Airway management in “tubeless” spontaneous-ventilation video-assisted thoracoscopic tracheal surgery: A Retrospective Observational Case Series Study

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Research Article

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Abstract

Background: Surgeon and anesthetist need not share the airway in the resection and reconstruction phase of tracheal surgery in spontaneous-ventilation video-assisted thoracoscopic surgery (SV-VATS).

Methods: Tubeless SV-VATS to anesthesiologist means tubeless in the resection and reconstruction phase under stable spontaneous ventilation, and unobstructed surgical field to surgeon. What is the ideal airway management strategy during “Visual Field tubeless” SV-VATS for intrathoracic tracheal surgery? Here we retrospectively reviewed the cases of 33 patients whose initial strategy manage with spontaneous ventilation for the common and simpler proximal tracheal resection and reconstruction, but did not discuss sleeve and carina resections, during the study period (2018–2020) in our hospital. To evaluate the device failure rate for tracheal resection in Tubeless SV-VATS, medical records obtained from our institution’s clinical medical records system and reviewed.

Results: Between 2018 and 2020, SV-VATS was first attempted in 33 patients who had intrathoracic tracheal surgery, sleeve and carina resections were not included. All patients underwent bronchoscopy (33/33) or partial resection (8/33) before surgery. During the surgery, the airway device comprised either a laryngeal mask airway (n = 27) or single lumen endotracheal tube (n = 6). During the resection and reconstruction phase, Visual Field tubeless SV-VATS failed in 9 patients, and breathing support switched to plan B smoothly: traditional ventilation including a single lumen endotracheal tube for crossfield intubation (n = 4) or a laryngeal mask airway alongside a high-frequency catheter (high-frequency jet ventilation, HFJV) (n = 5) into the distal trachea ventilation. Preoperative respiratory failure or other ventilation-related complications were not observed in this cohort.

Conclusion: The choice of a supraglottic airway device or endotracheal tube is an effective strategy for tubeless SV-VATS with appropriate patient selection, and provides breathing support conversion.

Background

Changes in surgical practice have resulted innovations in video-assisted thoracic surgery (VATS) and enhanced recovery after surgery (ERAS). Studies by other surgeons and attempts at Visual Field tubeless provided a good basis for its development(1–4).

SV-VATS has recently reported to be a safe and effective technique in several centers and reported to be technically feasible in several articles(1, 2, 5). It was first performed with simple pleural and lung procedures, and then progressed to pulmonary resections, sleeve resection and tracheal and carinal resections. Consistent intravenous sedation and analgesia are necessary, along with epidural or intercostal nerve blockage, incision regional anesthesia(2, 6) or vagal nerve blockage to offer complete pain control to maintain stable spontaneous ventilation and release the cough reflex(3, 7, 8).

Airway management of tracheal surgery divide into 3 stages(9, 10). Van Regemorte et al.(11) reported that controlled ventilation through the Rusch flexible intubation guide catheter showed satisfactory and

stable ventilatory parameters in two patients. The tracheal tubes obstruct access to the posterior tracheal wall and are prone to causing accidental surgical damage to the cuff. Extracorporeal membrane oxygenation (ECMO) was considered as a more invasive alternative or only as a rescue device (12–14). This problem can simplify and SV-VATS can make a progress.

The use of tubeless SV-VATS in the resection phase under stable spontaneous ventilation could reduce the apneic time required to perform airway reconstruction and with a good surgical field, the surgeon and anesthetist need not share the airway. There have been several published case series which reported the advantages of using SV-VATS as a novel approach in TRR(15, 16). For the specificity of airway surgery, there a possibility of device failure during the resection and reconstruction phase of tubeless tracheal resection. The use of SV-VATS is increasing, but still no instructive protocol for airway management in these patients.

To better understand tubeless SV-VATS for TRR, this report reviewed our airway management experience for intrathoracic tubeless tracheal resection over the last 3 years.

Methods

This study was approved by the First Hospital of Guangzhou Medical University Research Ethics Committee, and written informed consent was waivered. This article adheres to the applicable Consolidated Standards of Reporting Trials (CONSORT) guidelines. We retrospectively collected and reviewed medical records of all patients treated at our hospital from 2018 to 2020, who were diagnosed with tracheal stenosis, who underwent TRR and for whom the initial strategy was spontaneous ventilation, without main bronchial sleeve and carina resections.

