

Airway Control with a Laryngeal Mask Combined with High-Flow Oxygen During Tracheal Resection and Reconstruction for Tumor-Induced Critical Airway Obstruction: A Case Report

Ly Nguyen Minh

108 Military Central Hospital

Hung Tong Xuan

108 Military Central Hospital

Hai Ngo Vi

108 Military Central Hospital

Hung Tran Duc

108 Military Central Hospital

Trang Dinh Thi Thu

dttrang108@gmail.com

108 Military Central Hospital

Case Report

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Abstract

Background

Primary tracheal tumors are rare but it can cause critical airway obstruction requiring urgent surgical resection and reconstruction. Airway management during tracheal surgery is highly challenging because anesthesia and surgery share the same airway, increasing the risk of loss of ventilation. This report describes a multimodal airway strategy—including supraglottic airway ventilation, distal tracheal intubation, and high-flow oxygenation—used for emergency tracheal resection in a patient with > 95% tumor-induced obstruction.

Case Presentation:

A 76-year-old woman presented with hemoptysis and progressive dyspnea. Imaging and bronchoscopy revealed a friable intraluminal tracheal tumor causing near-complete obstruction at the cervical trachea. Because intubation through the stenosis was unsafe, anesthesia was induced using high-flow nasal oxygen and ventilation via a ProSeal laryngeal mask airway (LMA). After tracheal exposure, distal tracheal intubation provided controlled ventilation during tumor resection. During anastomosis, apnea with high-flow oxygen (70 L/min) through the proximal endotracheal tube provided an unobstructed surgical field while maintaining oxygenation. The patient was extubated in the operating room and discharged on postoperative day five.

Conclusions

Laryngeal mask ventilation combined with staged distal intubation and high-flow apneic oxygenation offers an effective and safe airway strategy for selected patients with critical tracheal obstruction due to tumor. This approach may reduce airway trauma and maintain surgical exposure without compromising oxygenation.

I. Introduction

Primary tracheal tumors are uncommon but can produce life-threatening airway narrowing. Patients with > 90% obstruction present significant challenges for anesthetic and surgical management due to the risk of complete airway collapse during induction. Multiple ventilation strategies have been described, including cardiopulmonary bypass (CPB), distal endotracheal intubation with intermittent positive-pressure ventilation (IPPV), high-frequency jet ventilation (HFJV), and high-flow oxygenation (HFO)^{1,2,3}. Selecting an appropriate method must be individualized according to tumor characteristics and the anticipated ease of airway access.

This report describes successful emergency tracheal resection in a patient with near-complete obstruction using sequential airway control: supraglottic ventilation, distal tracheal intubation, and high-flow oxygenation during anastomosis.

II. Case description

A 76-year-old woman, height 156 cm, weight 55 kg, with no significant medical history, presented with a 10-day history of progressive dyspnea, cough, and approximately 150 mL of bright red hemoptysis with clots. She had been evaluated and treated at another hospital but showed no improvement.

The patient was conscious, afebrile, and able to communicate normally. She produced small quantities of dark-brown sputum mixed with blood, had hoarseness, and presented with both inspiratory and expiratory stridor. Dyspnea was graded as Class II. Respiratory rate was 24 breaths/min, and SpO₂ measured 92% on room air. Wheezing was present with coarse breath sounds localized to the suprasternal region.

Laboratory tests

ECG

Normal sinus rhythm, HR 84 bpm.

- **Echocardiography:** EF 68%, mild aortic regurgitation.
- **Abdominal ultrasound:** Normal.
- **Laboratory results:** No abnormalities in renal/hepatic function, electrolytes, or coagulation.
- **MRI:** A mass measuring 18 × 18 mm at the C7 level, extending 2.1 cm, protruding into the tracheal lumen with poorly defined margins, nearly obstructing the airway (Fig. 1).
- **Bronchoscopy:** A friable tumor obstructing most of the upper one-third of the trachea; the bronchoscope could not pass the lesion.

Diagnosis

Primary tracheal tumor causing near-total cervical tracheal obstruction, requiring emergency surgical resection.

