CASE REPORT

One-lung Ventilation for Patients With Laryngo-tracheal Stenosis: A Case Report and Literature Review

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ABSTRACT

Context • Laryngo-tracheal stenosis (LTS) is a relatively rare disease, and conventional methods have difficulty achieving one-lung ventilation (OLV) when an anatomical abnormality exists. Selecting an appropriate method for patients with LTS can ensure oxygenation, collapse the lung, and reduce damage.

Objective • The study intended to perform a comprehensive review of the literature and a systematic review to examine the characteristics and management of OLV for LTS patients.

Design • The research team performed a narrative review by searching the PubMed and China National Knowledge Infrastructure (CNKI) databases. The search used the keywords one-lung ventilation and tracheal stenosis. The team then performed a review, including the studies found in the search and the research team's own case study.

Setting • The study took place at the First Hospital of Jilin University in Changchun, Jilin, China.

Participant • The participant in the current case study was a 72-year-old, female patient with generalized tracheal narrowing.

Results • Nine participants achieved OLV through BB, with the anesthesiologist performing SLT and using extraluminal BB for six participants.

Conclusions • Several methods can successfully achieve OLV for patients with difficult airways, but the current research team found that a small, single-lumen tube (SLT) and extraluminal bronchial blocker (BB) may be a better choice for patients with tracheal stenosis. (*Altern Ther Health Med.* 2024;30(1):278-281).

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Laryngo-tracheal stenosis (LTS) is a relatively rare disease, the cause of which is usually iatrogenic factors, such as intubation, tracheotomy, radiotherapy, or surgery of the larynx and trachea,[1] or external compression by a tumor. Other reasons for congenital tracheal stenosis are rare, such as the existence of complete tracheal rings, which are usually present in the early stages of life.[2]

Most patients with LTS experience no obvious discomfort in their daily lives. Respiratory symptoms can appear when the stenosis reaches 70% and the tracheal lumen is reduced to less than 5 mm.[3] In a preoperative setting, overlooked LTS can lead to loss of airway control without adequate ventilation or oxygenation. As a consequence, a clinical history, a physical examination, and imaging tests and bronchoscopy are crucial to anticipating potential airway emergencies.

Lung Isolation

Lung isolation in thoracic surgery is easy to implement for normal patients but challenging when patients have abnormal airways. For patients with LTS who need one-lung ventilation (OLV) for thoracic surgery, which is the mechanical separation of the lungs to allow ventilation of one lung only, the choice of devices depends on the anatomical assessment of the airway, the availability of devices, and the preferences of anesthesiologists. High quality of lung collapse can provide better surgical vision for surgeons.

Usually, anesthesiologists use two principal devices to establish one-lung ventilation (OLV): double-lumen tubes (DLTs) and bronchial blockers (BBs) that they insert through a conventional, single-lumen tube (SLT). When an airway is extremely narrow, an appropriate DLT can be difficult to insert. For patients with LTS, it can be challenging to perform an OLV during thoracic surgery. In addition, it's difficult to simultaneously place a BB and a fiberoptic bronchoscope (FOB) in the narrow entrance of a small SLT.[4]

Overall, a BB is a better choice for patients with difficult airways for selective lobar ventilation, even in emergencies, or whenever the surgeon contemplates postoperative mechanical ventilation.[5]However, the sharp margin of a BB's evacuated cuff can cause damage, such as excoriated tracheal mucosa, acute tracheal hemorrhage, damage to tumors, and

other potential complications, such as airway edema or obstructions.

Alternative Methods

Previous studies have examined alternative methods to achieve OLV for patients with complicated airways: (1) supraglottic devices and no intubation of the trachea, (2) extracorporeal membrane oxygenation (ECMO) and (3) an SLT smaller than the conventional one, with an extraluminal placement of a BB.

Supraglottic devices and no intubation. Supraglottic devices[1] and techniques not using intubation[6] can be alternatives to achieving OLV, even for patients who have critical airways such as those with an invisible glottis, in which it isn't feasible to insert a BB. Laryngeal mask airway with BB can be a non-intubated management variant that achieves immobilization with less invasiveness compared to the DLT.[1] However, intraoperative device-related complications are more frequent such as hypercapnia, device displacement, surgery interruption, unintentional lung expansion and ventilatory difficulty. Techniques not using intubation, however, require expert hands and high skills on every side of the surgical field.[7]

ECMO. For balloon dilatation and implantation of nitinol stents prior to surgery, ECMO may be an appropriate treatment for airways with extremely serious problems when it isn't feasible to use tracheal devices.[8]

SLT and extraluminal BB. Anesthesiologists can also use this novel method to facilitate exposure in thoracic surgery,[4,9,10] and its use can expand the use of BBs. The method has obvious advantages compared with the conventional intubation for BB and DLT. When using an extraluminal BB, anesthesiologists can use an endotracheal tube with an integrated high-resolution camera, to adjust the BB by continuous airway visualization. They can easily position the device to adjust the BB to the optimal position without interference from the FOB. The size of the lumen tube is no longer a limitation. Anesthesiologists can also use it for patients requiring nasal, oral, or tracheostomy intubation.[11]

Current Study

The current study intended to perform a comprehensive review of the literature and a systematic review to examine the characteristics and management of OLV for LTS patients.

