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Vanishing Bronchus After Lung Transplantation: The Role of Sequential Airway Dilatations

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Background: Airway complications after lung transplant play an important role in patient survival. Early recognition and treatment of these complications are necessary to help ensure that patients who receive lung transplants have good outcomes.
Case Report: A 61-year-old female with a history of pulmonary venous occlusive disease presented to our hospital for a double-lung transplant. Her postoperative course was complicated by severe primary graft dysfunction. Airway examination showed significant mucosal ischemia distal to the anastomosis bilaterally with diffuse narrowing of all distal bronchial segments. Repeat bronchoscopies with debridement of necrotic material and balloon dilatation of stenotic airways were performed to maintain airway patency.
Conclusion: Post–lung transplant airway necrosis and stenosis mandate early identification and treatment. Repetitive bronchoscopies with sequential balloon dilatations are mandatory to prevent future airway stenosis and airway vanishing.

Keywords: *Airway management, bronchi, lung transplantation, necrosis*

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INTRODUCTION

Airway complications (ACs) after lung transplant play an important role in survival.[1] Although adjustments to anastomosis surgical techniques and the development of new immunosuppressive regimens have reduced ACs and improved the outcomes of patients after lung transplant, ACs can present as bronchial stenosis, anastomosis dehiscence, bronchial fistulas, bronchomalacia, granulation tissue formation, and endobronchial infections.[2] Repetitive bronchoscopy with airway assessment is required for early detection and treatment of post–lung transplant ACs.[3]

CASE REPORT

A 61-year-old female with a history of pulmonary venous occlusive disease underwent double-lung transplant. Her intraoperative course was complicated by a significant amount of bleeding requiring multiple blood transfusions and prolonged time on cardiopulmonary bypass. Following the sternum closure, she had severe primary graft dysfunction with refractory hypoxemia and hemodynamic instability requiring support with centrally accessed venoarterial extracorporeal membrane oxygenation (ECMO). She was weaned from ECMO on postoperative day 3; however, she continued to require significant support with mechanical ventilation.

Ten days posttransplant, an airway assessment was performed with flexible bronchoscopy under general anesthesia. Bilateral main stem bronchi anastomoses appeared well healed with no evidence of stenosis or dehiscence at the level of the anastomosis. However, on the scale of airway mucosal necrosis, a diffuse grade IV ischemic mucosal necrosis[4] was seen distal to the anastomosis bilaterally with significant airway stenosis throughout the bronchial tree below the level of anastomosis (Figure 1). Airway mucosal necrosis is graded by the depth and the size of the necrotic area from grades I to IV (Table). The patient's ischemic and stenotic airway changes were worse on the right side. The necrotic areas diffusely involved the right upper lobe, bronchus intermedius, right middle lobe, and right lower lobe segments (Figure 2).

A multimodal technique was used to adequately debride the necrotic tissue that included scraping off the necrotic material with the tip of the bronchoscope and using suction with multiple saline bronchial washings. Mechanical debridement with forceps was also performed to clean the airways and remove necrotic tissue.

Significant narrowing was found in the lumen of the second and third airway bifurcations distal to the anastomosis. Multiple balloon dilatations were performed to improve the airway lumen and to enable more tissue debridement distal to the airway narrowing. Fogarty balloons (Nos. 4 and 5) were initially used to achieve the lumen and to minimize airway tears. The Fogarty balloon dilatation facilitated further balloon dilatations with a 3-cm-length, 8-9-10–mm diameter, and 3-5.5-9–atm controlled radial expansion (CRE) balloon dilator (Boston Scientific Corporation).