Anesthesia, ventilation management, and surgery:

The greatest perioperative concern was the risk of losing airway control during induction. The tumor caused > 95% luminal obstruction with ongoing bleeding. Conventional endotracheal intubation risked provoking hemorrhage and complete obstruction. Introducing a catheter for HFJV was also considered hazardous due to tumor friability. Because the patient maintained spontaneous ventilation, using a laryngeal mask airway (LMA) for initial airway control was deemed the safest approach.

After multidisciplinary discussion, the team adopted the following strategy: 1. Induction of general anesthesia and controlled ventilation using a ProSeal LMA. 2. IPPV after the surgeon exposed the trachea. 3. HFO during tracheal anastomosis.

Pre-induction

The patient arrived in the OR with Grade II–III dyspnea and biphasic stridor. Vital signs included: HR 82 bpm, BP 165/98 mmHg, and SpO₂ 93%. She was warmed and administered high-flow nasal oxygen (HFNO) at 40 L/min. Monitoring included ECG, SpO₂, BIS, TOF, and temperature. A left radial arterial catheter and 18G IV line were inserted.

(The photo was taken at the Anesthesia Department

108 Military Central Hospital.)

Emergency airway equipment—including a difficult airway equipments and HFJV device—were prepared. The surgical team was ready to perform a rapid tracheostomy if airway collapse occurred.

Step 1: Induction

After 10 minutes of HFNO, ABG showed: pH 7.45, PaCO₂ 40.6 mmHg, PaO₂ 378 mmHg, HCO₃⁻ 27.8 mmol/L, BE + 3.6.

Induction: fentanyl 2 µg/kg, propofol 1.5 mg/kg, rocuronium 0.6 mg/kg, dexamethasone 8 mg. A size-4 ProSeal LMA was inserted smoothly. Ventilation: Vt 425 mL, RR 14/min, FiO₂ 45%, Ppeak 29 cmH₂O, Pmean 12 cmH₂O, EtCO₂ 40 mmHg.

(The photo was taken at the Anesthesia Department

108 Military Central Hospital.)

Maintenance: Propofol TCI 3.5–4.0 µg/mL, fentanyl 2–3 µg/kg/h, rocuronium 0.3 mg/kg/h (BIS 40–60, TOF = 0).

Step 2: Tumor resection, distal endotracheal tube ventilation

After incision, the trachea was exposed. The LMA was removed, and a 7.0 Fr ETT was placed at the glottis. Simultaneously, the surgeon inserted another 7.0 Fr endotracheal tube (ETT) with a metal coil into the distal trachea, using IPPV with FiO₂ 45%.

The segment of the trachea containing the tumor, approximately 4 cm long and almost completely obstructing the trachea, was removed.

(The photo was taken at the Anesthesia Department

108 Military Central Hospital.)

Step 3: Anastomosis – High flow oxygen

To optimize the surgical field for anastomosis, the distal ETT was removed. HFO (70 L/min) was delivered through the proximal ETT at the glottic inlet, maintaining apnea for 23 minutes.

ABG values: after 10 minutes : PaO₂ 109.0 mmHg, PaCO₂ 65.2 mmHg, pH 7.26.

After 20 minutes: PaO₂ 102 mmHg, PaCO₂ 72 mmHg, pH 7.25.

These results represented acceptable temporary hypercapnia.

Step 4: End of surgery - recovery

After anastomosis, the proximal ETT was advanced beyond the repair. Controlled ventilation resumed (Vt 450 mL, RR 14/min, FiO₂ 45%). Neuromuscular blockade was reversed with sugammadex 2 mg/kg. A Cook airway exchange catheter with supplemental oxygen capability was inserted as a safeguard against potential reintubation, and the endotracheal tube was subsequently removed. After 10 minutes, the patient was fully awake and stable, allowing removal of the Cook catheter. The patient continued to receive supplemental oxygen via nasal cannula and was transferred to the ICU for further monitoring. The following day, the patient was able to perform light exercises and was discharged 5 days post-surgery.

