Original Article

The strategy of non-intubated spontaneous ventilation anesthesia for upper tracheal surgery: a retrospective case series study

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Background: Upper tracheal surgery is used to treat patients who with tracheal tumors or tracheal stenosis. The non-intubated spontaneous ventilation anesthesia (NSVA) may have advantages over endotracheal intubation and surgical cross-field intubation in upper tracheal surgery. This study aimed to illustrate and assess the feasibility of NSVA strategy for upper tracheal surgery.

Methods: This is a retrospective case series study in which 51 patients (from May 2015 to August 2020) who met the criteria in NSVA strategy were analyzed. Anesthesia was performed using total intravenous anesthesia (TIVA) combined with bilateral superficial cervical plexus block (CPB) or thoracic epidural anesthesia (TEA). Patients received spontaneous ventilation through laryngeal mask airway (LMA) during the surgery. Anesthesia conversion technique was applied to patients who met the anesthesia conversion criteria.

Results: In total, 51 patients met the NSVA criteria and were included in this study. Forty-six out of 51 patients (90%) had TIVA + bilateral superficial CPB and five patients (10%) had TIVA + TEA + CPB. During the airway-opened period, 46 patients had stable spontaneous ventilation. Five patients need anesthesia conversion, two patients had high-frequency ventilation (HFV), and three patients required cross-field intubation. Postoperative complications occurred in seven (14%) patients, no reintubation was needed after surgery. The median postoperative hospital stay was 6.31±4.30 days.

Conclusions: This NSVA strategy includes criteria for patient selection, preoperative assessment, surgical technique, airway management, criteria and technique for anesthesia conversion. The NSVA strategy is a feasible procedure in upper tracheal surgery.

Keywords: Spontaneous ventilation; trachea; resection and reconstruction; anesthesia

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Introduction

Upper tracheal surgery is the treatment of choice for patients with tracheal tumors or tracheal stenosis. Tracheal tumors are rare, accounting for 2% of upper respiratory neoplasms (1). Most patients are admitted to the hospital due to non-specific symptoms such as cough, hemoptysis, or exertion dyspnea. Some of them are unrecognized or misdiagnosed as asthma. The diagnosis and assessment of resectability of tracheal tumors are confirmed by bronchoscopy and chest/neck computed tomography (CT). Benign tracheal stenosis mostly results from prolonged mechanical ventilation or tracheotomy (2). In all these cases tracheal resection and reconstruction remains the treatment of choice. However, upper tracheal surgery is still a technically complex task for surgeons and anesthesiologists.

In conventional upper tracheal surgery, cross-field intubation is usually used for ventilation (3). Once the trachea is transected, a sterile endotracheal tube is inserted into the distal trachea and connected to a breathing circuit across the surgical field to continue ventilation. However, the endotracheal tube inevitably affects the anastomosis operation, and precise anastomosis becomes difficult (4). To address this, high-frequency ventilation (HFV) is connected through a small size orotracheal catheter is utilized in some centers (5). However, there are known disadvantages of HFV. Since the airway is open, HFV may not supply adequate oxygenation, and the accurate measurement of peak inspiratory pressure is not possible, resulting in dynamic hyperinflation and hypercapnia (6-8).

The progressive evolution of supraglottic airway devices and short-acting anesthetics has allowed for non-intubated spontaneous ventilation anesthesia (NSVA) in upper tracheal surgery. Laryngeal mask airway (LMA) is a supraglottic airway device that obviates the need for endotracheal intubation, and is beneficial for patients with tracheal tumors or tracheal stenosis (9). Anesthesia is maintained by total intravenous anesthesia (TIVA), using plasma target-controlled infusion (TCI) of propofol and continuous titration of remifentanil guided by bispectral index (BIS). The use of short-acting anesthetic and effective adjustment allows quick restoration of the patient's breathing to spontaneous ventilation and the patient does not develop into respiratory depression during the operation.