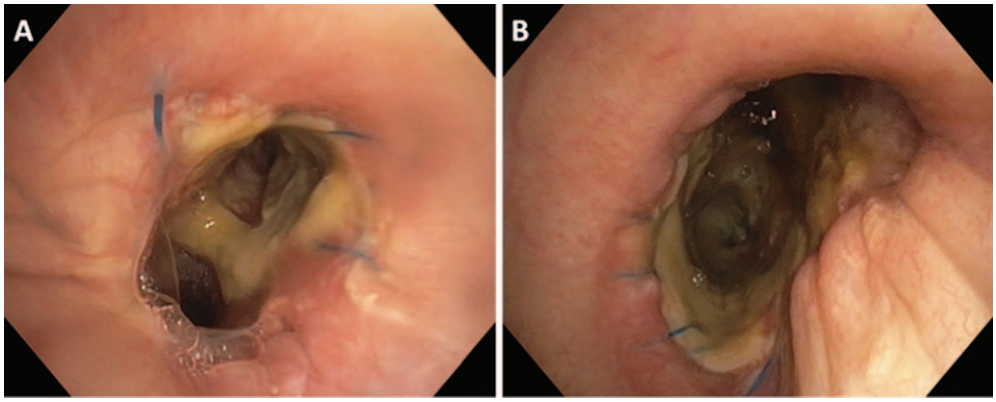

Figure 1. Significant ischemic mucosal necrosis was observed distal to the anastomosis bilaterally in the left main stem (A) and right main stem (B). (A color version of this photograph is available online at www.ochsnerjournal.org/toc/ochs/17/1 in the Focus on Transplantation section.)

Table. Airway Mucosal Necrosis Grading Scale

Grade	Airway Mucosal Changes
I	No slough or necrosis reported; anastomosis healing well
II	Any necrotic mucosal slough reported, but no bronchial wall necrosis
III	Bronchial wall necrosis within 2 cm of anastomosis
IV	Extensive bronchial wall necrosis extending 2 cm from anastomosis

CRE balloon dilatations were performed in all the segments of the right upper lobe, right middle lobe, superior segment of the right lower lobe, and lingular segments. The balloon was inflated 3 times for a 30-second duration in each segment with sequentially higher pressures starting at 1-2 atm up to a maximum of 3 atm, which corresponded to a diameter of 8 mm. A careful transballoon bronchoscopic vision of the airway was performed to look for any airway tearing or bleeding. After the procedure, the airway lumen size had improved considerably (Figure 3).

Flexible bronchoscopies with debridement of necrotic tissue and repetitive balloon dilatations were performed at regular 1- to 3-week intervals for a total of 10 procedures. Mucosal necrosis and airway patency significantly improved with each subsequent intervention (Figure 4A and 4B).

Airways previously narrowed at the level of the right upper lobe (apical and posterior segments), right lower lobe, and left upper lobe (lingula) remained patent and stable 10 months after the transplant; hence no further balloon dilatations were necessary. However, significant stenosis with complete obliteration of the anterior segment of the right upper lobe was noted, and an airway lumen could not be safely established. In addition, a dense fibrotic stricture developed at the level of the right middle lobe bronchus. More aggressive dilatations at a higher pressure of 9 atm, corresponding to a 10-mm balloon diameter, were applied at this level for a longer time of 60 seconds to achieve better airway patency. Eventually, deployment of a 7 $\times$ 16-mm iCAST (Atrium) balloon-expandable covered stent in the right middle lobe bronchus was necessary to help stabilize the airway lumen because of the recurrent strictures (Figure 4C). This particular stent was chosen because of its size and the ability for deployment in a small airway such as the right middle lobe. The iCAST stent was deployed by a flexible bronchoscope through the working channel. Using the flexible bronchoscope allowed the stent to be placed under direct vision with the balloon-expanding technique.

