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Case Report

Use of trans-nasal humidified rapid insufflation ventilatory exchange in a post-pneumonectomy patient undergoing injection laryngoplasty: a case report

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ABSTRACT

Post-pneumonectomy patients present significant anesthetic challenges because of severely reduced pulmonary reserve, altered ventilation-perfusion relationships, and limited tolerance to apnea. Airway procedures requiring a shared field further complicate management. We describe the perioperative management of a 40 years old patient with prior left pneumonectomy who presented with hoarseness of voice secondary to left recurrent laryngeal nerve palsy caused by tumor encasement. The patient underwent injection laryngoplasty using filler material under general anesthesia with trans-nasal humidified rapid insufflation ventilatory exchange (THRIVE) as the primary oxygenation strategy. THRIVE provided effective oxygenation, a tubeless surgical field, and avoidance of positive pressure ventilation in a single-lung patient. This report highlights the physiological considerations in post-pneumonectomy patients and discusses the advantages and limitations of THRIVE compared with microlaryngeal tube ventilation, jet ventilation, and conventional apneic oxygenation.

Keywords: THRIVE, Pneumonectomy, Injection laryngoplasty, Unilateral vocal cord paralysis, Shared airway anesthesia, Apneic oxygenation

INTRODUCTION

Loss of an entire lung produces profound and permanent alterations in respiratory physiology.[1] Post pneumonectomy patients have reduced functional residual capacity (FRC), diminished total lung capacity, increased pulmonary vascular resistance, mediastinal shift, and compensatory hyperinflation of the remaining lung.[2] Oxygen reserve during apnea is significantly reduced because FRC serves as the primary oxygen reservoir during periods of hypoventilation or apnea. In addition, the single lung must accommodate total cardiac output, increasing susceptibility to ventilation–perfusion mismatch and hypoxemia.[3] Left recurrent laryngeal nerve palsy following thoracic malignancy is not uncommon; however, hoarseness as the dominant presenting symptom after tumor encasement is relatively rare and may precede overt respiratory compromise.[4] Injection laryngoplasty requires optimal visualization of the glottis and minimal interference from airway devices.[5] Traditional endotracheal intubation may obstruct the surgical field, while jet ventilation carries a risk of barotrauma in patients with a single lung. We report the successful use of THRIVE in such a high-risk physiological setting.

CASE REPORT

A 40yr old patient with a history of left pneumonectomy (Figure 1) performed for bronchogenic carcinoma presented with progressive hoarseness of voice. The tumor had previously encased the left recurrent laryngeal

nerve, resulting in unilateral vocal cord paralysis. The patient reported vocal fatigue but denied dyspnea at rest or stridor. Exercise tolerance was mildly reduced compared with preoperative baseline. On examination, oxygen saturation on room air was 97%. Breath sounds were absent over the left hemithorax, with compensatory expansion of the right chest. Airway assessment was unremarkable. Flexible laryngoscopy confirmed immobility of the left vocal cord in the paramedian position. Preoperative evaluation revealed stable hemodynamics and acceptable baseline arterial blood oxygenation. Pulmonary function tests demonstrated restrictive physiology consistent with prior pneumonectomy. After multidisciplinary discussion, the patient was scheduled for injection laryngoplasty under general anesthesia. Considering the reduced pulmonary reserve and need for an unobstructed laryngeal view, THRIVE was selected as the primary oxygenation technique.

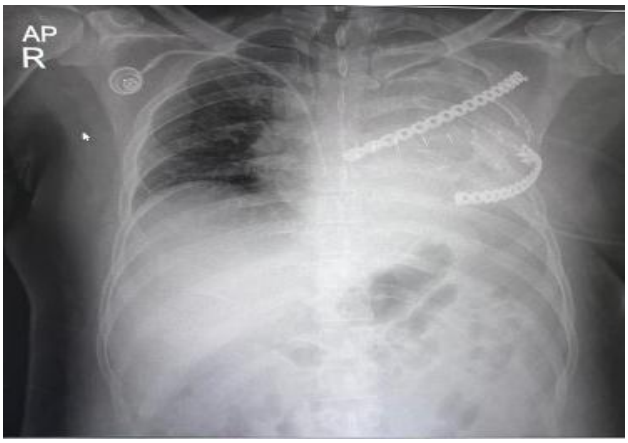

Figure 1: Post pneumonectomy status X-ray.

Diagnostic assessment

Unilateral vocal cord paralysis was confirmed using flexible laryngoscopy. The underlying cause was attributed to recurrent laryngeal nerve encasement by tumor during the previous disease course. No evidence of airway obstruction was present. The anticipated anesthetic concern centered on reduced oxygen reserve, rapid desaturation during apnea, and risk of ventilator-induced lung injury to the remaining lung. The patients' blood work was unremarkable and was taken up for proposed procedure under ASA-II.