Table 1
The hemodynamics and arterial blood gases

HR	T0 Before surgery	T1 After HFNO 10 mins	T1 After LMA 15 mins	T2 After HFO 10 min	T3 After HFO 20 mins	T4 15 mins after HFO finishes	T5 After extubation
	89	80	84	83	87	98	82
NBP	183/ 94	143/86	128/70	127/56	125/67	123/68	128/76
EtCO2	-		38	-	-	32	-
SpO2	95	100	99	99	99	99	99
ABG							
pH	7.38	7,45	7.45	7.26	7.25	7.44	7.53
PCO2	48	40,6	39.7	65.2	72	43	39
PO2	75	378	148.8	109.0	102	115	74
sO2	93.5	99.6	97.7	97.2	96.6	95.5	95
HCO3-	24.7	27,8	26.1	24.2	31	28.0	31.9
BE	0.5	3,5	3.6	- 0.3	2.3	4.8	8.2
Lac	0,8	0,85	1.03	1.02	0.99	1.26	1.1

III. Discussion

Primary tumors of the trachea are rare pathology. When a mass occupies more than 90% of the tracheal lumen, corresponding to Cotton grade III–IV stenosis, anesthetic management becomes extremely challenging due to the high risk of airway obstruction. In this patient, we aim to discuss the strategy for airway control throughout induction and the entire surgical procedure.

Induction of anesthesia in this case posed a significant challenge for the anesthesiologist because of the substantial risk of losing airway control. The tumor caused near-complete occlusion of the tracheal lumen (Cotton IV)⁵. Its friable nature predisposed it to bleeding or fragmentation, potentially resulting in total airway obstruction if a small endotracheal tube or catheter were advanced through the stenotic segment. Intubation above the level of obstruction was also not feasible because the tumor was located proximally, leaving insufficient space (no landing zone) for secure endotracheal tube placement.

In cases of proximal tracheal stenosis caused by tumors, several authors have employed HFJV during surgery by advancing a 10–14 Fr catheter (external diameter 3.3–4.7 mm) through the stenotic segment and delivering jet ventilation^{6,7,8}. Ventilation frequencies typically range from 100–150 breaths per minute with driving pressures of 2–4 bars. This technique is relatively simple, provides an unobstructed

surgical field, and ensures adequate oxygenation. However, it carries inherent risks such as barotrauma, obstruction of the distal bronchi by blood or secretions, and catheter malfunction owing to the small lumen, which predisposes it to blockage or displacement. Moreover, HFJV may result in hypercapnia because of CO₂ elimination.

For patients with > 90% tracheal lumen obstruction, some authors advocate the use of CPB to ensure perioperative safety^{9, 10}. CPB, however, is a complex modality associated with significant risks, including coagulopathy and the necessity for highly specialized technical expertise. In this case, although CPB was not immediately employed, we prepared all emergency rescue modalities—including ECMO and CPB—in anticipation of potential tumor fragmentation, hemorrhage, or complete airway loss.

In this patient, we applied ProSeal mask ventilation during the initial phase of anesthesia and obtained favorable results. The ProSeal is capable of achieving an effective seal at pressures exceeding 30 cmH₂O without causing soft-tissue injury. Because adequate ventilation can be maintained without inserting an endotracheal tube through the trachea, we selected LMA for this case to avoid the risk of tumor fragmentation or bleeding, which could otherwise lead to complete airway obstruction.

ETT placement and cuff inflation above the level of stenosis could have been difficult due to the tight stenosis and could be associated with a high risk for dislocation, bleeding, perforation of the trachea, or loss of the airway control¹¹. Moreover, patients could experience hypoxia due to the numerous intubation attempts. Unlike the tracheal tube, SAD can not bypass tracheal stenosis, but they may have several advantages in this situation¹². A supraglottic device allows control of the airway without interfering with the subglottic region and permits a fiberoptic bronchoscopy to check the vocal cords and tracheobronchial tree while the patient is ventilated¹³.

Because of the concern that ventilation through the LMA might be difficult due to near-complete tracheal obstruction, we employed nasal high-flow preoxygenation at 40 L/min while the patient was still awake to increase oxygen reserve for induction. The results demonstrated excellent improvement in arterial blood gas parameters, with pH 7.45, PaCO₂ 40.6 mmHg, and PaO₂ 378 mmHg (Table 1). Numerous studies have shown that high-flow oxygen at 40–70 L/min can extend safe apnea time by 5–10 minutes and reduce the risk of desaturation during endotracheal intubation in high-risk patients^{14, 15, 16}.