When a patient came to our hospital and was suspected of having tracheal stenosis, a high-resolution computerized tomography (CT) scan of the neck and upper thorax were performed. Tracheal lesions were evaluated in computed tomography images. Examination with a fiber optic bronchoscope (FOB), biopsies and histological diagnosis were carried out in all patients except those with iatrogenic subglottic tracheal stenosis. If there was more than 70–80% obstruction of the trachea along with aggravation of exertion dyspnea, intervention dilation or laser coagulation through FOB was used preoperatively.

After stricter patient selection, intraoperative management of the patients was provided by an experienced anesthesiologist. Routine cardiac and pulmonary functions were evaluated carefully, and a multidisciplinary consultation was held to assess risks and benefits, coexisting medical conditions and the preoperative situation. Careful choreographing of each step and efficient teamwork between anesthesiologists, operating room (OR) staff and surgeons are absolutely necessary.

For selected patients the standard monitors were placed, bispectral index (BIS) was used to monitor anesthetic depth to maintain adequate sedation levels, a central venous line (in cases in which the need for potent vasoactive drugs is anticipated, the subclavian or internal jugular approach was optional and should be away from the surgical field) and an intra-arterial catheter (preferably in the left radial artery, for

hemodynamic changes and arterial blood gas monitoring) also needed to be made available for this operation.

Epidural anesthesia, thoracic paravertebral block or intercostal nerve blocks were performed. After thoracic epidural catheterization, anesthesia was induced with target-controlled infusion (TCI) of propofol. A laryngeal mask airway (LMA) or well-lubricated endotracheal tube was placed according to standard technique. The choice of airway device was reviewed.

A vagal block was performed adjacent to the vagus nerve at the level of the lower trachea for right-sided operations and at the level of the aortopulmonary window for left-sided operations. Topical lidocaine was applied to the surface of the lung before surgery under direct thoracoscopic vision.

All those patients we focused on were treated by tracheal resection with end-to-end anastomoses, which was mainly divided into three distinct phases: the dissection phase, the resection phase (incision/ resection and reanastomosis of the airway) and the closure phase. Normally, spontaneous respiration was maintained before completion of the anastomosis. To surgeons, “tubeless” means tubeless in the resection phase under stable spontaneous ventilation. During the resection and reconstruction phases, supplemental oxygen was provided via the airway device to maintain an adequate oxygenation supply. If spontaneous respiration failed to provide adequate ventilation, airway management would be changed to conventional airway management approaches and traditional ventilation models, and crossfield intubation or high frequency ventilation (HFV) would be used. We reviewed the device failure rate.

Patient demographics, etiology, location and morphology of the stenotic area, preoperative treatment, airway device and device failure, functional status, anesthetic management, medical therapy, hemodynamic measurements, clinical course and outcomes, blood chemistry, and capillary blood gas analysis were reviewed.

Normally-distributed data were expressed as mean ± standard deviation. Non-normally distributed data were expressed as median and interquartile range. Data analysis was performed using SPSS version 22.0 (SPSS, Inc, IBM Inc., Armonk, NY, USA).

Anesthetic agents were almost the same for intravenous analgesia and sedation. Anesthesia was maintained with propofol (target plasma concentration of 1.5–2.5 μg/mL), dexmedetomidine 0.5–1 μg/kg/h, and remifentanil 0.01–0.05 μg/kg/min. In these procedures, anesthetists try to reduce neuromuscular blockade, but not stop it completely. A small dose of muscle relaxant was chosen in several patients with diaphragmatic contraction and pendelluft. We tested the ability to ventilate spontaneously after each administration until the ventilation and surgical field was balanced. The patient was ventilated with 100% oxygen *via* the airway device under spontaneous breathing, the dosage is presented in Table 2. Furthermore, dopamine, or norepinephrine was used to maintain cardiac output and systemic blood pressure perioperatively. Unfortunately, we did not record the rate of cough reflex and that will be our focus in the future.

Thoracic epidural anesthesia (TEA) or other local anesthesia was administered in the operation room before anesthesia induction. The choice of local anesthetic is presented in Table 2. Epidural anesthesia, thoracic paravertebral block or intercostal nerve blocks were performed, and vagal block was performed adjacent to the vagus nerve at the level of the lower trachea for right-sided operations and at the level of the aortopulmonary window for left-sided operations. Topical lidocaine was applied to the surface of the lung before surgery under direct thoracoscopic vision.