Macchiarini *et al.* first reported a case series of 21 upper tracheal resections for benign stenosis in awake patients (10). The patients maintained spontaneous ventilation during surgery, and no intraoperative intubation or HFV was required. The investigators suggested awake and tubeless upper airway surgery is feasible and safe, and has a high level of patient satisfaction. The feasibility and safety of tracheal surgery via NSVA have been demonstrated (11-13). Since there is no obstruction of the tracheal tube during NSVA, the flexibility of the anastomosis can be significantly improved. Also, the complications related to conventional anesthesia as well as mechanical ventilator-induced lung injury can be avoided. The feasibility of NSVA is based on a comprehensive plan and the collaborative teamwork by the surgeon and anesthetist. However, there are no studies that provided a comprehensive NSVA strategy for upper tracheal surgery. This study describes a NSVA strategy includes criteria for patient selection, preoperative assessment, preoperative preparation, airway management, criteria and technique for anesthesia conversion, aiming to to assess the feasibility of NSVA strategy for upper tracheal surgery. We present the following article in accordance with the STROBE reporting checklist (available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-302/rc).

Methods

This retrospective cases series study included 51 patients who underwent NSVA for upper tracheal surgery in The First Affiliated Hospital of Guangzhou Medical University between May 1st, 2015 and August 1st, 2020. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was reviewed and approved by the Research Ethics Committee of The First Affiliated Hospital of Guangzhou Medical University (No. 2020-69), and individual consent for this retrospective analysis and case series study was signed and collected from the patients. Their medical data and images would be demonstrated with their official permission.

Preoperative assessment

All patients received meticulous preoperative assessment for surgery, including clinical features, electrocardiogram, echocardiogram, thoracic CT, and lung function analysis. Fiberoptic bronchoscopy was performed by a team of surgeons and anesthesiologists who were responsible for the subsequent procedure. If patients experienced obvious dyspnea or body-posture-related dyspnea, a transbronchial electrocision would be applied during the preoperative preparation.

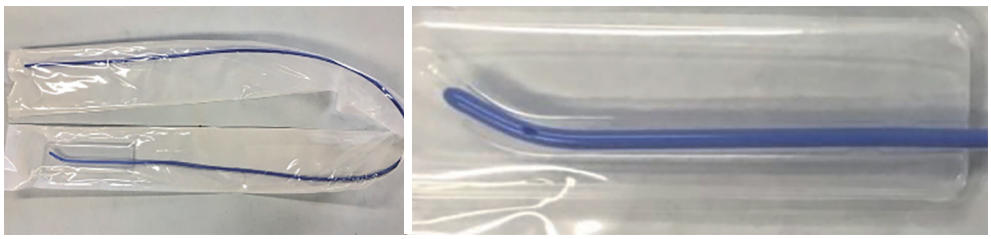

Figure 1 Equipment used in NSVA upper tracheal surgery. 15-F sterile extra-long hollow tube. NSVA, non-intubated spontaneous ventilation anesthesia.

Criteria of NSVA for upper tracheal surgery

(I) Surgical approach via cervical incision with or without or partial sternotomy;
(II) Age 16–70 years old;
(III) American Society of Anesthesiologists (ASA) Standard grade of ≤ III;
(IV) Body mass index (BMI) <28 kg/m^2;
(V) Lack of clinically relevant dyspnea. Patients with resting dyspnea/orthopnea underwent further preoperative treatment;
(VI) No massive hemoptysis;
(VII) Lack of massive arrhythmia [frequent atrial fibrillation or premature ventricular contractions (PVCs)];
(VIII) Lack of coronary artery disease (CAD). Patients with diagnosed or suspected CAD or other high-risk conditions underwent preoperative coronary artery CT angiography or coronary angiography. When required, coronary angiography with the intervention was performed prior to the procedure;
(IX) Normal cardiac function [ejection fraction (EF) >50%] (14).

Anesthesia management

Preoperatively, a clear and authentic surgical procedure and anesthesia management were communicated between surgeons and anesthesiologists. In addition to the usual thoracic anesthesia preparation, the following equipments were required to be within the reach for upper tracheal surgery via spontaneous ventilation anesthesia (SVA): (I) 3#, 4#, 5# LMAs; (II) 2.8 and 3.5 mm fiberoptic bronchoscopes; (III) wire-reinforced single-lumen endotracheal tube from 4.5 to 6.5; (IV) a 15-F sterile extra-long hollow tube (*Figure 1*), and (V) a high-frequency jet ventilator.

We performed ultrasound-guided bilateral superficial cervical plexus block (CPB) with 10 mL of 0.375% ropivacaine on each side for cervical incision, or CPB + thoracic epidural anesthesia (TEA) with 0.5% ropivacaine infusion at 5mL/h for partial cervico-sternotomy (*Figure 2*). After 15 minutes of dexmedetomidine infusion at a rate of 1.0 μg/kg/h, propofol (TCI) 2–3 μg/mL and sufentanil 0.2 μg/kg were initiated. A LMA was placed with BIS <60. To maintain anesthesia, propofol (TCI) 1.5–3 μg/mL, remifentanil 0.03–0.08 μg/kg/min, and dexmedetomidine 0.5 μg/kg/h were continually infused according to BIS (target range, 40–60). Muscle relaxants were not used during anesthesia.