In these patient, LMA was inserted successfully on the first attempt, and a gastric tube was easily advanced through the ProSeal drainage channel. Because the tumor almost completely occluded the airway, airway pressures were elevated, with peak airway pressures (P_{peak}) > 29 cmH₂O and mean airway pressures (P_{mean}) > 12 cmH₂O; at such pressures, a portion of insufflated gas may enter the stomach. In this context, use of a classic laryngeal mask airway would have been contraindicated due to the high risk of regurgitation and gastric insufflation.

The use of supraglottic airway devices and HFJV in open tracheal surgery has been described in several isolated reports^{11, 12, 13}. A retrospective study of 54 patients further demonstrated that the LMA may

serve as a feasible alternative to the endotracheal tube for airway management and conventional ventilation during open tracheal surgery¹⁷.

In 2006, Bouaggad successfully used a LMA in a 37-year-old male patient with a cervical tracheal tumor; the author inserted the LMA during the initial phase, passed a flexible bronchoscope through it, and subsequently guided the surgeon to incise the trachea and insert a distal endotracheal tube¹⁸. Divatia JV and colleagues also reported the use of a LMA in a similar case in 1994¹⁹. Sandberg Warren and co-authors further suggested that when tumors are located close to the vocal cords, the LMA represents a prudent and appropriate choice⁴.

Similarly, in our case, use of the LMA yielded favorable outcomes. Heart rate and arterial blood pressure after LMA insertion remained largely unchanged compared with preinduction values. Ventilation through the device was effective, with Vte 405 mL, Ppeak 29 cmH₂O, Pmean 12 cmH₂O, and EtCO₂ 40 mmHg. Analysis of arterial blood gases, in conjunction with SpO₂ and EtCO₂ monitoring, demonstrated that pH, arterial oxygen tension, oxygen saturation, and CO₂ levels all improved immediately after LMA placement compared with preinduction measurements.

After the trachea was transected, the surgeon inserted a distal endotracheal tube into the peripheral airway to provide ventilation. This method is relatively simple, physiologically, safe, and allows easy suctioning of blood and secretions from the tracheobronchial lumen (Figs. 4 and 5)^{4,20,21}.

During the anastomosis phase, HFO was delivered at 70 L/min through the proximal end of the endotracheal tube positioned at the level of the glottis, with the oxygen stream directed toward the distal segment. This method of respiratory control optimizes surgical exposure, enabling the surgeon to perform the anastomosis without obstruction or interference in the operative field. With the HFO system, oxygen was delivered directly through the endotracheal tube situated at the glottic inlet. Apneic oxygenation refers to the ability to maintain oxygen transfer from the alveoli to the bloodstream despite the absence of active ventilation, thereby meeting metabolic oxygen requirements during apnea^{22,23}.

During the anastomosis, HFO ventilation yielded the following results: arterial oxygen tension (PaO₂) and peripheral oxygen saturation (SpO₂) remained within normal limits, with PaO₂ values of 116 mmHg and 102 mmHg after 10 and 20 minutes of HFO, respectively. Mild respiratory acidosis occurred, with pH 7.26 and PaCO₂ 65 mmHg after 10 minutes of HFO, and pH 7.25 with PaCO₂ 72 mmHg after 20 minutes (Table 1). Multiple studies have documented the occurrence of acute respiratory acidosis during HFO; however, short-term hypercapnia with pH > 7.15 does not result in significant complications and is considered acceptable in patients without contraindications^{24,25,26}.

Egan M. and colleagues⁷ also employed high-flow oxygen delivered through a LMA during tracheal resection and reconstruction in one patient, achieving a prolonged apnea time of 44 minutes with oxygen saturation consistently maintained between 98–100%. No significant complications were reported, aside from acute respiratory acidosis. The operative field remained spacious and optimized for the technical steps of tracheal anastomosis²⁷.

