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Anesthesia Management of Severe Hypoxemia During Total Arch Replacement for Acute Aortic Dissection: A Case Report

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Abstract

Background: Acute aortic dissection poses a life-threatening condition that typically necessitates immediate surgical intervention, such as total arch replacement. However, hypoxemia is a severe complication in such surgeries, potentially resulting in organ dysfunction, prolonged hospital stays, and even mortality. Hypoxemia presents significant challenges to anesthesiologists. Through this case, we can enhance our comprehension of anesthetic management for total arch replacement.

Case presentation: A 43-year-old man with acute type A aortic dissection underwent total arch replacement. After a smooth surgery, severe hypoxemia occurred during weaning off cardiopulmonary bypass. Initial interventions, including airway suction and recruitment maneuvers, failed to improve oxygenation. Further investigations found left lung atelectasis and pleural effusion on transesophageal echocardiography, with minimal improvement after drainage. Fiberoptic bronchoscopy revealed extensive tenacious secretions occluding the airways. Conventional suctioning was ineffective due to high sputum viscosity. Ultimately, techniques including pulmonary lavage, bronchoscopic suctioning, and repeated lung recruitment controlled the refractory hypoxemia. The patient recovered after treatment in the intensive care unit.

Conclusions: It is worth noting that our case highlights the challenges posed by severe hypoxemia during total arch replacement surgery. The successful management of this complication underscores the importance of a multidisciplinary approach and close monitoring during the perioperative period. Individualized anesthetic management plays a critical role in addressing severe hypoxemia during total arch replacement surgery.

Keywords

Aortic Dissection, Total Arch Replacement, Hypoxemia, General Anesthesia, Case Report

Abbreviations

AD: Aortic Dissection; ARDS: Acute Respiratory Distress Syndrome; CPB: Cardiopulmonary Bypass; CTA: Computed Tomography Angiography; ABG: Arterial Blood Gas Analysis; TEE: Transesophageal Echocardiography; ICU: Intensive Care Unit; MODS: Multiple Organ Dysfunction Syndrome; PEEP: Positive End-Expiratory Pressure

Introduction

Aortic dissection (AD) is a life-threatening condition that poses substantial risks to patients, including inadequate circulation to vital organs, stroke, acute respiratory distress syndrome (ARDS), cardiac arrest, and aortic rupture [1]. Consequently, urgent surgical intervention is often imperative. Total aortic arch replacement represents one of the main surgical procedures used to treat this condition [2]. However, hypoxemia is a critical complication of cardiac surgery that can result in challenges in weaning off cardiopulmonary bypass (CPB) and other major complications, such as organ dysfunction, prolonged hospitalization, and even mortality [3].

The causes of hypoxia are diverse. In this case report, we describe a scenario where a patient experienced challenging intraoperative hypoxemia without pre-existing pulmonary conditions. The elusive factors often complicate diagnostic pathways. However, we ultimately identified and corrected the hypoxemia through systematic and thorough investigation.

Case presentation

A 43-year-old man (168 cm, 80 kg) presented with chest pain lasting over 10 hours and a single episode of syncope. On admission, his vital signs were as follows: blood pressure 102/65 mmHg, heart rate 85 beats/min, respiratory rate 20 breaths/min, pulse oximetry 95% in room air, and temperature 36° C. Bilateral lung auscultation revealed clear breathing sounds without rales. Computed Tomography Angiography (CTA) indicated aortic dissection involving the aortic arch, ascending aorta, cephalic trunk, and left common carotid artery from its origin. Chest CT showed scattered inflammation in the lower lobes of both lungs (**Fig-1**).

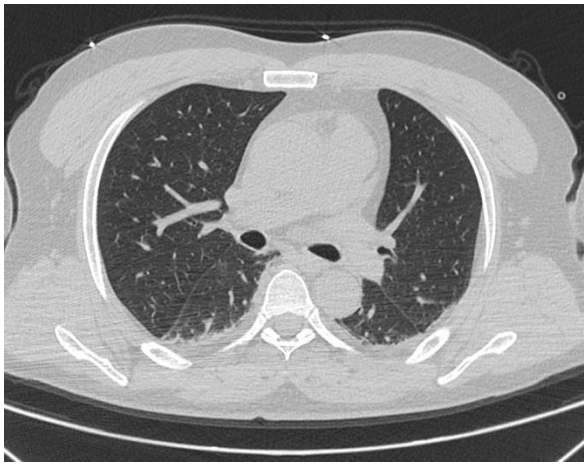

Fig-1:

Chest CT showing scattered inflammation in the lower lobes of both lungs.