METHODS

Procedures: Systematic Review

The study took place at the First Hospital of Jilin University in Changchun, Jilin, China. The research team performed a narrative review by searching the PubMed database for literature in English and the China National Knowledge Infrastructure (CNKI) database for Chinese literature. The search used the keywords one-lung ventilation and tracheal stenosis. To identify potentially missed reports, the research team manually searched the reference lists of the included articles. Finally, the research team searched for eight case reports, all of which were successful OLV for patients with difficult airways.

Procedures: Case Study

The study took place at the First Hospital of Jilin University in Changchun, Jilin, China.

The research team obtained informed consent from the patient for the purpose of the current article. The team presented the article in accordance with the CAse REport (CARE) checklist. The anesthesiologist at other hospital suspended the patient's thoracoscopic lobectomy of the upper right lobe of the lungs after general anesthesia due to a failure to insert a 35.0 French DLT, which was the smallest tube available. Then the patient was admitted to our hospital from the outpatient department to resort to a better solution. The key issue for the patient is how to smoothly implement OLV during surgery.

RESULTS

Current Case Study

The participant in the current case study was a 72-year-old woman with generalized tracheal narrowing, who was 156 cm in height, weighed 50 kg, and had received an American Society of Anesthesiologists (ASA) grade III. Surgeons had scheduled her for a video-assisted thoracoscopic lobectomy of the upper right lobe of the lungs. The patient were healthy previously and surgical history: thyroidectomy was performed under general anesthesia 30 years ago.

The findings from her physical examination were unremarkable, and she had no dysphagia or dyspnea. Neck and chest computed tomography (CT) revealed serious tracheal stenosis. The narrowest area was located at the subglottis, which is the cross section of the trachea, and was a fissure 7.73 mm × 11.2 mm (Figure 1A). The inner diameter widened gradually along the trachea and was 12.8 mm above the carina (Figure 1B) and 14.7 mm in the right main-stem bronchus (Figure 1C).

The patient underwent standard monitoring during surgery, including invasive measurement of arterial blood

Figure 1. Video-assisted Thoracoscopic Lobectomy. The photographs show: (1) the narrowest area of the trachea, a fissure 7.73 mm × 11.2 mm (Figure 1A); (2) the 12.8-mm inner diameter of the trachea above the carina (Figure 1B); (3) the 14.7-mm inner diameter of the right, main-stem bronchus (Figure 1C); (4) the insertion of an extraluminal bronchial blocker (BB) using a visual laryngoscope (Figure 1D); (5) the BB and single lumen tube as it passed the glottis (Figure 1E); (6) the adjustment of the BB to the right, main-stem bronchus (Figure 1F); (7) the optimal collapse of the right lung (Figure 1G); and (8) a layer of about 3 mm of mucosal tissue around the proximal cuff (Figure 1H).

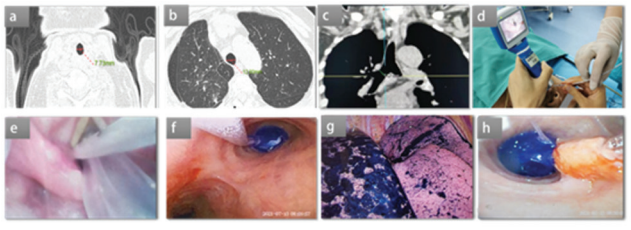

Table 1. Clinical Data of Patients With Laryngo-tracheal Stenosis to Acquire One-lung Ventilation