From 2016 to 2017, C. Lyons and M. Callaghan utilized nasal high-flow oxygen at 35–40 L/min without endotracheal intubation in 28 patients undergoing laryngeal and tracheal surgery. General anesthesia was administered, and the average apnea time was 19 minutes, with a maximum of 34 minutes. The majority of patients maintained $\text{SpO}_2 > 95\%$ throughout the procedure; four patients experienced transient desaturation with SpO_2 ranging from 86–90%. PaCO_2 levels fluctuated between 45–86 mmHg. The authors concluded that high-flow nasal oxygen during apnea can provide adequate oxygenation for laryngeal surgery without the need for ventilation²⁸.

A prospective study was performed on 16 patients with tracheal stenosis, with ages ranging from 19 to 70, who underwent tracheal resection and reconstruction from April 2019 to August 2020 in 108 Military Central Hospital. During the anastomosis phase using high flow oxygen of 35–40 L.min⁻¹ delivered across the open tracheal with an endotracheal tube (ETT) at the glottis in apnoeic conditions. The mean (SD) apnoea time was 20.91 (2.53) mins. The saturation of oxygen was stable during all procedures at 98–100%. Arterial blood gas analysis showed mean (SD) was hypercapnia and acidosis acute respiratory after 10 mins of apnoea and 20 mins apnoea respectively. All 16 patients were extubated early and safely at the end of the operation. There were no complications, such as bleeding, hemothorax, pneumothorax, or barotrauma²⁹.

IV. Conclusion

The combined use of a LMA and HFO in this patient proved to be both safe and effective, with gas-exchange parameters showing improvement compared with preoperative values. Airway control during induction was well maintained, and throughout the surgical procedure, the operative field remained completely unobstructed. The surgery was not hindered by ventilatory tubing, connectors, or the need to exchange airway devices. No arrhythmias, pneumothorax, hemothorax, or pressure-related pulmonary injury were observed.

Airway management during tracheal surgery remains a challenge for anesthesiologists. We recommend having adequate airway management equipment available; the method used depends on the available equipment and the anesthesiologist's experiences. In particular, a detailed strategy developed by a team of experienced anesthesiologists, surgeons, radiologists, and resuscitation specialists is essential. The induction must be conducted cautiously, anticipating the risk of airway loss that could occur at any time.

Abbreviations

CPB

cardiopulmonary bypass

IPPV

distal endotracheal intubation with intermittent positive-pressure ventilation

HFJV

high-frequency jet ventilation

HFO
and high-flow oxygenation
HFNO
high-flow nasal oxygen
ETT
Endotracheal tube
TCI
Target-controlled infusion
LMA
Laryngeal mask
SAD
Supraglottic Airway Device
ECMO
Extracorporeal Membrane Oxygenation.

Declarations

Author contributions

LNM and TDDT: conceived the concept of this study, manuscript writing, data analysis and interpretation. HTX and HNV: data revising, data interpretation and approval of the version to be published. LNM, TDDT, and HTD: ensuring questions related to the accuracy or integrity of the work are appropriately investigated and resolved. All authors reviewed the manuscript and approved the final version.

Declaration of patient consent

The authors certify that the patient has given her consent for her images and other clinical information to be reported in the journal. The patient gave written informed consent for her personal and clinical details along with any identifying images to be published in this study. The patient understands that her name will not be published and due efforts will be made to conceal her identity, but anonymity cannot be guaranteed.

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None

Conflicts of interest

There are no conflicts of interest.

Availability of data and materials

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The research was conducted following the guidelines and approval of 108 Military Central Hospital Clinical Researches Ethics Committee under the approval number 28/QĐ-BVTWQĐ108. All human research procedures followed were by the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

Clinical trial number: not applicable.

Author details

1.Department of Anesthesiology and Pain Medicine, 108 Military Central Hospital, No.1 Tran Hung Dao Street, Hai Ba Trung District, Ha Noi City 100000, Vietnam. 2.Department of Thoracic surgery, 108 Military Central Hospital, Hanoi, Vietnam.