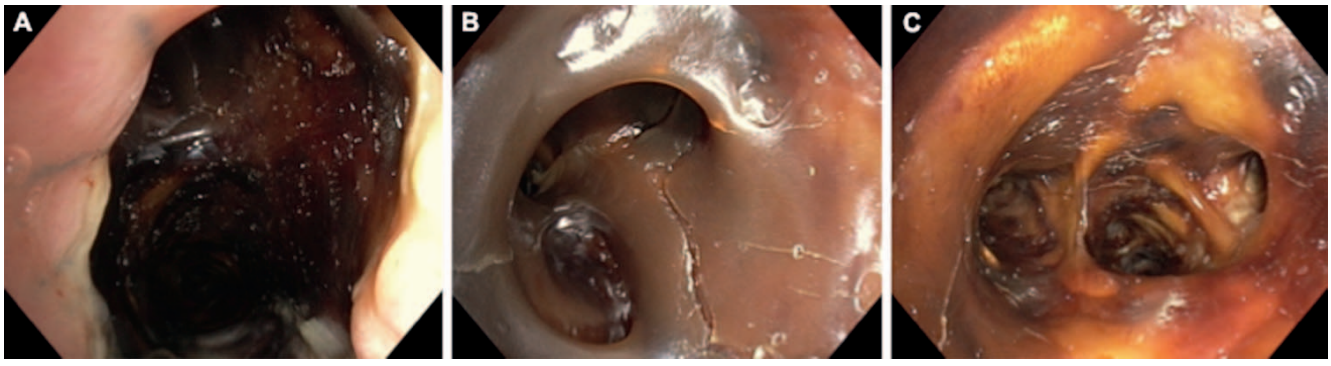

Figure 2. A. Bronchoscopic view of intact right main stem anastomosis with significant distal mucosal necrosis. B. Ischemic mucosal necrosis with thick overlying debris at the level of the right upper lobe. C. Mucosal ischemia extending distally at the level of the bronchus intermedius, the right middle lobe, and the right lower lobe segments. (A color version of this photograph is available online at www.ochsnerjournal.org/toc/ochs/17/1 in the Focus on Transplantation section.)

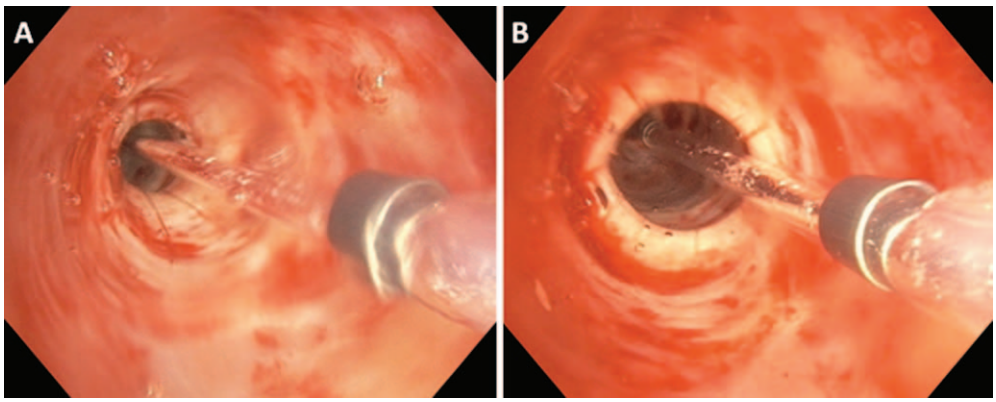

Figure 3. Transballoon bronchoscopic view of the right middle lobe with sequential CRE balloon dilation at 1 atm (A) and 3 atm (B) shows improvement in the lumen size with no evidence of airway tear. CRE, controlled radial expansion. (A color version of this photograph is available online at www.ochsnerjournal.org/toc/ochs/17/1 in the Focus on Transplantation section.)

Our patient had significant mucosal ischemia in the setting of hypoperfusion that progressed into diffuse postanastomotic airway strictures. Left untreated, this complication would have led to significant narrowing and even loss of distal airways.

The patient reported significant improvement in her symptoms and was successfully discharged from the hospital on postoperative day 66. She was followed up according to our posttransplant protocol for lung transplant bronchoscopy surveillance. Her spirometry reading showed progressive improvement in FEV_1 (forced expiratory volume in the first second of expiration) from 1.1 L to a peak of 1.88 L. Given the patient's stable-to-improved lung function and absence of respiratory symptoms, the treatment team decided to suspend further airway examinations unless the patient became symptomatic. The patient is followed by the lung transplant team and has not had any recent hospital admissions.