The electrocardiogram was normal, and echocardiography detected a widened aorta with an intimal tear at the aortic root. The patient had a history of hypertension, managed with amlodipine. Following the diagnosis of acute type A dissection, immediate interventions were implemented, including oxygenation, analgesia, and blood pressure control. Subsequently, a total arch replacement under CPB was performed.

Intraoperatively, the patient received 6 L/min oxygen through a face mask. Invasive arterial pressure monitoring showed blood pressure 100/70 mmHg, heart rate 84 beats/min. Arterial blood gas analysis (ABG) showed: pH 7.327, PCO_2 48.4 mmHg, PO_2 106.1 mmHg, Hb 124.3 g/L. Anesthesia was induced conventionally with sufentanil (100 ug), vecuronium bromide (8 mg), midazolam (3 mg), and etomidate (4 mg). Sevoflurane, propofol, remifentanil, and vecuronium maintained anesthesia. Aortic arch replacement surgery was successful under CPB.

However, when CPB flow was reduced to 1 L/min, the patient developed hypoxemia with oxygen saturation dropping to 85% despite 100% oxygen, preventing CPB weaning off. The patient had no pre-existing respiratory diseases and no high-risk factors such as smoking, advanced age, or obesity. Transesophageal echocardiography (TEE) excluded surgical complications like pneumothorax or diaphragm injury but detected left lung atelectasis and minimal left pleural effusion (**Fig-2**). The surgeon promptly aspirated the effusion.

Simultaneously, we performed endotracheal suctioning, easily inserting the catheter with minimal yellow sputum retrieved, ruling out airway obstruction. Subsequently, the ventilator settings were adjusted to implement a lung-protective ventilation strategy. After lung recruitment maneuvers, another attempt was made to wean off CPB, yet oxygenation

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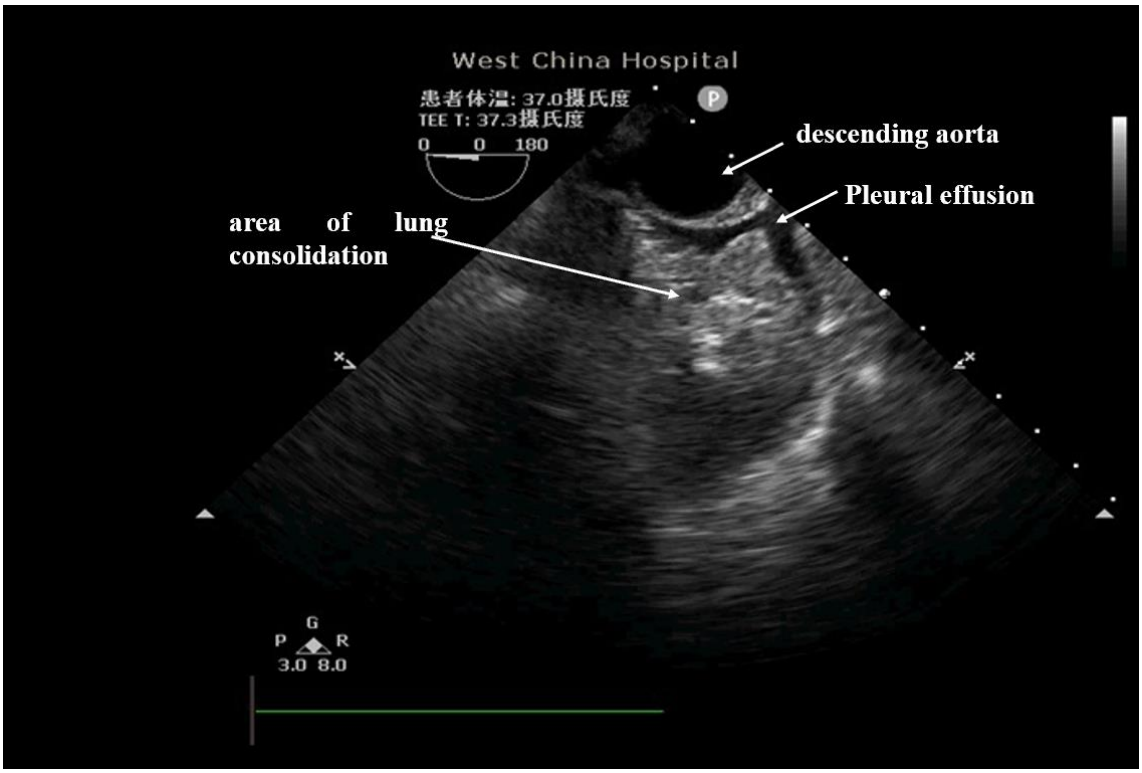