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Figures



Figure 1

MRI images of the patient: The tumor in the tracheal, 18 × 18 mm at the C7 level, extending 2.1 cm.



Figure 2

Patient with HFNO pre-induction

(The photo was taken at the Anesthesia Department

108 Military Central Hospital.)

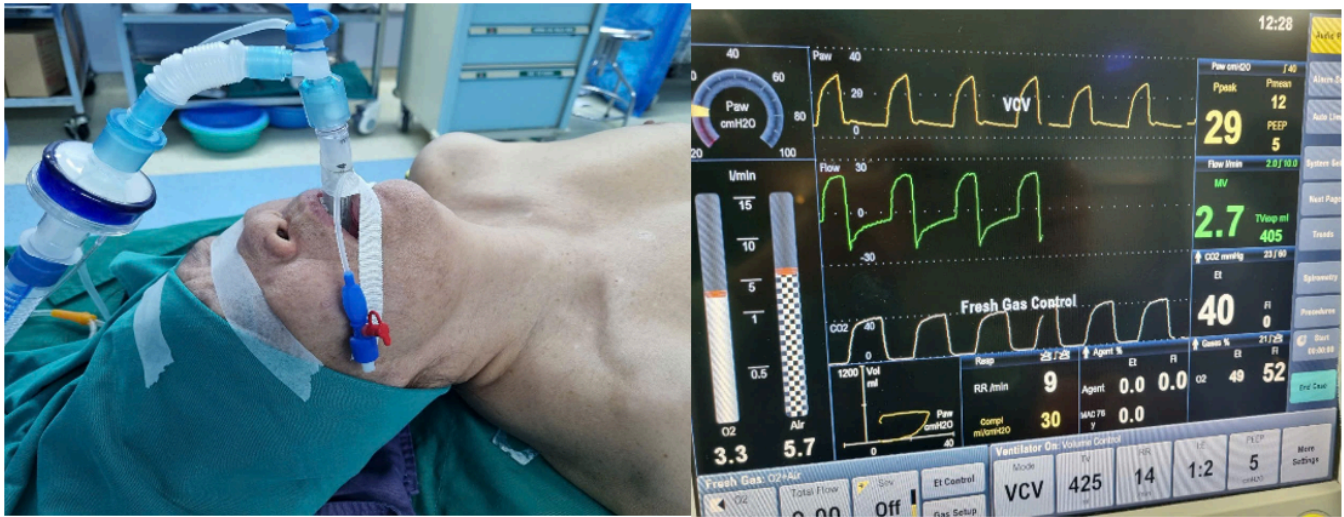


Figure 3

Patient with laryngeal mask and mechanical ventilation

(The photo was taken at the Anesthesia Department
108 Military Central Hospital.)

