approach difficult, or even impossible in some situations [2]. Furthermore, tracheostomy is sometimes required in TORS cases to avoid interference of the instruments with the ETT [3]. The Flex System (Medrobotics, Raynham, Massachusetts, USA) is designed to address the limitations of large, rigid instruments and is designed a priori for the head and neck. The Flex system is comprised of a single flexible endoscope covering a 3-dimensional working space of 180° maneuvered by a 3D-joystick haptic tactile feedback to the surgeon 15 mm wide, assisted with 2 separate arms, each of them 3.5 mm wide held similar to laparoscopic instruments [4]. The Flex Retractor (Medrobotics) offers the ability to adjust not only the depth and pitch angle of the blade, but also its axial rotation. While the comparison is intuitively measured up to the DaVinci system, the FLEX is not entirely robotic as the DaVinci, and applying the nomenclature of TORS is not entirely correct. With a variety of blade shapes available, the surgeon has multiple options to achieve the right exposure in advanced transoral procedures [4]. Given the dimensions, it appears that both systems require a working space beyond their own 18–21 mm with additional

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limitation of maneuverability through and beyond the oral cavity [5]. Bearing in mind that the same space is also used to provide anesthesia, working seamlessly with the anesthesiology team is required more than ever. Therefore, we set to formulate the type of anesthesia, particularly the method of airway maintenance for the various procedures treated with the FLEX robotic system from oral cavity, tongue base, hypopharynx, nasopharynx, epiglottis, hyoid suspension and larynx.

2. Methods

A retrospective chart review was performed for all procedures identified as robotic assisted regardless of the completion of the procedures performed by the senior author YPK. Data of the procedure type, anesthesia used, any airway manipulation with its result, type of ventilation, anesthesia related events, demographics, intra and post operative complications were collected. The study was approved by the Nortwell Health IRB committee # 18-0622.

3. Results

A total of 52 patients were identified. A total of 80 FLEX procedures, requiring 64 airway manipulations were recorded. Patients treated for sleep apnea were suffering from severe obstructive sleep apnea and had multilevel surgery.

Among them, 38 were males and 14 were females. The average age was 47(± 14), with the oldest being 85 years old and the youngest 15. Of all the procedures performed, 28 were UPPP, 22 lingual tonsillectomies, 21 hyoid suspensions, 4 direct laryngoscopies, 2 transoral excision of cervical spine osteophyte, 1 epiglottectomy, 1 cricopharyngeal myotomy and 1 calcified stylohyoid ligament release. Excision of cervical osteophyte, hyoid suspension and calcified stylohyoid ligament release were novel indications not associated prior with trans-oral robotic surgery, as appearing on PubMed and free online publications search. Twenty-two of the intubations were trans-nasal, 27 trans-oral and 8 were jet ventilations. Of the JV, all but one began trans-orally, to be converted to jet ventilation once the FLEX was brought into the field and converted back to oral ETT upon the end of the procedure for awakening. Jet ventilation was performed only with benign disease and excluded respiratory papillomatosis. As seen in Figs. 2,3 (before and after), the view and surgical field with the FLEX robotic system is enhanced several folds and yet only the jet ventilation allows adequate exposure for the ablation of the lesion. All the available spectrum of robotic tools (laser holder, grasper, monopolar spatula and scissors, needle cautery, Maryland dissector and needle holder) were used. One oral intubation was converted from an oral RAE tube to a wire reinforced tube due to collapse of the tube from the pressure from the FLEX retractor. In the postoperative follow up, no events of bleeding, hematoma or excessive pain beyond anticipated were noted; 1 suture of the hyoid suspension tore loose and needed to be removed orally 1 week after the procedure.

4. Discussion

We report the experience following the 52 procedures performed with the FLEX robotic system. This series represents the largest single institution experience. In this series three new possible indications for FLEX (hyoid suspension, cervical osteophyte excision and calcified stylohyoid ligament release) emerged. By comparison, a multicenter study, representing the European experience with the FLEX robotics system which included 80 patients from several institutions, upon breakdown by the contributing centers, had the largest center contributing 18 cases [6,7]. TORS allows the otolaryngologist true 3-dimensional endoscopic vision of the surgical field with accurate depth perception. The degrees of movement (flexion, extension, supination, and pronation) is vastly improved [8]. The sway of long instruments in a narrow deep field is eliminated allowing a precise motion. The need for additional external cuts to enlarge the field is reduced allowing the procedures to become minimally invasive. However, the learning curve is different from instrumentation that the surgeon is acquainted to. As the field of surgery is used by the anesthesia team, a working paradigm has to be formulated. We were surprised to find absence of jet ventilation and transoral robotic surgery or TORS as mesh words in the medical literature query [9]. Moreover, the dilemma during intubation was emphasized particularly when an experienced head and neck surgeon had the anesthesia team exchange the intubation tube to facilitate TORS. The FLEX system arrives with a multitude of blades of different length, angulations, curvature and allows lateral rotation with concomitant suction. Once the oral retractor is inserted, the applied force to move the blade is operated by rotating the various bezels allowing adequate exposure. The most versatile endotracheal (ETT) intubation tube used is a wire reinforced tube. It has several advantages over a regular ETT tube. It does not get kinked and therefore no loss of continuous ventilation. The force generated by the FLEX retractor will often kink a regular ETT tube to occlusion. As the surgery is performed in the airway constant micro manipulation of the tube is to be expected. A reinforced tube was previously shown to likely reduce microaspirations and produce less lateral pressure on the trachea [10].