Results

1. Baseline Characteristics

Between 2018 and 2020, spontaneous ventilation was first attempted in 33 patients who had been diagnosed with primary tracheal tumor/neoplasm preoperatively, sleeve and carina resections were not included.

Baseline demographic characteristics are depicted in Table 1. The mean age was 44.3 ±12.9 years. The average size of the tracheal lesion was 11±6.9 mm and the narrowest tracheal diameter was approximately 0.4 mm with a crescent-shaped channel to breathe. Patients had an average extent of approximately 7.9 ±14.3 cm distal to the vocal cords. All patients underwent bronchoscopy (33/33) and bronchoscope freezing, balloon dilation or partial resection (8/33) before surgery.

2. Airway Management and Ventilation Models

In the operating theater, the patient was comfortably positioned on the table being careful not to aggravate exertion dyspnea or difficulty in mechanical ventilation after induction of anesthesia. These were partially confirmed by examination with an FOB and, intervention dilation or laser coagulation through the FOB during preoperative preparation. 33 patients successfully completed the surgery in the operating room. In 24 patients (24/33) the surgery was completed by tubeless SV-VAT in the resection phase under stable spontaneous ventilation as depicted in Table 2. The average operation time was 4.3 ± 1.3 h. All the patients were initially tried with spontaneous respiration under sedation throughout the surgery.

LMA (27 patients) or a single lumen endotracheal tube (6 patients) was selected in 33 patients. 24 patients were managed successfully under spontaneous respiration during resection and re-anastomosis of the trachea. Instability of spontaneous ventilation resulted in oxygen desaturation in 9 cases (5 patients chose LMA and 4 patients chose a single lumen endotracheal tube) during dissection and resection of the airway, failure of tubeless SV-VAT and a switch to mechanical ventilation throughout the operation. Elective crossfield intubation was then used by the surgical staff during resection and anastomosis of the airway. Before the trachea was opened, we inserted a jet catheter (A type guide wire hollow type, WELL LEAD MEDICAL CO., LTD, 20182021075) under direct laryngoscopy through an LMA or single lumen endotracheal tube. The catheter passed through the stenosis and positioned below the carina, and high frequency ventilation was used. After the trachea was opened, crossfield intubation was

used. After complete airway separation, crossfield intubation was also helpful. Those processes are depicted in Figure 1.

Mechanical ventilation support was available for all patients in the closure phase, including SIMV mode that is compatible with spontaneous breathing. All patients resumed spontaneous breathing in the anesthesia resuscitation room, no longer requiring ventilation support, and returned to the ICU for future observation.

3. Postoperative Complications and Outcomes

Postoperatively, surgical complications occurred in two patients: anastomosis dehiscence (patient 11), and atrial fibrillation within 24 hours after surgery (patient 12). Preoperative respiratory function index and APACHE 2 scores about patient quality of life are presented in Table 2. The average APACHE 2 score was 4.4 ± 3.2 and the average ICU stay was 1.3 ± 1.0. No data was collected during the operation regarding the vigorous mediastinal movement. There were no cases of preoperative respiratory failure or other ventilation-related complications. No intraoperative complications, including persistent hypercarbia, laryngeal edema or hoarseness related to anesthetic management were reported.

Discussion

Airway management in tracheal stenosis is a controversial topic in clinical practice(17, 18). The goals for airway management are to maintain a secure and unobstructed airway (tubeless) and to provide optimal access and surgical conditions. Tubeless SV-VATS holds the promise of a valuable approach for thoracoscopic surgery(19, 20). Surgeon and anesthetist need not share the airway, the objective benefit of SV-VATS in the resection phase of tracheal surgery remains the improved visual field and unobstructed surgical field. With Visual Field tubeless and reduced surgical field interference, with better subjective psychic outcome, it was an innovative attempt in tracheal surgery.