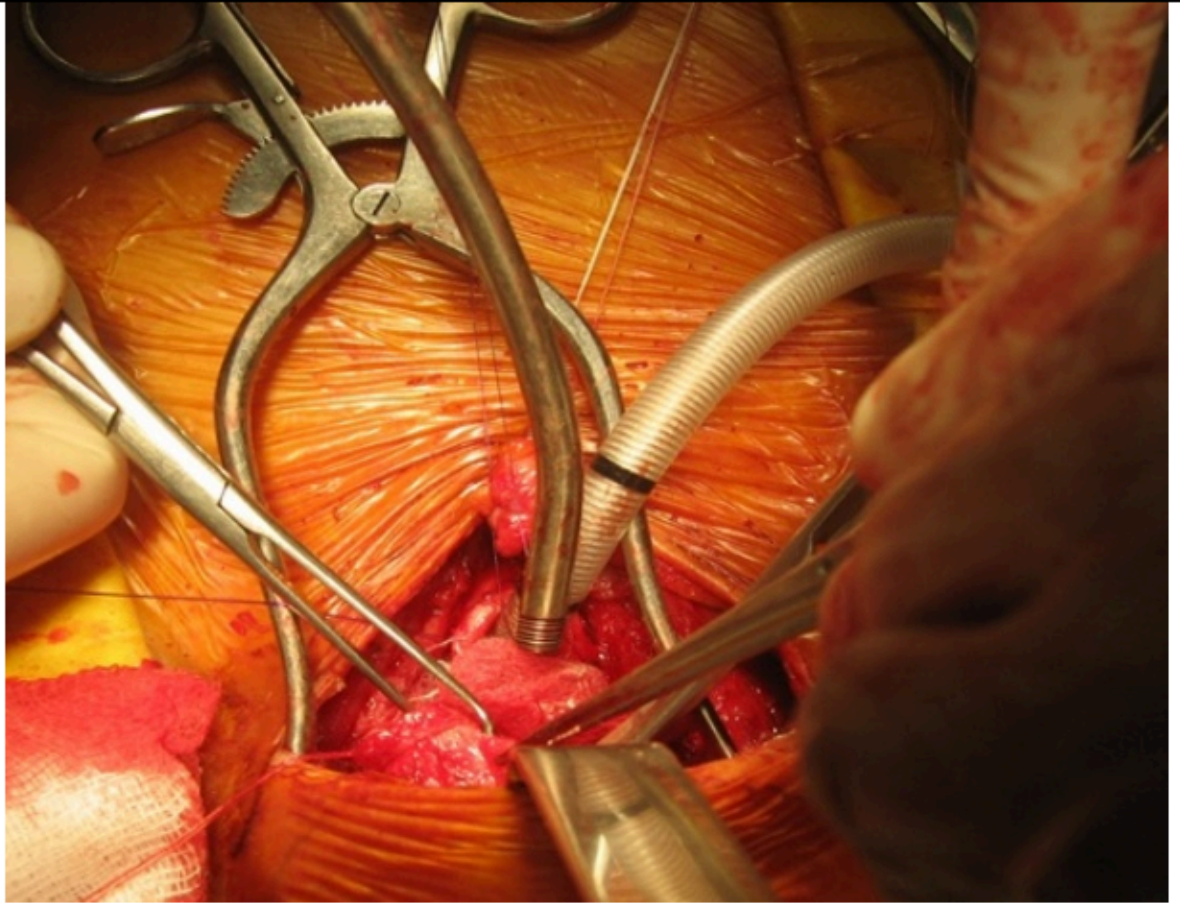


Figure 4

endotracheal tube inserted into the distal stump of trachea during surgical resection

(The photo was taken at the Anesthesia Department, 108 Military Central Hospital.)