Airway management

Spontaneous ventilation or synchronized intermittent mechanical ventilation (SIMV) [tidal volume (VT) 3–5 mL/kg, respiratory rate (RR) 12–15 times/min, inhaled oxygen fraction (FiO_2) 0.5–1.0] could be applied prior to tracheal transection. Recovery of spontaneous ventilation was induced by manually-assisted ventilation or by reducing anesthetic dose (mainly propofol and remifentanil) 15 minutes before opening the airway.

Patients were on spontaneous ventilation before the trachea was incised, and a fiberoptic bronchoscopy was performed to reconfirm the location of the lesion. A sterile hollow tube was placed into the distal trachea (oxygen flow rate 4–5 L/min) after the trachea was transected (*Figure 3*).

Satisfactory NSVA for upper tracheal surgery

NSVA was considered satisfactory for upper tracheal surgery if the patients had stable spontaneous ventilation (VT 3–5 mL/kg, RR 10–15 times/min, FiO_2 0.5–1.0), pulse oxygen saturation (SpO_2) >90%, partial pressure of carbon dioxide ($PaCO_2$) in arterial blood <80 mmHg, as well as stable breathing movements and hemodynamics.

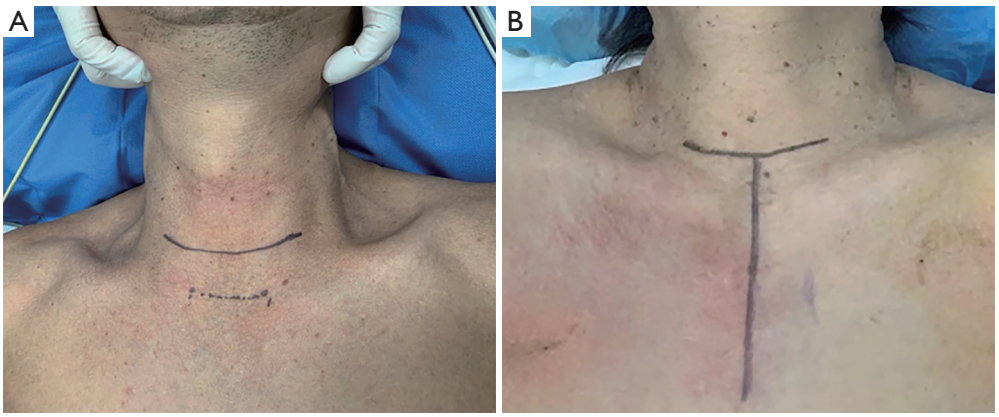

Figure 2 Two surgical approaches for upper tracheal surgery. (A) Cervical incision; (B) partial cervico-sternotomy.

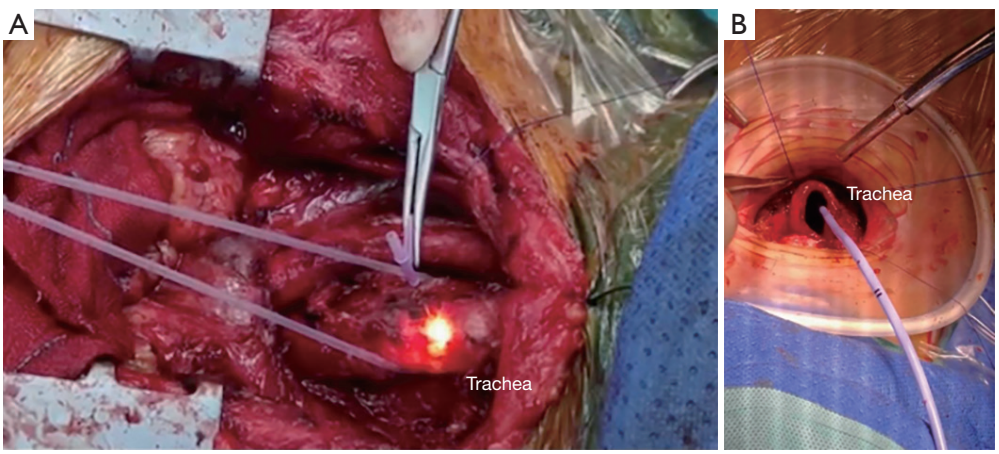

Figure 3 Key techniques in upper tracheal surgery. (A) Reconfirmed margins of the lesion under the bronchoscopic view; (B) a sterile hollow tube was placed in the distal trachea to insufflate oxygen.

