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Case report
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Contralateral pneumothorax: the hidden culprit in failed oxygenation during non-intubated video-assisted thoracoscopic surgery

Wan Nabilah **Nik Nabil**, Amiruddin **Nik Mohamed Kamil**, Azrin **Mohd Azidin**, **Lau** Chiew Lui

Department of Anaesthesiology and Critical Care, Hospital Kuala Lumpur, Kuala Lumpur, Malaysia

Abstract

The occurrence of contralateral pneumothorax during non-intubated video-assisted thoracoscopic surgery (NiVATS) is rare and difficult to diagnose intraoperatively due to its non-specific clinical presentations. Temporary desaturation is not uncommon in NiVATS. This report highlights a case where maintaining oxygenation proved challenging despite various remedial interventions, ranging from use of high-flow oxygen delivery to manual jet ventilation via Cook airway exchange catheter during right NiVATS for distal tracheal mass resection and reconstruction. Intermittent cross-field ventilation was employed during tumour removal and tracheal anastomosis to maintain oxygenation. Postoperative chest X-ray revealed the reason for oxygenation failure: pneumothorax on the left side. The left-side chest tube was not inserted because the patient remained asymptomatic post-extubation. The patient was discharged well on postoperative day 8. Repeated bronchoscopy at 1-month post-surgery revealed intact anastomosis. Prompt diagnosis of pneumothorax in high-risk surgeries and contingency airway plans are imperative in managing patients undergoing NiVATS to prevent airway mishaps.

Keywords: distal tracheal mass resection, non-intubated video-assisted thoracoscopic surgery, oxygenation, pneumothorax, reconstruction

Correspondence: Wan Nabilah Nik Nabil, Department of Anaesthesiology and Critical Care, Hospital Kuala Lumpur, 50586 Kuala Lumpur, Malaysia.
E-mail: nabilahnabil@yahoo.com

Introduction

Spontaneous ventilation in non-intubated video-assisted thoracoscopic surgery (NiVATS) has garnered increasing interest from anaesthesiologists, as it has been shown to result in fewer perioperative side effects compared to general anaesthesia and tracheal intubation. The technique is carried out with minimal or no muscle relaxants to maintain spontaneous respiration, which hastens recovery after surgery. Surgeons also favour this approach because it simplifies, accelerates, and tidies end-to-end tracheal anastomosis without the interference of the tracheal tube.[1,2]

NiVATS poses its own set of challenges to the anaesthesiologist: major bleeding, severe hypoxaemia, hypercapnia, excessive mediastinal and diaphragmatic shifts, and inadequate lung collapse and coughing. It is therefore crucial that the anaesthesiologist has ample experience to overcome these concerns accordingly.[2,3]

This report highlights a case of difficult oxygenation during right NiVATS for distal tracheal mass resection and reconstruction. Maintaining oxygenation proved a challenge despite various interventions, ranging from the use of high-flow oxygen delivery to manual jet ventilation via Cook airway exchange catheter. Ultimately, a postoperative chest X-ray revealed the reason for oxygenation failure: left-side pneumothorax.

Case presentation

Written informed consent was obtained from the patient. A 58-year-old female with a body mass index of 18 kg/m^2, known case of bronchial asthma and breast cancer, presented with a 6-month history of progressively worsening shortness of breath and cough. Physical examination revealed a prolonged expiratory phase upon auscultation. A computed topography (CT) scan of the chest confirmed the presence of a distal tracheal lesion located 1 cm from the carina (Fig. 1a). Bronchoscopy identified a 1-cm tumour on the lateral wall of the distal trachea obstructing 90% of the tracheal lumen (Fig. 1b). Based on the distal lesion causing 90% of tracheal obstruction, NiVATS with supraglottic airway (SGA) device was planned for the patient. Our initial airway plan for all phases of the surgery was to maintain the patient's spontaneous ventilation with high-flow oxygen 60 L/min through SGA. The surgical phases included anaesthesia induction, tracheal mobilisation and dissection, tracheal transection, tracheal anastomosis, and closure (Fig. 2).

