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Respiratory Support with Veno-Venous Extracorporeal Membrane Oxygenation during Stenting of Tracheobronchomalacia

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Abstract

A subset of patients with severe airway disease cannot be adequately supported with conventional mechanical ventilation during complex airway procedures. We report the first successful respiratory support of a patient with severe tracheobronchomalacia with veno-venous extracorporeal membrane oxygenation during rigid bronchoscopy with stent removal and stent placement.

INTRODUCTION

Tracheobronchial stenting via rigid bronchoscopy is a common intervention for patients with tracheobronchomalacia (TBM). [1] Although airway collapse is a problem in patients with TBM, [2] adequate respiratory function can usually be supported with jet ventilation. [1] However, in some patients with severe TBM, airway collapse may prohibitively limit the ability to oxygenate and ventilate patients undergoing complex tracheobronchial intervention. [3] We report a case of severe TBM requiring the use of veno-venous extracorporeal membrane oxygenation (VV-ECMO) to provide adequate respiratory support during rigid bronchoscopy.

CASE REPORT

A 36-year-old woman with severe TBM, 6 months status post tracheobronchial metallic stent placement at a different institution presented with increasing dyspnea. Bronchoscopy revealed near complete airway obstruction secondary to granulation tissue around the stents. The granulation tissue was debrided and the stents were removed, revealing severe and diffuse dynamic airway collapse from the cricoid to the mainstem bronchi bilaterally necessitating the placement of a silicone Y stent (Novatech, Boston Medical, Boston, MA) under jet ventilation. Throughout the procedure the patient was difficult to oxygenate and ventilate, and despite taking multiple measurements prior to placement of the Y stent, there

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was significant collapse of the distal left mainstem and bronchus intermedius. We elected to stabilize the patient in the ICU without further intervention.

Two days later, the patient continued to experience progressive hypercapnia and respiratory failure. Repeat bronchoscopy revealed severe airway obstruction secondary to granulation tissue and malacia at the proximal tracheal and distal bronchial limbs of the Y stent. Granulation tissue was debrided and a hybrid metallic stent(Aero, Merit Medical Endotek, South Jordan, UT) was placed in the bronchus intermedius. Further intervention was limited by an inability to provide sufficient respiratory support during the procedure, requiring a positive end-expiratory pressure(PEEP) of 15 to maintain any degree of airway patency.

Given the profound airway collapse during previous interventions that severely compromised the ability to complete the tracheobronchial intervention, we elected to utilize VV-ECMO for temporary respiratory support to revise her stents. Under local anesthesia, after heparinization with only 1,000 units to limit the risk of airway hemorrhage during the procedure, 19Fr and 21Fr venous Biomedicus cannulas(Medtronic, Fridley, MN) were placed through the right and left femoral veins. After cannula positions were confirmed by transesophageal echo(TEE), VV-ECMO was established. Under rigid bronchoscopy, the silicone Y stent and the right bronchus stent were removed. After careful measurements, a smaller Y stent was placed along with Aero hybrid stents in the right bronchus intermedius and in the left mainstem bronchus. The patient was weaned off of ECMO without complication, extubated, and returned to the ICU.

Due to the critical airway obstruction when the stents were previously removed, a multidisciplinary decision to proceed with surgical stabilization with the airway stents in place was made and the patient underwent definitive surgical tracheobronchoplasty. Five days after tracheobronchoplasty, the stents were removed resulting in complete airway collapse, requiring re-intubation and a PEEP of 20 to maintain airway patency. VV-ECMO was again established under local anesthesia. The right and left femoral veins were cannulated with 19Fr and 21Fr Carmeda coated cannulas(Carmeda, Vasby, Sweden) respectively. A Rusch Y stent(Boston Scientific, Natick, MA) was placed successfully. The patient was extubated 24 hours later without problems and underwent frequent surveillance bronchoscopies to assist with secretion clearance and assess for airway patency. After 3 months of surveillance and clinical stability it was thought that her prior tracheobronchoplasty healing and stabilization would be complete and she was electively brought back for stent removal. VV-ECMO was again established. The right and left femoral veins were cannulated with 17Fr and 21Fr Carmeda coated cannulas. The previously placed stent was then removed via rigid bronchoscopy which revealed stent-related granulation tissue with distal patent bronchial limbs and persistent tracheomalacia. To avoid further stenting and allow additional time for airway stability after the tracheobronchoplasty, a tracheostomy was placed electively for continued airway control and secretion clearance without the need for positive pressure ventilation. The patient was discharged home and continues to do well. Her tracheostomy has been downsized, her granulation tissue has resolved and bronchoscopic assessment has revealed a marked decrease in malacia. She is currently being evaluated for decannulation without any further need for airway stent support.