In the application of any new procedure, the safety of the patients is always of paramount importance. Several studies reported SV-VATS and the patients were relatively young and not obese, with good health and no complex anatomy(21, 22). This characteristic introduced a selection bias. Those reports, however, indicate that SV-VATS is at least as safe and efficient as traditional anesthesia with appropriate patient selection(23), though the evidence quality of all available studies about SV-VATS remains low. Thus, when starting SV-VATS tracheal reconstruction, proper patient selection, adequate airway management experience, and preferably a certain amount of training are recommended to minimize complications and conversions. Disease features and patients' features, as well as efficient teamwork between anesthesiologists, operating room (OR) staff and surgeons are absolutely necessary, are considered. Nevertheless, to enhance our sensitive to the potential complications, all patients returned to the ICU after meeting the PACU discharge criteria and without breath support. No cases of preoperative respiratory failure or other ventilation-related complications.

In this trial, 33 patients were analyzed. We showed that a supraglottic airway device or endotracheal tube were both alternative airway options as traditional airway devices. Tubeless is better but the conventional airway techniques for tracheal stenosis is the technology-bases (10, 24). When unstable spontaneous-ventilation condition and difficulty in progression in the resection and reconstruction phase, conversion to mechanical ventilation is necessary to ensure patient safety. Plan B: laryngeal mask airways alongside a high frequency catheter or crossfield intubation were selected(25, 26). The device failure rate was about 27.3% (9/33). The develop of new devices for airway management (eg, igel, more and better intravenous anesthetics such as dexmedetomidine) (27, 28), and stricter patient selection will surely reduce the device failure rate of this surgery when ERAS of VATS was just beginning(29, 30). Nevertheless, in this review, instab of spontaneous breath resulted in failure of tubeless during dissection and resection of the airway in 9 cases with smooth process for respiratory support conversion. Limited by the number of cases, serious complications such as pulmonary aspiration, early postoperative bleeding or suture dehiscence were not observed in this cohort.

LMA was considered as a feasible alternative during open tracheal surgery, and still used in several studies of SV-VATS (25, 31). As a superior glottic airway can't be affected by narrow airways, it has a unique advantage in cases of tumors near the glottis or stenosis after intubation. This device is effective for various types of airway surgery, presents excellent clinical outcomes and be recommend for use in cervical trachea reconstruction or cases near the glottis. In some patients, a single-lumen endotracheal catheter can selected if the stenosis area is far away from the glottis.(32, 33) We selected this option for obese patients but high quality randomized trials are recommended to further objectify this decision. Kashii. et al. reported that after ETT insertion, a patient maintained spontaneous respiration without any hypoxic event(27). For patients with high BMI, high risk of a regurgitate or other factors that may cause unstable spontaneous breath, some anesthetists chose a single-lumen endotracheal tube because an LMA cannot ventilate with high pressure. However, use of endotracheal tube may be impossible if the stenotic segment is too high and too near the glottis. On the other hand, given that difference in airway management preferences of anesthesiologist, whether these potential benefits can be proved in future by well designed RCTs are not known. Even if currently SV-VATS offers some potential advantages, technical difficulties still need to be overcome, includ diaphragmatic contraction and pendelluft, airway hyperreactivity and cough, reverse trigger and breath stack when mechanical ventilation(34). Moreover, in an attempt to minimize non-uniform transmission of pleural pressure generated by diaphragmatic contraction under spontaneously breath, several patients choose a small dose of muscle relaxant to balance diaphragmatic contraction of spontaneous ventilation and mediastinal swing in surgical field.

In conclusion, our experiences suggested that the choice of a supraglottic airway device or endotracheal tube is a very effective and prospective strategy for tubeless TRR, and also provided conditions for the convert to traditional ways under the condition of unstable spontaneous ventilate. A sample of 33 patients will not allow a comprehensive safety evaluation, especially with regards to rare TRR surgery. However, given the small number of cases examined, limitations of apply indications, contraindications, and per-operative period safety need further evaluate. But large patient cohorts are difficult to evaluate, as

cervical tracheal resections are relatively rare, even in specialized centers. This method needs more patients before definite predications for potential guidelines.

Conclusion

The choice of a supraglottic airway device or endotracheal tube is an effective strategy for tubeless SV-VATS with appropriate patient selection, and provides breathing support conversion.

Declarations

Ethics approval and consent to participate: This study was approved by the First Hospital of Guangzhou Medical University Research Ethics Committee.

Consent for publication: Not Applicable.