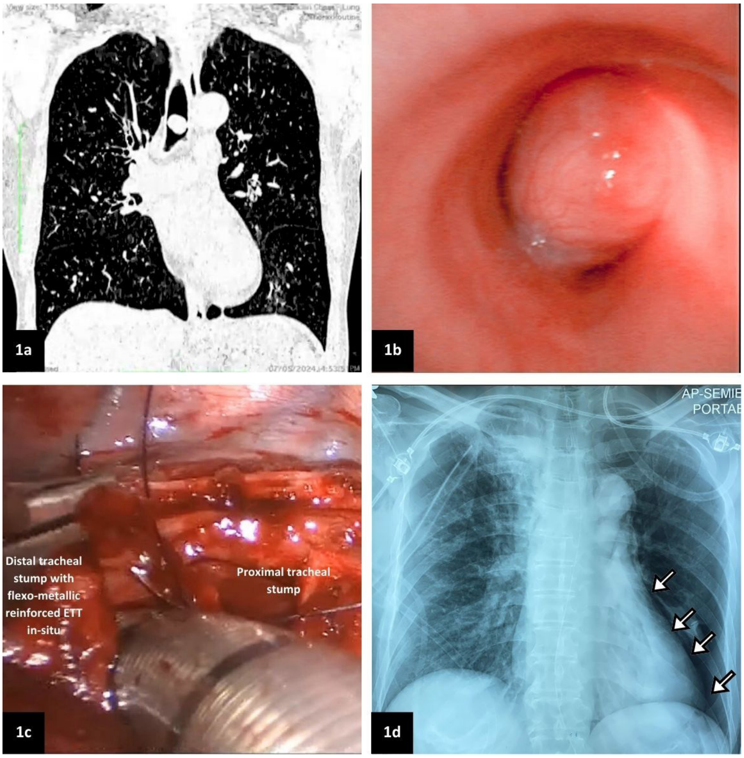

Fig. 1. (a) Computed topography image showing a pedunculated tracheal mass above the carina. *(b)* Bronchoscopic view of the tracheal mass obstructing the trachea above the carina. *(c)* Thoracoscopic view of the distal tracheal stump intubated with an flexo-metallic reinforced endotracheal tube (ETT) during cross-field ventilation. *(d)* Postoperative chest X-ray revealing a left pneumothorax (white arrow). The right chest tube is *in situ*.

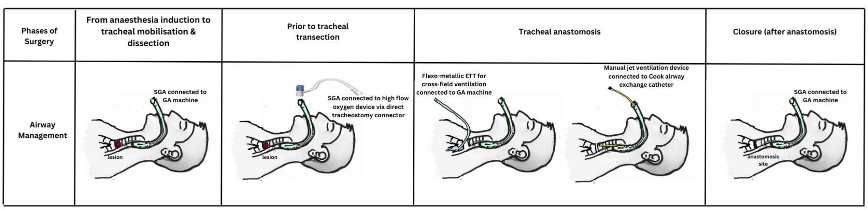

Fig. 2. Diagram illustrating the airway device used in each phase of the surgery. SGA: supraglottic airway; GA: general anaesthesia; ETT: endotracheal tube

Prior to anaesthesia induction, standard vital sign monitoring (non-invasive blood pressure, pulse rate, saturation oxygenation and capnography) was applied in the supine position and the patient was pre-oxygenated with 100% oxygen. Total intravenous anaesthesia was achieved using target-controlled infusions of propofol 1% and remifentanil using the Schnider and Minto models, respectively, aiming for a bispectral index reading between 45 to 60. A size 3 i-gel® SGA device (Intersurgical Ltd., Pabradė, Lithuania) was inserted after induction, and spontaneous ventilation was maintained with 100% oxygen at 4 L/min via a general anaesthetic (GA) machine (GE Aestiva®5, Datex Ohmeda). Target-controlled infusions of propofol 1% and remifentanil were titrated to achieve spontaneous a respiratory rate less than 10 breaths/min. An arterial line for invasive monitoring and blood gas sampling was inserted into the left radial artery. The patient was then positioned in the left lateral decubitus position for tracheal excision and reconstruction via a right uniport NiVATS.

During tracheal mobilisation and dissection and before the trachea was transected, high-flow oxygen (50–60 L/min) was delivered using an Airvo™ 2 (Fisher & Paykel Healthcare Ltd., Auckland, New Zealand) via a tracheostomy direct connection (Optiflow +, Fisher & Paykel Healthcare Ltd.) through the i-gel 15-mm connector. Despite the use of high-flow oxygen and spontaneous breathing, maintaining the patient's oxygen saturation above 88% was challenging. We then assisted the patient's breathing by providing manual intermittent positive pressure ventilation via the GA machine in spontaneous mode, with oxygen at 15 L/min, which increased her oxygen saturation levels to above 92%.