Authors	Age	Gender	Symptoms Relative to Respiration	Operation	Reason for Stenosis	Intubation	Complication
Zhang et al, 2002[12]	28	Female	Cough, expectoration	Right middle and lower lobectomy	Tuberculosis	Stent implantation/ SLT (7.5) / extraluminal BB	No
Granell et al, 2018[3]	60	Male	No	Metastasis	Radiotherapy tracheostomy	SLT (8.0) / exchanger (14F) / Univent tube and BB	Tracheal hemorrhage
	56	Female	NM	Superior right lobectomy	Radiotherapy tracheostomy	Caliber Vivasight SL tube (ID7) / BB (9F)	NM
Zhou et al, 2018[13]	54	Male	No	Esophageal carcinoma	Tracheomalacia	SLT (7.5) /BB	No
Liu et al, 2018[10]	51	Male	NM	Lung resection	A large mass on the vocal cords	SLT (5.5) / extraluminal BB	No
Zheng et al, 2018[14]	68	Male	NM	Mediastinal tumor	Compression	Reinforced SLT (ID7.0) / extraluminal BB (9F)	No
Liu et al, 2020[9]	66	Male	Difficulty breathing	Mediastinal tumor	Compression	SLT (ID6.0) / extraluminal BB (9F)	No
Jia et al, 2021[4]	65	Male	NM	Adenocarcinoma	Tracheostomy	SLT (5.5)/ extraluminal BB (9F)	No
Kodia et al, 2021[8]	29	Female	Dyspnea, occasional stridor, dysphagia	Mass resection	Compression	VV-ECMO / 38F DLT	No
Present case study	72	Male	No	Upper right lobectomy	Unknown	SLT (ID5.5)/ extraluminal BB (7F)	No

Abbreviations: BB, bronchial blockers; DLT, double-lumen tube; ID, inner diameter; NM, not mentioned; SLT, single-lumen tube; VV-ECMO, venovenous-extra corporeal membrane oxygenation.

pressure and heart rate, an electrocardiogram, use of a bispectral index, and measurement of peripheral oxygen saturation. The surgeons prepared a 7.0 and a 5.0 French BB, lubricated using gelatum; an SLT with an inner diameter of 5.0-6.5 mm, lubricated using gelatum; and a #3 laryngeal mask.

The patient received anesthesia using 0.3mg/kg of etomidate and 0.15 ug/kg of sufentanil. After confirming mask ventilation, the anesthesiologist administered 0.15 mg/kg of cisatracurium for tracheal intubation and then: (1) inserted a 7.0 French BB into the trachea using a visual laryngoscope (Figure 1D) and turned it forward to the right; (2) made an attempt to insert a small SLT with an inner diameter of 6.0 mm but removed it because resistance occurred when it reached the stenosis; (3) changed to a smaller SLT with an inner diameter of 5.5 mm and inserted it successfully without resistance (Figure 1E); and (4) inserted the fiberoptic bronchoscope (FOB) into the SLT's lumen to adjust the BB to the right main-stem bronchus (Figure 1F), ensuring that only the left lung was ventilated.

The procedure was successful without hypoxemia. The anesthesiologist reconfirmed the position after the lateral decubitus position. Exposure of the operational field was ideal for acquiring optimal collapse of the right lung (Figure 1G).

If the BB can't block the bronchus fully, the anesthesiologist can insert a 7.0 French BB into the right lung's middle and lower trunk while simultaneously inserting a 5.0 French BB into the lung's right upper lobe.

When the anesthesiologist inserted the FOB to adjust the BB during the current surgery, we found that a layer of approximately 3 mm of mucosal tissue covered the lumen around the proximal cuff (Figure 1H), which was a complication from excoriated tracheal mucosa that movement of the BB had caused. The anesthesiologist removed both the BB and the mucosal tissue under the vision of the FOB after surgery, which caused no mucosal damage or edema. The patient recovered well, and no dyspnea, sore throat, or hoarseness appeared during postoperative followup.

Systematic Review

Through the systematic review, the research team found eight previous case studies, in addition to the current case study, in which participants were patients with abnormal airways who required OLV.[3,6,8,9,10,12-14] Of them, one studies included 2 participants,[3,] for 10participants in total, including the current study's participant (Table 1).

Seven patients were male (70%),[3,6,9,10,13,14] including the participant in the current case study, and three were female (30%).[3,8,12] The reasons for stenosis included: (1) three participants with a tracheostomy (30%),[3,6] (2) one with tracheomalacia (10%),[13] (3) one with a vocal-cord mass (10%),[10] (4) three with compression by the tumor (30%),[8,9,14] (5) one with stenosis due to tuberculosis (10%),[12] and (6) one, the patient in the current case study, who had unexplained stenosis (10%).

Nine participants achieved OLV through BB , with the anesthesiologist performing SLT and using extraluminal BB for six participants (66.7%%).[6,9,10,12-14] For the remaining four participants, the anesthesiologist used: (1) conventional BB for two participants (20%);[3,13] (2) a Vivasight SL in combination with BB for one participant (10%);[3] and (3) venovenous (VV)-ECMO for one participant (10%).[8]

DISCUSSION

The current systematic review found that anesthesiologists successfully used an SLT and extraluminal BB to facilitate exposure in thoracic surgery for 60% of participants, with varying degrees of airway stenosis.