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Tables

Tables 1 to 2 are available in the Supplementary Files section

Figures

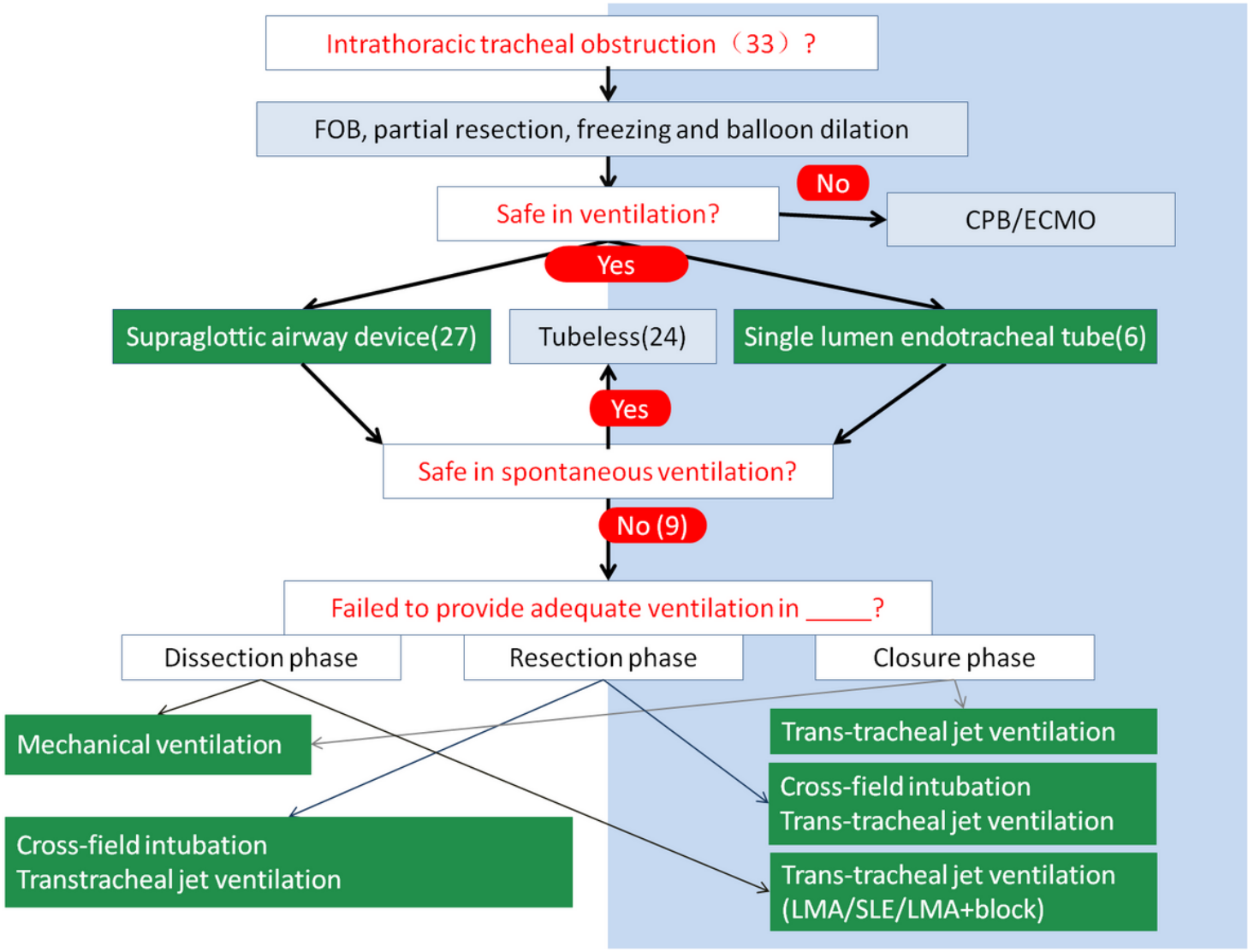

Figure 1

Spontaneous ventilation was first attempted in 33 patients with intrathoracic tracheal stenosis.

The airway device was chose by the attending anesthetist and comprised either a laryngeal mask airway (n = 27) or single lumen endotracheal tube (n = 6). During the resection and reconstruction phase, “tubeless” failed in 9 patients, and they choose plan B: switched to traditional ventilation.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- table101.docx
- table202.docx