Fig-2:

TEE showing a solid area of significant pulmonary atelectasis was detected in the patient's left lung that had lost all respiratory mobility, accompanied by pleural effusion.

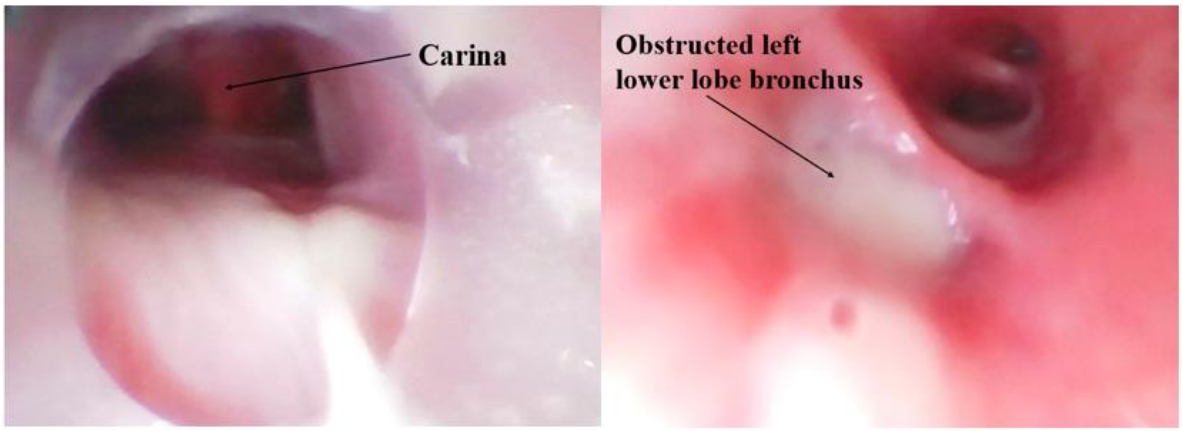

Fig-3:

Bronchoscopy showing a substantial amount of viscous yellow secretion adhered to the tracheal wall in the main airway and bilateral bronchi, with complete occlusion of the opening of the left lower bronchial lobe by secretion.

did not significantly improve despite these efforts. After ruling out anesthesia machine and monitor malfunction, as well as any issues with the breathing circuit, ABG showed: pH 7.388, $PaCO_2$ 38.5 mmHg, PaO_2 62.4 mmHg, and Hb 104.4 g/L.

Throughout this period, the patient's blood pressure remained normal, excluding the possibilities of shock or anemia. Upon re-evaluation with TEE, there was no notable improvement observed in the left lung atelectasis. Subsequent fiberoptic bronchoscopy revealed extensive yellow viscous secretions adhering to the airways, completely obstructing the opening of the left lower lobe bronchus (**Fig-3**). Bronchoscopic suctioning proved challenging due to the tenacious secretions, causing repeated blockages of the fiberoptic bronchoscope (**Fig-4**).

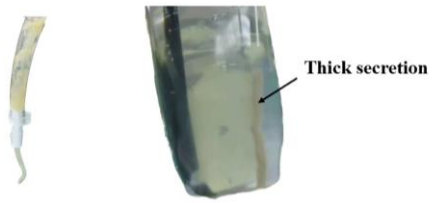

Fig-4:

The secretion in this patient was large, sticky, and difficult to remove. And a long column of solid secretion clogging the bronchoscope.

Bronchial washing with suctioning then extracted significant viscous secretions. After recruitment maneuvers, oxygenation gradually improved, and the patient was successfully weaned off CPB. The patient was transferred to the intensive care unit (ICU) postoperatively.