Following that we came with a breakdown of the various anatomical areas treated with TORS. Those areas were divided in two planes. One plane (EU plane) is an anterior to posterior plane created by an imaginative line from the uvula to the petiole of the epiglottis and the other a lateral line of the collapsed tissue. With the loss of muscle tone and postural loss in the recumbent position the sectional area is reduced when compared to the same area during awake endoscopy. The EU plane is seen in Fig. 1 with the nasal and oral intubation tube following depicting clearly the sites addressed when oral or nasal intubation is employed. When the lateral plane in the working area is less than 2.5 cm and the anticipated procedure is less than 15–30 min we try to use the Monsoon jet ventilation (Acutronic, Pittsburgh, PA). Jet ventilation is using the principle of passive exhalation while inhalation is supplied by high pressure high frequency automated ventilation delivered through a 2–3 mm cannula. With the Monsoon tissue movement is minimized due to the small tidal volumes used. The Laser Jet 40 is a double lumen Jet catheter for ENT laser procedures. One lumen delivers the gas, the second monitors airway pressure and end tidal CO2. Typical settings on the Monsoon are a driving pressure (DP) of 20 PSI, frequency (f) of 100 cpi, inspiratory time (%IT) of 35–40% with humidity as needed. Pressure monitoring values typical are a pause pressure (PP) of 24 cm H_2O, this approximates mean airway pressure and is measured in between jet breaths. A peak inspiratory pressure (PIP) of 28 cm H_2O is a common upper pressure limit to reduce barotrauma. A Laser FiO2% setting is typically set at 40% or less to minimize airway fire. Procedures that are anterior to EU plane are intubated with a Glidescope or Miller blade. Procedures posterior to this plane (except the posterior pharyngeal wall) are intubated trans-nasally. All the tubes used are reinforced tubes, as the oral retractor will crush the regular tube rendering the patient without patent for the airway. Procedures that require the use of a laser are begun with a laser tube. A breakdown of the procedures and the advised anesthesia with preferred tube placement according to EU plane is outlined in Table 1.

As the tongue blade pushes the tongue anteriorly, any surgery to be performed on the soft palate is amenable to nasal and oral intubation. Base of tongue procedures including ablation of lingual tonsils are better suited with nasal intubation. In hyoid suspension, where a suture is passed through the tongue base and looped backward toward the hyoid nasal intubation will allow a much broader view. If we take into account that hyoid suspension and some base of tongue procedures are to be performed for a patient suffering from sleep apnea and having a smaller airway, nasal intubation allows better maneuverability. The access to the posterior pharyngeal wall including the nasopharynx and spine is best achieved through an oral intubation with the tube being pressed anteriorly toward the tongue. Anesthetic route, whether nasal