Anesthesia conversion criteria during the airway-opened period

(I) Hypoxemia: SpO_2 <90% persisting more than 5 minutes after adjusting the dose of anesthetic;
(II) Hypercapnia: $PaCO_2$ ≥80 mmHg persisting more than 5 minutes, along with the presence of any of the following criteria: (i) changes in circulation: HR >100 bpm or a systolic pressure change of >30% compared with the baseline value; (ii) arrhythmia not caused by surgical stimulation; (iii) pH <7.15 at twice arterial blood gases (ABGs) analyses (performed at intervals of 15 minutes or more);
(III) Severe bleeding, blurring the surgical field and entering the distal trachea;
(IV) Pneumothorax: the integrity of the pleural cavity is broken;
(V) Persistent cough (>2 times/min);
(VI) Changes in the surgical approach (14).

Anesthesia conversion technique

(I) If the patient had stable spontaneous ventilation but SpO_2 <90%, a 15-F tube would be inserted into the distal trachea and connected to high-frequency ventilator to begin HFV;
(II) If SpO_2 did not improve after HFV or the patient met the (II)-(VI) conversion criteria mentioned above, cross-field intubation was immediately performed to begin SIMV;
(III) When end-to-end anastomosis was about to be

completed, the 15-F hollow tube/endotracheal tube was removed and SIMV was started.

Anesthesia monitors

Electrocardiogram (ECG), heart rate (HR), invasive blood pressure (IBP), SpO_2, and BIS were continuously monitored before induction. End tidal carbon dioxide (ET CO_2), VT and FiO_2 were continuously monitored except when the airway was opened. The ABG was intermittently monitored.

Surgical technique

After placing the patient in supine position, their neck and anterior chest were prepared and draped, and the neck was maximally extended using an inflatable bag behind the shoulders. A collar incision was made using platysma flaps that progressed upward to the level of the hyoid bone superiorly and the sternal notch inferiorly. The strap muscles were separated in the midline and the dissection was continued in the midline to the trachea. If the initial dissection through the neck indicates need for further exposure, the upper sternum is split to a point just beyond the angle of Louis. Because of the great vessels present anteriorly, this allows for more space to maneuver in managing the more distal trachea. Divisions of the innominate vein and incisions beyond the upper sternum do not help with tracheal exposure and are thus not routinely performed. The trachea was loosened circumferentially at the lower resection margin, taking care to avoid injury to the bilateral recurrent laryngeal nerves and excessive circumferential loosening that could interfere with the blood supply to the unresected trachea. The anterior portion of the trachea was well into the mediastinum. After cutting the distal resection margin and dividing the trachea along the circumference, a sterile hollow tube was placed into the distal airway. The upper portion of the separated trachea was clamped and the segment to be resected was moved to the level of the proximal resection margin and removed. If a portion of the cricoid cartilage needed to be removed to obtain a clear margin, a partial laryngectomy with the trachea tailored to repair the irregular proximal defect may be required. Care was taken to protect the recurrent laryngeal nerve whenever possible.

Tracheal anastomotic sutures were placed as described previously. The neck was removed from the extension and flexed under the support of a pillow. The silk sutures were pulled towards each other to relieve tension and the tracheal sutures were tied tightly (starting posteriorly). In addition to a standard anterior tracheal release technique, supraglottic release was performed if any tension was present on the sutures. The endotracheal tube was advanced and positioned distal to the anastomosis. After closure of the incision, the chin stitch was placed and held for one week to avoid inadvertent patient neck extension.

Postoperative care

LMA was removed once the patients awakened in the post-anesthesia care unit (PACU), and were transferred to an intensive care unit (ICU) if necessary.

Statistical analysis

All statistical tests were performed using SPSS version 26.0 (SPSS Science Inc., Chicago, IL, USA). Most of the statistical analyses are descriptive in this study. Categorical variables were presented as a count and percentage. Normally-distributed measurement data were presented as mean ± standard deviation, while non-normally-distributed measurement data were presented as median (interquartile range).