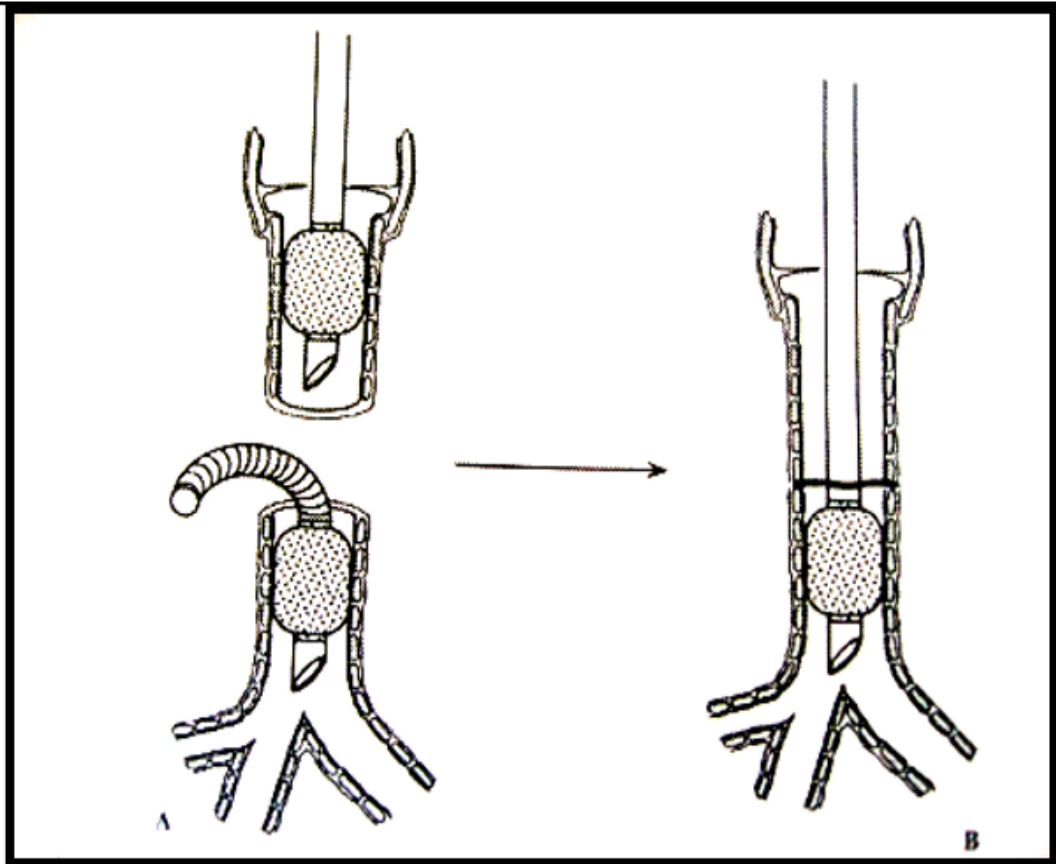


Figure 5

distal tracheal intubation and intermittent positive pressure ventilation (Sandberg⁴)

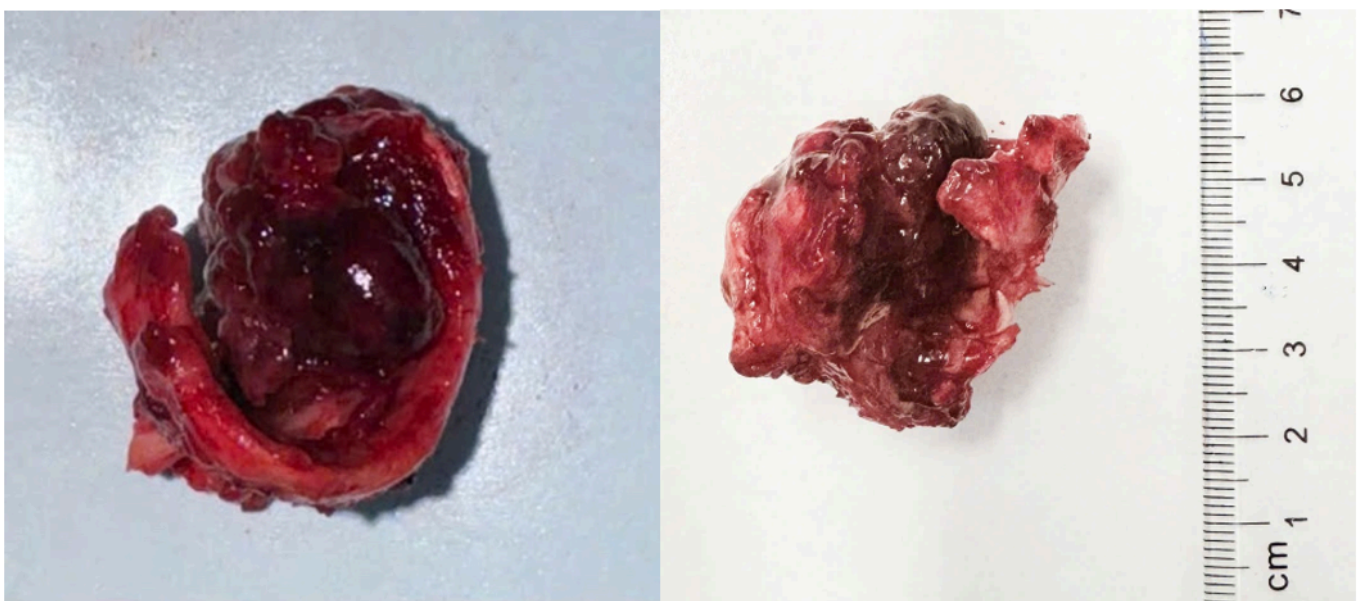


Figure 6

Tumor and trachea after resection.

(The photo was taken at the Anesthesia Department
108 Military Central Hospital.)