In the ICU, ventilator support and upgraded antibiotics were provided. Further bronchoscopy showed residual thick sputum, from which Klebsiella pneumoniae and carbapenem-resistant Acinetobacter baumannii were cultured. Continued anti-infective therapy was administered, with tigecycline added to the treatment regimen. On postoperative day 4, the endotracheal tube was removed, and noninvasive ventilation initiated. The patient was weaned off ventilation on day 6 and discharged from the hospital on day 12.

Discussion

Aortic dissection patients face a heightened risk of perioperative pulmonary complications, including progressive intraoperative lung injury and infection. Various factors contribute to intraoperative lung injury in these patients. The disruption of blood flow to the lungs during surgery stands out as a potential cause, leading to reduced oxygenation and subsequent lung damage. Additionally, manipulation of the aorta and surrounding structures during the procedure can induce inflammation and edema, further compromising lung function. The use of cardiopulmonary bypass during total arch replacement also contributes to lung injury, causing systemic inflammatory response and oxidative stress [4].

Patients with aortic dissection, mandated to bed rest, are prone to pulmonary infections. Despite the seemingly adequate condition of the patient's lungs pre-surgery, the systemic response to aortic dissection results in progressive lung injury and infection, culminating in severe hypoxemia. The incidence of ARDS during the perioperative phase of type A aortic dissection is reported at 15.9% [5]. Severe hypoxemia, compared to patients without pulmonary complications, poses significant risks, including higher postoperative incidences of heart failure, pulmonary infections, multiple organ dysfunction syndrome (MODS), and elevated hospital mortality rates [6].

Therefore, individually tailored therapies targeting these specific causes are crucial for effectively managing high-risk aortic dissection surgery and reducing the risk of lung injury.

Due to the obstruction of the airways by viscous secretions, hypoxemia often occurs unnoticed. Prevention is superior to treatment, and preventive measures include inhibiting inflammatory responses and implementing protective ventilation strategies. Patients with aortic dissection exhibit severe systemic inflammation, mitigated through strategies involving glucocorticoids, aprotinin, anticytokine antibodies, optimized CPB circuits, and specialized leukocyte filters [7]. Additionally, implementing lung-protective ventilation strategies with low tidal volumes, lower drive pressures, and positive end-expiratory pressure (PEEP) prevents further lung injury, improves oxygenation, and reduces postoperative pulmonary complications [8].

For patients with thick, tenacious secretions, routine suctioning alone may be inadequate. Extra techniques like bronchial washing should be used when necessary, as demonstrated in this case. Airway humidification is equally important, as reduced humidity from artificial airways and prolonged bedrest exacerbate secretion viscosity and infection risk in these patients. Timely expectoration facilitated by humidification maintains a patent, obstruction-free respiratory tract [9].

Diagnosing hypoxemia in this case was complex, with the cause ultimately identified by TEE and fiberoptic bronchoscopy. Despite multiple

interventions, including pleural effusion drainage, endotracheal suctioning, protective ventilation, and recruitment maneuvers, hypoxemia persisted. Fiberoptic bronchoscopy finally revealed a sputum-occluded bronchus. Moreover, the sputum viscosity impeded aspiration using routine suctioning, further challenging hypoxemia correction. In this case, bronchoscopy and bronchial washing were crucial for diagnosis and treatment. Bronchial washing is a procedure in which fluid is injected to dilute and remove sputum, helping to clear the airways and improve breathing and oxygen levels [10]. Thus, hypoxemia diagnosis and management require comprehensive patient examination and assessment, with individualized treatment plans tailored to the specific situation.

Conclusion

In conclusion, aortic dissection patients undergoing total arch replacement are at risk of developing profound hypoxemia, despite minimal preoperative pulmonary abnormalities. Anesthesiologists should closely monitor oxygenation levels and perform dynamic respiratory evaluations to anticipate and mitigate any acute postoperative lung injury. Early initiation of lung protection, airway humidification, and secretion management is recommended. Individually tailored therapies that target the underlying cause are essential for safely managing high-risk aortic dissection surgery.

Availability of Data and Materials

All data generated or analyzed during this study are included in this published article and its supplementary information files.

Authors' Contributions

LQ collected the patient initial data and drafted the manuscript; HBL completed the anesthesia management and editing; YJZ review and editing. All authors have read and approved the final manuscript.

Consent for Publication

Written informed consent was obtained from the patient for publication of this article and any accompanying images.

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Competing Interests

The authors declare that they have no competing interests.

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