The current case study found that the sharp margin of the BB's evacuated cuff caused damage, excoriated tracheal mucosa. Therefore, the current research team suggests inserting the BB under the guidance of an FOB or an endotracheal tube with an integrated high-resolution camera to minimize damage. In addition, retaining a small amount of gas in the cuff to make the edge smoother is feasible to reduce damage. Practicing skilled manipulation during normal times is important.

There is a limitation about the current case that the cause of stenosis in this patient is unclear. Due to the inability to contact the thyroid surgeons 30 years previously, we can't determine whether the airway stenosis is related to the thyroidectomy.

CONCLUSIONS

Several methods can successfully achieve OLV for patients with difficult airways, but the current research team found that a small SLT and extraluminal BB may be a better choice for patients with tracheal stenosis.

AUTHORS' DISCLOSURE STATEMENT

The authors declare that they have no conflicts of interest related to the study.

REFERENCES

1. Nakanishi T, Sento Y, KamimuraY. Combined use of the ProSeal laryngeal mask airway and a bronchial blocker vs. a double-lumen endobronchial tube in thoracoscopic surgery: A randomized controlled trial. *J Clin Anesth* 2023;88
2. Nagappan R, Parkin G, Wright CA, et al. Adult long-segment tracheal stenosis attributable to complete tracheal rings masquerading as asthma. *Crit Care Med*. 2002;30(1):238-240. doi:10.1097/00003246-200201000-00034
3. Granell Gil M, Solís Albamonte P, Córdova Hernández C, Cobo I, Guijarro R, de Andrés Ibañez JA. Intubation in two patients with difficult airway management and tracheal stenosis after tracheostomy in thoracic surgery. *Rev Esp Anestesiol Reanim (Engl Ed)*. 2018;65(6):347-350. doi:10.1016/j.redare.2017.12.017
4. Jia H, Tan WF, Ma H, Cui Y. A novel method using a single lumen tube and extraluminal bronchial blocker for one-lung ventilation in severe tracheal stenosis: a case report. *Ann Palliat Med*. 2021;10(1):749-753. doi:10.21037/apm-20-1676
5. Campos JH. Which device should be considered the best for lung isolation: double-lumen endotracheal tube versus bronchial blockers. *Curr Opin Anaesthesiol*. 2007;20(1):27-31. doi:10.1097/ACO.0b013e3280111e2a
6. Ke HH, Liou JY, Teng WN, et al. Opioid-sparing anesthesia with dexmedetomidine provides stable hemodynamic and short hospital stay in non-intubated video-assisted thoracoscopic surgery: a propensity score matching cohort study. *BMC Anesthesiol*. 2023;23(1):110. doi:10.1186/s12871-023-02032-0
7. Aymerich H, Bonome C, González-Rivas D. Non intubated video-assisted thoracoscopic lung resections (NI-VATS) in COVID times. *Saudi J Anaesth*. 2021;15(3):362-367. doi:10.4103/sja.sja_421_21
8. Kodia K, Liu Y, Ghodsizad A, Turner D, Briski L, Nguyen DM. Use of venovenous extracorporeal membrane oxygenation for resection of a large paratracheal mass causing critical tracheal stenosis: A case report. *J Card Surg*. 2021;36(1):367-370. doi:10.1111/jocs.15207
9. Liu Z, Jia Q, Yang X. Awake intubation and extraluminal use of Uniblocker for one-lung ventilation in a patient with a large mediastinal mass a case report. *BMC Anesthesiol*. 2020;20(1):125. doi:10.1186/s12871-020-01041-7
10. Liu Z, Yang X, Jia Q. One-lung ventilation in a patient with a large mass on the glottis: A case report. *Medicine (Baltimore)*. 2018;97(36):e12237. doi:10.1097/MD.0000000000012237
11. Campos JH, Kernstine KH. Use of the wire-guided endobronchial blocker for one-lung anesthesia in patients with airway abnormalities. *J Cardiothorac Vasc Anesth*. 2003;17(3):352-354. doi:10.1016/S1053-0770(03)00064-8
12. Zhang C. Airway management of one lung anesthesia after stent implantation for tracheal stenosis: a case report. *Chin J Anesthesiol*. 2002;22:9.
13. Zhou C. Anesthesia management of esophageal cancer resection in asthmatic patients with tracheomalacia and right main bronchiectasis: a case report. *J Clin Anesthesiol*. 2018;34(5):516-517.
14. Zheng M. Placing bronchial blocker outside endotracheal tube guided by FOB for one-lung ventilation in a patient with giant mediastinal tumoe: a case report. *Chin J Anesthesiol*. 2018;38(4):511-512.