DISCUSSION

We report a case of successful tracheobronchial stenting of a patient with severe TBM supported with VV-ECMO. This patient's diffuse and severe airway collapse made adequate oxygenation and ventilation impossible, prohibitively limiting the duration of each tracheobronchial intervention. Given the complexity of the necessary airway intervention and the time constraints imposed by the patient's poor respiratory status, VV-ECMO with minimal heparinization was used without complication to support the patient during tracheobronchial intervention.

Severe TBM with significant central airway collapse can be treated with tracheobronchial stenting.[1,5] Although complications are common, they are typically reversible, but may require repeat intervention.[1] In our case, the patient initially underwent metallic stenting at an outside hospital. Metallic stents are typically a poor choice for benign airway disease because they have been associated with granulation tissue formation and potential stent fracture.[1] Therefore we removed the metallic stents and elected to place a silicone Y stent. Silicone Y stents are the least likely to migrate,[1] and can be placed as a trial to determine candidacy for surgical intervention.[2] Although silicone stents can cause granulation tissue formation, they are easy to manipulate and remove with rigid bronchoscopy.[1] However, the airways of patients with TBM are often larger than the largest available pure silicone Y stents, or dynamic Y stents(18mm and 15mm diameter, respectively).

ECMO has evolved to treat adults with partial or complete cardiopulmonary failure. In this case, we elected to use ECMO to support our patient's respiratory function during tracheobronchial interventions. Minimal heparinization was used to avoid hemorrhagic complications during the airway intervention. VV-ECMO has a low risk of neurological complications, compared to VA-ECMO, improves myocardial perfusion, and allows for normal, pulsatile arterial blood flow.[3] While others have described VV-ECMO cannulation through the right internal jugular vein and right femoral vein, we feel that bilateral femoral venous cannulation is less invasive, allows for better airway access, achieves equivalent right heart drainage, and is preferred if the patient's vessel size will accommodate it. Because of the repeated cannulation of femoral arteries with large bore catheters, we performed serial ultrasound examinations to evaluate for vascular complications.[6] We agree with previous reports emphasizing the need to verify cannula placement prior to ECMO initiation and utilized a TEE probe in this case.[3]

This is the first report of utilizing VV-ECMO for elective stabilization of TBM. To our knowledge, there are only four reports of using ECMO to support respiratory function during tracheobronchial intervention all of which were performed due to stent complications. The first case utilized VV-ECMO preemptively for removal of a tracheal stent because extraction was likely to cause complete airway obstruction.[3] The next two cases involved inoperable tracheal stenosis requiring ECMO for stent placement.[7] The final patient underwent tracheal stent replacement, but during the procedure the metal frame of the stent twisted resulting in near complete airway obstruction. The stent fragment was retrieved with ECMO support.[8]

In conclusion, we report the successful VV-ECMO support of a patient undergoing complicated tracheobronchial stenting for TBM. In this case, ECMO was established safely three times, with minimal anticoagulation, and without complication. While conventional ventilation is sufficient for the vast majority of patients undergoing tracheobronchial intervention, a subset of patients cannot maintain respiratory function during intervention and can be safely bridged with ECMO support.

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