Results

A total of 63 patients underwent upper tracheal surgery at The First Affiliated Hospital of Guangzhou Medical University between May 1st, 2015 and August 1st, 2020. Fifty-one of these patients met our SVA criteria and were included in our study. The clinical characteristics of the patients are shown in *Table 1*.

Forty-six patients (90.2%) received TIVA + ultrasound-guided bilateral superficial CPB for cervical incision, and five patients (9.8%) had TIVA + TEA + CPB for partial cervico-sternotomy. The intraoperative data are summarized in *Table 2*. All patients were restored to spontaneous ventilation prior to tracheal incision. During the airway-opened period, all 51 patients had satisfactory spontaneous ventilation, with two patients (3.9%) requiring HFV because their SpO_2 dropped to 85% and 87%, respectively, and did not improve for more than 5 minutes despite reducing the dose of anesthetic (propofol and remifentanil). Spontaneous ventilation of these two patients was not interrupted (no muscle relaxants applied), and their SpO_2 increased immediately after HFV. Also, two patients required cross-field intubation due to bilateral

Table 1 Clinical characteristics

Variables	NSVA upper tracheal surgery (n=51)
Age, years, mean ± SD	47.02±14.89
Gender, n [%]	
Male	32 [63]
Female	19 [37]
BMI, kg·m^{-2}, mean ± SD	22.20±3.19
ASA physical status, n [%]	
I	3 [6]
II	36 [71]
III	12 [24]
Comorbidity, n [%]	
Hypertension	4 [8]
Coronary artery disease	1 [2]
Emphysema	2 [4]
ILD	0 [0]
Diabetes	3 [6]
Others	4 [8]
Smoking status, n [%]	
Never smoker	30 [59]
Former smoker	12 [24]
Current smoker	9 [18]
Preoperative treatment, n [%]	
Tracheal stent implantation	6 [12]
Transbronchial electrocision	14 [27]
No preoperative treatment	31 [61]
Pulmonary operation history, n [%]	1 [2]
Pathological diagnosis, n [%]	
Fibrillar connective tissue	11 [22]
Adenoid cystic carcinoma	15 [29]
Mucoepidermoid carcinoma	3 [6]
Glomangioma	8 [16]
Squamous-cell carcinoma	8 [16]
Lymphoepithelioma-like carcinoma	0 [0]
Thyroid carcinoma	4 [8]
Other	2 [4]

NSVA, non-intubated spontaneous ventilation anesthesia; BMI, body mass index; ASA, American Society of Anesthesiologists; ILD, interstitial lung disease; Former smoker, quit smoking for more than 3 months; Current smoker, quit smoking for less than 3 months; SD, standard deviation.

Table 2 Intraoperative data

Variables	NSVA upper tracheal surgery (n=51)
Anesthesia method, n [%]	
TIVA + bilateral superficial CPB	46 [90]
TIVA + TEA + CPB	5 [10]
Surgical approach, n [%]	
Cervical incision	46 [90]
Partial cervico-sternotomy	5 [10]
Length of excision, cm, median [IQR]	3.5 [1.0]
Positive surgical margins, n [%]	3 [6]
Blood loss, ml, mean ± SD	41.81±47.34
Surgical duration, min, mean ± SD	230.58±84.19

NSVA, non-intubated spontaneous ventilation anesthesia; TIVA, total intravenous anesthesia; CPB, cervical plexus block; TEA, thoracic epidural anesthesia; IQR, interquartile range; SD, standard deviation.

pneumothorax and unilateral pneumothorax, respectively. The surgeon discerned a punctured pleura with SpO_2 dropping quickly at the same time. Cross-field intubation was commenced immediately. One patient needed cross-field intubation due to a persistent cough, which interfered with the surgical field (*Figure 4*). No complications resulting from HFV were observed. The intraoperative characteristics in the airway-opened period are shown in *Table 3*. Following airway anastomosis, fiberoptic bronchoscopy and the air leak test were performed in all patients, and no air leak was found intraoperatively. At the end of the operation, thoracic close drainage was applied for the treatment of pneumothorax whenever necessary.

The LMA was removed after patients were fully awake in all cases. Seven patients (13.7%) were transferred to the general ward and 44 patients (86.3%) were transferred to ICU. The median ICU stay of these 44 patients was 1 day. In addition, the median postoperative hospital stay was 6.31±4.30 days. Postoperative complications occurred in seven patients (13.7%), with the most common complication being pneumothorax (6/51, 11.8%), which was managed with chest tube placement and drainage. The postoperative data are shown in *Table 4*.