To maintain acceptable oxygenation and prevent tumour movement during bagging while performing tracheal transection and tumour removal, we employed cross-field ventilation to the distal tracheal stump by requesting the surgeon to intubate the left main bronchus with a size 6 flexo-metallic reinforced endotracheal tube (Figs. 1c and 3c). Tracheal reconstruction began once frozen section analysis confirmed no malignancy on either side of the tumour margins. We intermittently removed the endotracheal tube and selectively ventilated the appropriate bronchus to provide the surgeon access to specific areas of the trachea during reconstruction. We alternated between manual jet ventilation using a Cook airway exchange catheter and cross-field ventilation during tracheal anastomosis, as the patient desaturated easily and oxygenation was difficult to maintain during manual jet ventilation. Small boluses of intravenous atracurium (5–10 mg) were administered to facilitate ventilation during anastomosis. The patient's haemodynamic profile remained stable, with end-tidal carbon dioxide levels ranging from 60–80 mmHg and no significant increase in airway pressure throughout the surgery. After completing the tracheal anastomosis, the patient was able to breathe spontaneously and was able to maintain oxygen saturation of 98–99% *via* the i-gel.

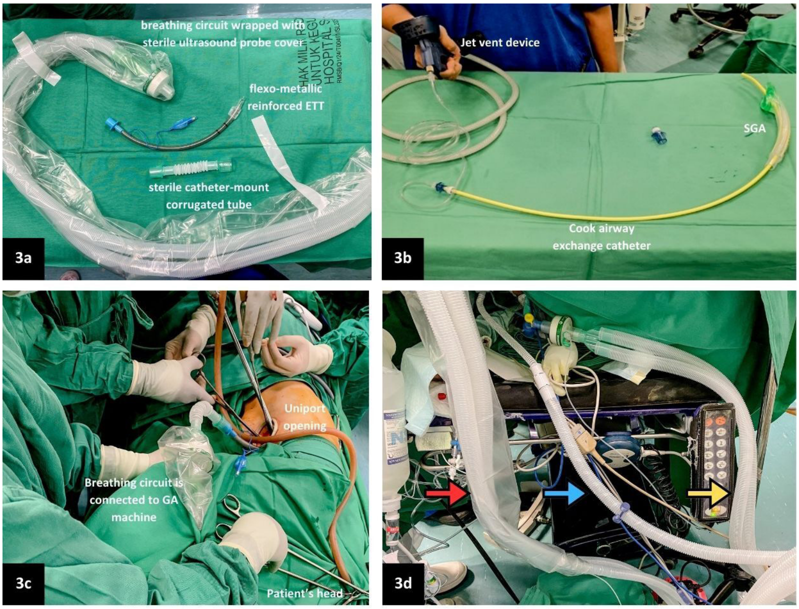

Figure 3 *(a)* The equipment for cross-field ventilation prepared by the surgical scrub team, including a flexo-metallic reinforced endotracheal tube (ETT), sterile catheter-mount corrugated tube, and a breathing circuit wrapped with a sterile ultrasound probe cover. *(b)* Preparation for manual jet ventilation using a supraglottic airway (SGA) device. The Cook airway exchange catheter is inserted through the SGA glottic opening and attached to the jet vent device. *(c)* A flexo-metallic reinforced ETT is inserted into the distal tracheal stump by the surgeon, through a uniport opening over the right chest. The sterile breathing circuit is connected to the general anaesthesia machine. *(d)* Different breathing circuit at the patient's head. Red arrow: cross-field ventilation; blue arrow: high-flow oxygen device; yellow arrow: breathing circuit to the general anaesthesia machine

The patient was extubated to a facemask with 5 L/min oxygen and transferred to the post-anaesthesia care unit for close monitoring. Postoperative chest X-ray revealed a left-side pneumothorax (Fig. 1d). No intervention was necessary as the patient remained asymptomatic, and the right chest tube was functioning well. Bronchoscopy performed on postoperative day 1 revealed a small tracheal cartilage fragment lodged in the left main bronchus. The fragment was successfully removed endoscopically. The final histological diagnosis was reported as benign hamartomatous polyp.

The patient's pain was manageable with oral analgesics during her hospital stay. She did not experience any other complications, such as dysphagia or voice changes. A repeated bronchoscopy prior to discharge on postoperative day 8 and at 1-month post-surgery showed an intact anastomosis. She stated that her functional status improved after the surgery.