DISCUSSION

ACs secondary to ischemia of the donor bronchus are a well-recognized complication in lung transplantation and are a cause of morbidity and mortality in patients who receive a lung transplant.[3] Bronchial anastomosis in lung transplantation is devoid of direct blood supply, and in the absence of bronchial arterial revascularization, airway viability of the donor organ relies on the retrograde low blood flow from the poorly oxygenated pulmonary circulation.[5] Systemic revascularization of the bronchial circulation through collaterals typically takes 3-4 weeks; during this period, the risk for airway ischemia and necrosis is considerable.[6,7] Other factors, such as reperfusion edema, rejection, immunosuppressant therapy, infections, and inadequate organ preservation, have also been identified as risk factors for ischemia and airway necrosis beyond the anastomosis area.[3,5] The clinical presentation of ischemic airways may include respiratory insufficiency, bronchopleural fistulas, pneumothorax, and hemodynamic collapse. Different surgical techniques have been used to prevent dehiscence, such as shortening the donor bronchus, securing the anastomosis with a vascularized tissue (omental wrap or intercostal muscle), bronchial intussusception, and bronchial artery revascularization.[4]

Anastomosis ischemia can be worsened by prolonged ventilation and high positive end-expiratory pressure. The positive pressure can add mechanical stress at the

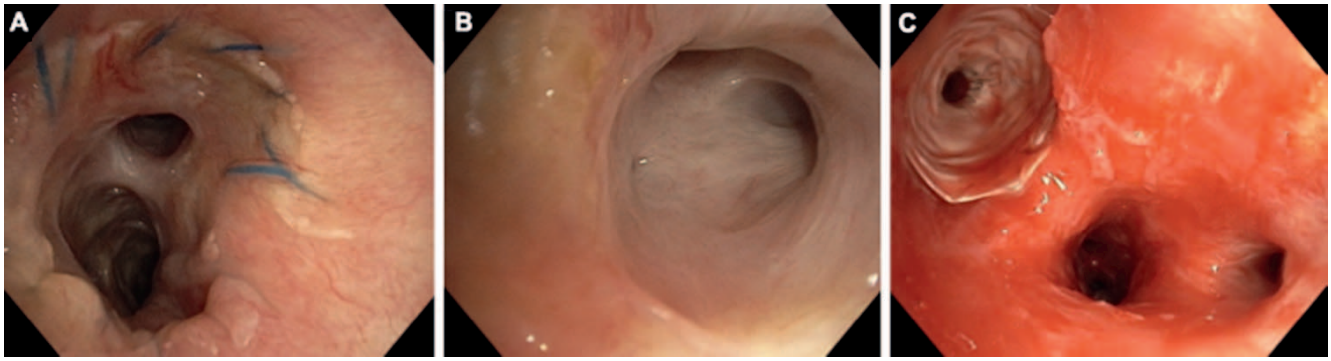

Figure 4. A. Bronchoscopic view of a well-healed right main stem anastomosis at 3 months posttransplant with significant improvement in distal mucosal necrosis. B. Right upper lobe segments at 3 months posttransplant show significant improvement of mucosal ischemia and patent airway lumen with mild stenosis. C. Bronchus intermedius at 3 months posttransplant with patent right lower lobe airways after iCAST stent (7 × 16 mm) deployment in the right middle lobe. (A color version of this photograph is available online at www.ochsnerjournal.org/toc/ochs/17/1 in the Focus on Transplantation section.)

anastomosis site and the bronchial wall, reduce the perfusion pressure, and increase the edema. The incidence of ACs is doubled in patients with prolonged mechanical ventilation (>7 days).[7]

Our patient had a complicated perioperative course (Figure 5) with significant intraoperative blood loss that mandated blood transfusion. The patient was also placed on ECMO for 72 hours and required prolonged mechanical ventilation through a tracheostomy tube for 51 days after lung transplantation. The tracheostomy tube was successfully decannulated 2 months after transplantation. Along with this complicated course, the patient experienced diffuse grade IV ischemic mucosal necrosis. This severe airway necrosis can lead to significant airway narrowing and airway vanishing because of scarring during the healing process.[8] The vanishing bronchus intermedius syndrome has been described in post–lung transplant patients.[9] Airway necrosis complicated with airway narrowing mandates intervention with bronchoscopy and sequential pneumatic balloon dilatations,[10] and temporary airway stent