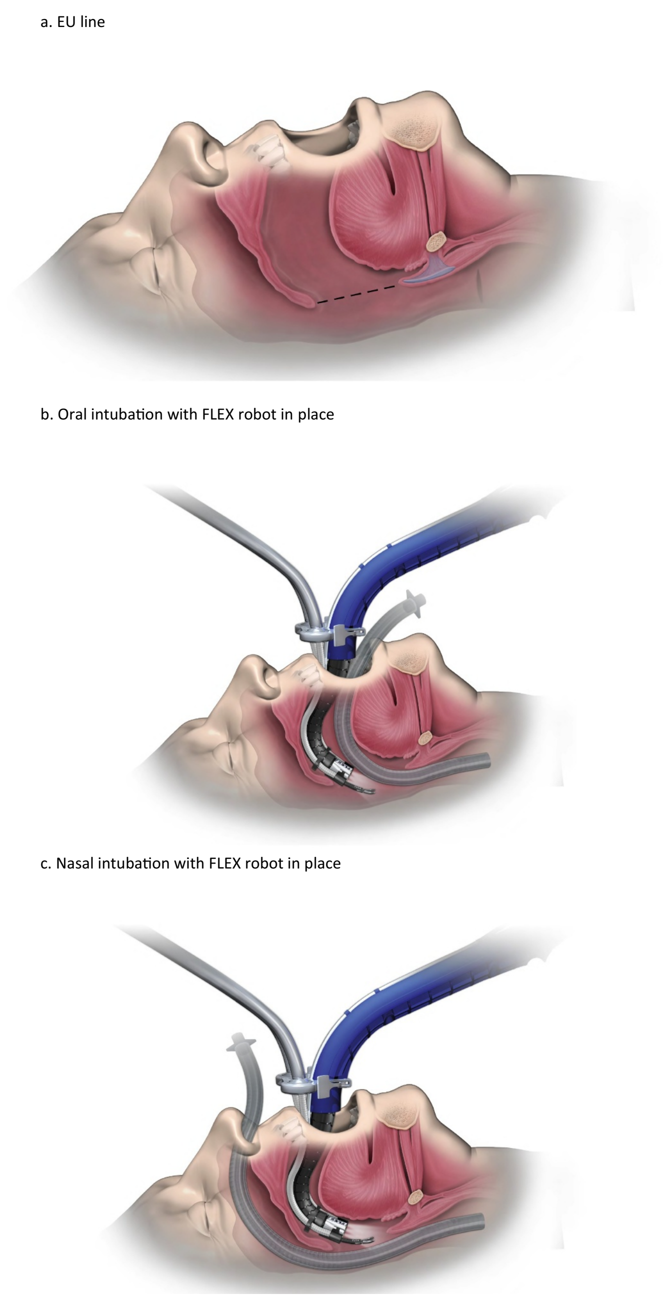
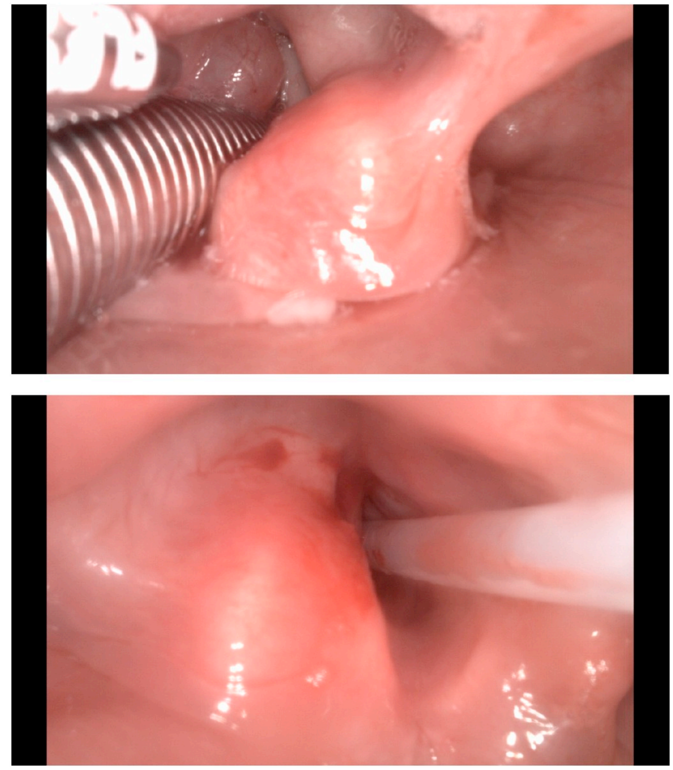


Fig. 1. a. EU line.
b. Oral intubation with FLEX robot in place
c. Nasal intubation with FLEX robot in place.

Table 1
(RAMISH robotic assisted minimally invasive hyoid suspension).

Procedure	Oral intubation	Nasal intubation	Oral or nasal intubation	Jet (no-tube) ventilation
Lingual tonsil		XX		
UPPP			XX	
RAMISH		XX		
Epiglottoplasty		XX		
Tonsils			XX	
Posterior pharyngeal wall	X			X
Vocal folds	X			X
Hypopharynx	X			X



Figs. 2 & 3. Lesion seen prior to jet ventilation and after FLEX surgery with jet.

or oral, will be determined on the part of the epiglottis. Laryngeal surgery is tailored according to the surgeons' preference [11,12], however, robotic surgery is not a contraindication for jet ventilation. Robotic surgery in the larynx eliminates the sway incurred due to the introduction of longer instruments needed to reach the larynx. This allows a precise dissection with an additional advantage of working in a field larger than the usual endoscopic view obtained through a laryngoscope. The feasibility of jet ventilation combined with robotic surgery, which is the first to be reported, increases the surgical field and while vision is increased to HD future direction can be applied toward neighboring sites such as the hypopharynx. The lesion demonstrated in the false vocal cords could be removed only after introducing the jet ventilation. In comparison, the Essen group reported on 2 patients with a similar location lesion where the procedure was converted from robotic to transoral microscopic approach [6].

5. Summary

We report the largest single institution experience with the FLEX robotic system for TORS. Although advantageous in many aspects, vision, exposure, limiting human error it cannot go unplanned. Planning for robotic surgery starts with collaboration with the anesthesia team in planning proper airway placement and ventilation methods, rather than compete over it. We outlined and suggested intubation route for each type of TORS procedures. Flex robotic hypercurved laryngeal blades, micro laryngeal instruments and Jet ventilation, makes robotic endolaryngeal surgery a reality, further expanding its use.

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