The median follow-up time was 10.6 months. The minimal diameter of tracheal anastomotic position on

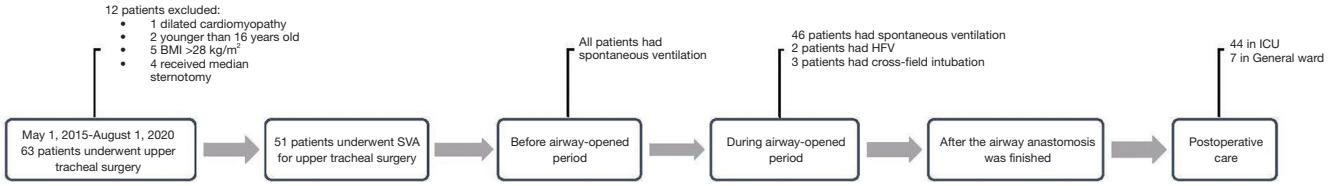

Figure 4 Flow chart. BMI, body mass index; HFV, high-frequency ventilation; SVA, spontaneous ventilation anesthesia; ICU, intensive care unit.

Table 3 Intraoperative characteristics during transected airway period

Variables	NSVA group, (n=46)	Conversion group, (n=5)
Minimum SpO_2, %, median (IQR)	95 (4.8)	85 (5.0)
Maximum $PaCO_2$, mmHg, median (IQR)	55 (11.4)	62 (12.4)
Intraoperative cough, n [%]	2 [4]	1 [2]
Intraoperative restlessness, n [%]	1 [2]	0 [0]
Intraoperative pneumothorax, n [%]	0 [0]	2 [4]
Intraoperative arrhythmia, n [%]	0 [0]	0 [0]
Anesthesia conversion technique, n [%]		
HFV	–	2 [4]
Cross-field intubation	–	3 [6]

NSVA, non-intubated spontaneous ventilation anesthesia; SpO_2, pulse oxygen saturation; $PaCO_2$, partial pressure of carbon dioxide; HFV, high frequency ventilation; IQR, interquartile range.

Table 4 The postoperative data

Variables	NSVA upper tracheal surgery (n=51)
Complications, n [%]	
Pneumonia	0 [0]
Pleural effusion requiring drainage	1 [2]
Hemothorax	0 [0]
Pneumothorax	6 [12]
Respiratory failure	0 [0]
Atrial arrhythmia	1 [2]
Vocal cord paralysis	0 [0]
Anastomotic fistula	0 [0]
Anastomotic stenosis	0 [0]
Reintubation, n [%]	0 [0]
Postoperative hospital stay, days, mean ± SD	6.31±4.30

NSVA, non-intubated spontaneous ventilation anesthesia; SD, standard deviation.

chest CT (transverse plane) was 1.6±0.3 cm at 6 months postoperatively. Fourteen patients (27.5%) received adjuvant chemo- or radiotherapy. Two cases of recurrence and one death were observed during the follow-up period, with a mortality rate of 2% during follow-up.

Discussion

We present a comprehensive NSVA strategy for upper tracheal surgery, including recommendations for preoperative assessment, preparation, airway management, criteria and technique for anesthesia conversion. Fifty-one out of 63 patients underwent upper tracheal surgery under NSVA, five required anesthesia conversion during tracheal transection. Anesthesia conversion should not be considered a failure; on the contrary, during NSVA it requires a highly skilled multidisciplinary team and established protocols to be performed successfully. And our conversion rate is well in line with those of other groups performing non-intubated major thoracic procedures (15). Furthermore, we would like

to emphasize four important issues.

Firstly, in addition to routine clinical investigation, a thorough airway assessment is key prior to upper tracheal surgery under NSVA. We encourage an enhanced CT scan (which is better with a three-dimensional airway reconstruction), and fiberoptic bronchoscopy. Most patients are initially admitted to the hospital due to non-specific symptoms like cough, hemoptysis or exertion dyspnea (16). The development and aggravation of dyspnea, degree of shortness of breath in the supine and lateral positions when awake and asleep, degree of hemoptysis, and improvement after medication were also assessed. NSVA was not considered if dyspnea or massive hemoptysis could not be resolved by preoperative bronchoscopic treatment. Enhanced CT and three-dimensional airway reconstruction helped to assess the airway and pulmonary involvement of tumors, their blood supply of tumor and concomitant lung disease. They were essential to determine the surgical and anesthesia plan. Fiberoptic bronchoscopy was performed by a surgeon and anesthesiologist who were responsible for the subsequent upper tracheal surgery. Meticulous preoperative assessment and strict selection of patients are conducive to the uneventful progress of NSVA.