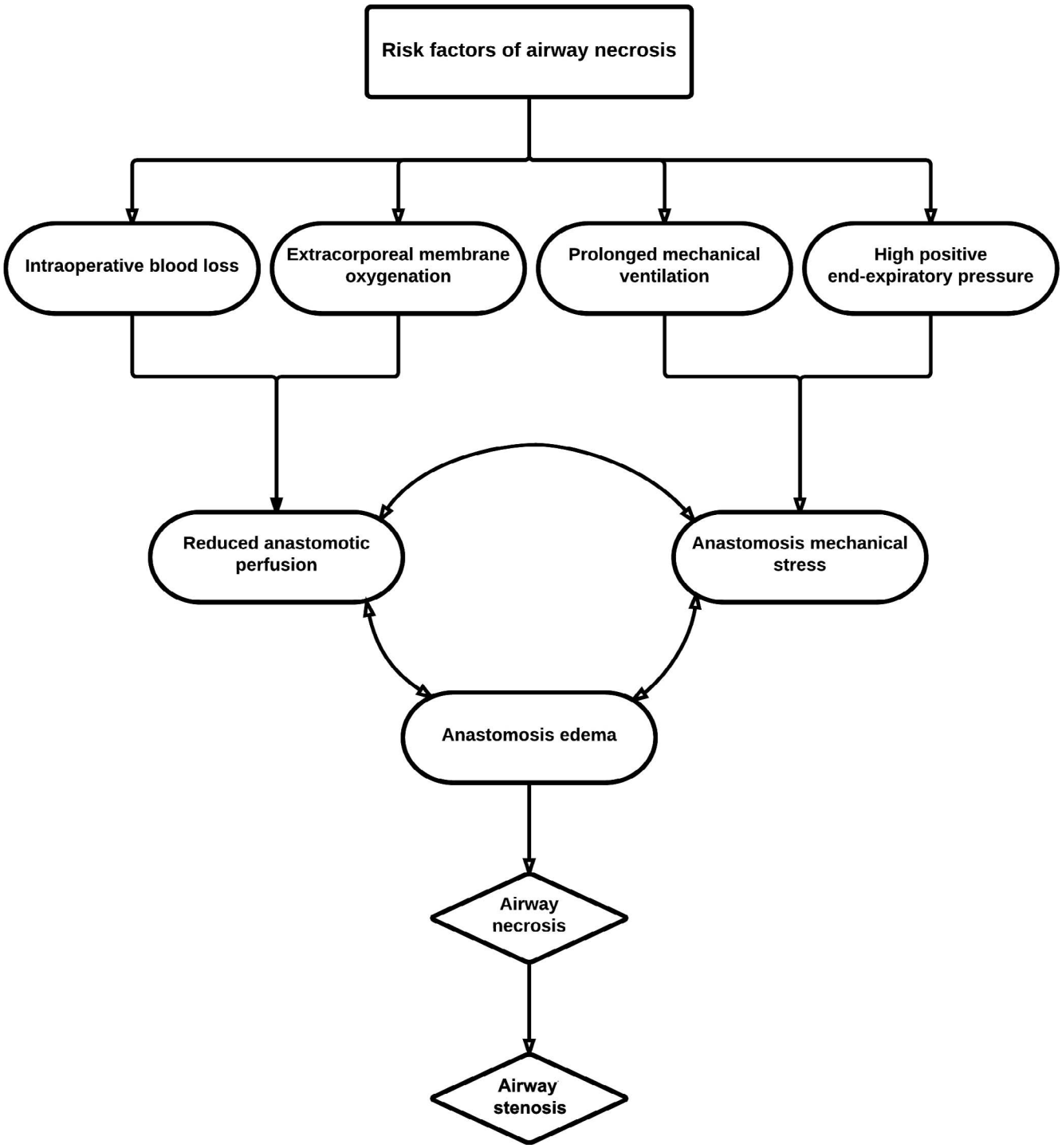

Figure 5. Risk factors that promoted airway necrosis and stenosis post–lung transplant in this case.

deployment is indicated in some cases to keep the airway patent.[11,12] Postintervention surveillance bronchoscopy has shown considerable improvement in the diameter of the narrowed airways compared to baseline bronchoscopy.[13]

CONCLUSION

Post–lung transplant ACs are serious conditions that can influence patient outcomes and require early identification and airway intervention. Repetitive bronchoscopies with sequential balloon dilatations are mandatory to prevent future airway stenosis and airway vanishing.

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