Discussion

A common option for airway management during tracheal resection and reconstruction surgery typically involves endotracheal intubation, followed by cross-field ventilation during anastomosis. However, with appropriately selected patients, experienced anaesthetists, and skilled surgeons, NiVATS may offer additional benefits for tracheal resection.[1] The exclusion criteria for NiVATS patients are the following: obesity (body mass index ≥ 30 kg/m^2), anticipated difficult airway, American Society of Anesthesiologists Class 3 or higher, haemodynamic instability, elevated intracranial and pulmonary pressure, excessive airway secretions, persistent cough, risk of gastric regurgitation, and surgeries expected to last more than 5 hours. [1,3]

Over the past 3 years, our centre has successfully performed 3 NiVATS procedures out of 14 tracheal resections, with no conversions to intubation.[4,5] Based on the criteria for NiVATS, our patient was deemed a suitable candidate. More importantly, her tracheal lesion was located 1 cm from the carina and caused 90% tracheal obstruction, making NiVATS with SGA device —a tubeless technique—the best option of intraoperative airway management to facilitate the surgical procedures. The choice of airway management device is the responsibility of the attending anaesthetist, with common options including SGA device, facemask, Venturi mask, high-flow nasal cannulas, with nasal cannulas being the least favoured option.[6]

In NiVATS, desaturation is not uncommon. It can occur initially when artificial pneumothorax is introduced and later during tracheal transection and anastomosis. Oxygenation generally improves within 5 to 10 minutes after artificial pneumothorax because pulmonary mechanics are preserved without muscle relaxants, and effective contraction of the dependent hemidiaphragm during spontaneous one-lung ventilation (OLV) ensures a favourable match between ventilation and perfusion.[2]

High-flow oxygen and manual jet ventilation via an SGA device are usually appropriate remedial manoeuvres if the patient desaturates during tracheal dissection.[6] Most of the time, oxygen is effectively delivered to the distal resected trachea due to the high flow applied across it via diffusion. Notably, this case report is the first to highlight the use of high-flow oxygen via an SGA device, delivering up to 60 L/min of oxygen during NiVATS. The use of high-flow oxygen was part of our initial planning for this patient.

Our patient did not experience desaturation when artificial pneumothorax was initiated. She did subsequently desaturate during tracheal transection despite the aforementioned manoeuvres, with oxygenation remaining below 88% for long periods. Therefore, as the last resort, we had to employed intermittent selective cross-field ventilation during tumour manipulation and removal. She was able to maintain acceptable oxygen saturation levels (88–95%) beyond tumour removal stage until completion of tracheal anastomosis; her saturation exceeded 95% during the closure phase.

Contralateral pneumothorax is a rare but life-threatening complication of OLV. It can occur due to surgical or anaesthetic procedures that breach the pleura, with its incidence being even lower in spontaneously ventilating patients.[7,8] One possible explanation for the difficulty in maintaining optimal oxygenation during spontaneous OLV intraoperatively for this patient was pneumothorax of the contralateral lung. This can occur when the surgeon dissects the mediastinal pleura and accidently incises the contralateral lung pleura. The predicted ventilation/perfusion match was not achieved due to the presence of pneumothorax in the dependent lung. Apart from the clinical signs that arise from impaired respiratory mechanics (increased peak airway pressure, low tidal volume, hypoxaemia, and hypotension), it is possible for the surgeon to diagnose contralateral pneumothorax macroscopically by assessing mediastinal herniation into the non-dependent hemithorax.[9] However, as the contralateral pneumothorax was small in this patient, the sign was not noticeable. Furthermore, compared to patients with extensive thoracotomy, this sign can be harder to detect in limited views of VATS.[7]

Conclusion

Pneumothorax is always a diagnosis of exclusion during general anaesthesia due to its variable and non-specific clinical presentations. It should remain as one of the differential diagnoses for hypoxaemia in high-risk surgeries such as NiVATS. Contingency airway plans are vital in managing patients undergoing NiVATS for tracheal resection and reconstructions to prevent airway mishaps. Nevertheless, NiVATS is a feasible approach for tracheal surgery in suitable patients.

Declarations

Informed consent for publication

The patient provided informed written consent for the publication of the clinical data contained in this case report.

Competing interests

The authors declare that they have no competing interests.

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None to declare.

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