Secondly, hypoxemia and hypercapnia are common concerns of NSVA. Unlike video-assisted thoracoscopic surgery (VATS), transcervical tracheal surgery under NSVA maintains pleural cavity integrity (17). Therefore, patients had bipulmonal spontaneous ventilation intraoperatively, which increases the gas exchange area when compared to transthoracic VATS tracheal surgery. By excluding patients with manifest dyspnea in the resting or supine positions, we additionally ascertained that only patients in good clinical shape underwent NSVA, adding to the overall safety of our approach. Thus all our patients were successfully restored to spontaneous ventilation and did not develop hypoxemia prior to tracheal transection. Following tracheal transection, a sterile catheter was placed in the distal trachea to insufflate oxygen. In this study, 51 (90%) patients had satisfactory spontaneous ventilation during the airway-opened period, and two patients required HFV due to SpO_2 dropping to 85% and 87%, which was improved immediately after HFV. The principal advantage of HFV is that it allows oxygenation and spontaneous ventilation through an interrupted airway without obstructing the surgical field (18). No complications related to HFV were observed in this study. In NSVA, pneumothorax may break the spontaneous ventilation. It may be caused by puncturing the pleura at any time during the operation; when the steady spontaneous ventilation is suddenly broken, shortness of breath occurs and SpO_2 drops rapidly, and in this situation, pneumothorax may occur. In this case, immediate cross-field intubation should be considered.

Most patients have satisfactory oxygenation but mild hypercapnia due to decreased minute ventilation volume (19). Interestingly, we found that in upper tracheal surgery, the $PaCO_2$ had a slight decrease compared with that before tracheal transection (2). Since the trachea is usually incised from the lower part of the lesion, the airway obstruction was effectively relieved, which can explain the phenomenon.

Thirdly, enhanced recovery after upper tracheal surgery is a significant advantage of NSVA (20). In this study, all patients were fully awake and had LMA removed in the PACU, with no reintubation being required. In conventional general anesthesia, extubation with the neck in flexion is a risky step following surgery. Premature extubation may be followed by the patient becoming unresponsive and apneic, necessitating reintubation (3). Conversely, vigorous cough or uncontrollable neck extensions when the patient becomes fully alert will also endanger the fresh anastomosis (3). However, we chose LMA as the ventilation device in NSVA, as it is well tolerated and leads to stable spontaneous ventilation until they are awake (21). Thus, premature extubation-related apnea can be eliminated, and cough and restlessness rarely occur during anesthesia recovery, which greatly improves safety and comfort.

Fourthly, potentially owing to the improvement of the surgical field, precise anastomoses were feasible in all included cases. In this study, no anastomosis-related complications occurred (such as anastomosis dehiscence and anastomotic stenosis). The most common postoperative complication in this study was pneumothorax, which might have been caused by the surgical procedure. Because unilateral open pneumothorax does not necessarily cause a significant drop in SpO_2, it is possible that pneumothorax may have occurred intraoperatively, but was not detected. This situation explains that why few patients had adequate minute ventilation, but SpO_2 was maintained at 90–95% during the operation.

As this is a retrospective cases series study from a single center, some limitations should be acknowledged. Firstly, given the lack of a control group under the same eligibility criteria, our results cannot demonstrate the superiority of NSVA over conventional intubated anesthesia. Secondly, the sample size is small, limiting the power of analysis and conclusions. Thirdly, certain inclusion criteria, such as BMI, are very specific to our Chinese population, and may not be

transferable to other settings.

In conclusion, we present our institutional experience in NSVA for upper tracheal surgery. Our data suggests that NSVA may be a safe and effective alternative to conventional intubated anesthesia for upper tracheal surgery.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-302/rc

Data Sharing Statement: Available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-302/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://tlcr.amegroups.com/article/view/10.21037/tlcr-22-302/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Research Ethics Committee of The First Affiliated Hospital of Guangzhou Medical University (No. 2020-69), and individual consent for this retrospective analysis and case series study was signed and collected from the patients. Their medical data and images would be demonstrated with their official permission.

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