Therapeutic intervention

In the operating room, standard monitoring was instituted. A difficult airway cart, microlaryngeal tubes, and rigid bronchoscope were kept available as backup. THRIVE was initiated using a high-flow nasal oxygen delivery system with heated and humidified oxygen (Figure 2).[6] Pre-oxygenation was commenced at 30 L/min and increased to 60 L/min with a fraction of inspired oxygen of 1.0. Intravenous induction was performed using propofol at 2 mg/kg and fentanyl as opioid at 2 mcg/kg, followed by administration of depolarizing neuromuscular blocking agent succinylcholine at 1 mg/kg. For maintenance of adequate depth propofol at 1 mg/kg/hr and dexmeditomidine bolus of 1mcg/kg over 10 minutes. Once adequate depth of anesthesia was achieved, laryngoscopy was performed without endotracheal intubation (Figure 3). THRIVE was continued at 60 L/min throughout the apneic period. The injection laryngoplasty was completed within approximately 20 minutes. Oxygen saturation remained between 98% and 100% during the procedure. Although end-tidal carbon dioxide could not be measured due to the absence of a closed circuit, the limited duration and stable hemodynamics supported acceptable ventilation-perfusion status. After completion of surgery, assisted mask ventilation was provided until spontaneous respiration resumed. The patient recovered uneventfully and was discharged after observation.

Figure 2: THRIVE.

Figure 3: Suspended laryngoscopy.

Follow-up and outcomes

Postoperatively, oxygen saturation remained stable on room air. There were no episodes of respiratory distress or desaturation. Voice quality improved significantly on

follow-up examination. No delayed pulmonary complications were observed.

DISCUSSION

Post-pneumonectomy physiology fundamentally alters anesthetic planning. Removal of one lung reduces FRC by approximately 30-50%, significantly decreasing oxygen reserve. During apnea, oxygen continues to be absorbed into the bloodstream at a rate of approximately 200-250 mL/min, while carbon dioxide accumulates more slowly because of buffering and reduced alveolar excretion.[7] In patients with intact lungs, the large FRC delays desaturation. In single-lung physiology, however, desaturation occurs rapidly once alveolar oxygen stores are depleted.[8] Furthermore, positive pressure ventilation in post-pneumonectomy patients may increase pulmonary vascular resistance and impair right ventricular function. Over distension of the remaining lung risks volutrauma and barotrauma.[9] The mediastinal shift and altered chest wall compliance further complicate ventilation strategies. THRIVE delivers heated, humidified oxygen at high flow rates, generating several physiological effects. First, apneic oxygenation maintains alveolar oxygen content through mass flow driven by the negative pressure gradient created by continuous oxygen uptake into the pulmonary circulation.[10] Second, high flow rates wash out nasopharyngeal dead space, improving effective oxygen delivery. Third, flow-dependent positive airway pressure of approximately 3-7 cm H_2O may provide mild alveolar recruitment, partially compensating for reduced FRC. Finally, although carbon dioxide elimination during apnea is limited, high flow may facilitate some degree of diffusion-mediated CO_2 clearance. Compared with microlaryngeal tube intubation, THRIVE avoids obstruction of the surgical field and eliminates the need for intermittent removal of the tube.[11] In a single-lung patient, it also reduces exposure to positive pressure ventilation, potentially minimizing lung injury. Jet ventilation, while providing a tubeless field, introduces significant risk of barotrauma, air trapping, and pneumothorax-complications that would be catastrophic in a post-pneumonectomy setting.[12] Conventional low-flow apneic oxygenation lacks humidification, provides no meaningful PEEP effect, and may not sustain oxygenation for adequate duration in patients with reduced FRC.[13] Despite its advantages, THRIVE has limitations. Progressive hypercapnia is inevitable during apnea, with carbon dioxide levels rising approximately 1-3 mmHg per minute. The technique is therefore best suited for short procedures <30 minutes duration.[14] Continuous capnography is not feasible without airway instrumentation. Additionally, THRIVE depends on a patent upper airway and is contraindicated in cases of complete obstruction, in procedures involving airway lasers, high inspired oxygen concentrations increase fire risk. Alternative strategies could have included awake fiberoptic intubation with a small-caliber microlaryngeal tube, maintenance of spontaneous respiration under total intravenous anesthesia, or cautious use of high-frequency jet ventilation.[15] However, each of these approaches carries specific disadvantages in the context of single-lung physiology and shared airway requirements. This case demonstrates that THRIVE can safely extend the apneic window and maintain oxygenation even in patients with markedly reduced pulmonary reserve, provided that procedure duration is limited and contingency plans are in place.

CONCLUSION

This case highlights the feasibility of using THRIVE as a primary oxygenation strategy in a post-pneumonectomy patient undergoing shared airway surgery. Despite reduced pulmonary reserve and an anticipated risk of rapid desaturation, THRIVE enabled effective maintenance of oxygenation while providing a completely unobstructed surgical field and avoiding the potential harms of positive pressure ventilation to the solitary lung. Careful patient selection, thorough preoperative assessment, strict limitation of apneic duration, and readiness with backup airway and ventilation strategies were critical to success. Although progressive hypercapnia and lack of continuous capnographic monitoring remain inherent limitations, this experience supports the role of THRIVE as a valuable alternative to conventional techniques in short-duration airway procedures, particularly in high-risk single-lung physiology where minimizing ventilatory stress is essential.

The patient reported satisfaction with the perioperative experience and significant improvement in voice quality without respiratory complications.

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