Elective perioperative veno-venous extracorporeal membrane oxygenation for the management of severe tracheal stenosis: a case report

Christopher G. Lui[1]^, Yael Bensoussan[2], Karla O'Dell[2], Diana H. Yu[3]

[1]Keck School of Medicine, University of Southern California, Los Angeles, CA, USA; [2]Caruso Department of Otolaryngology-Head and Neck Surgery, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA; [3]Division of Pulmonary, Critical Care and Sleep Medicine, Department of Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA

Correspondence to: Diana H. Yu, MD. Division of Pulmonary, Critical Care and Sleep Medicine, Department of Medicine, Keck School of Medicine, University of Southern California, Los Angeles, CA 90033, USA. Email: dhyu@usc.edu.

Background: Few cases of elective veno-venous extracorporeal membrane oxygenation (VV-ECMO) for surgical management of severe tracheal stenosis have been previously described. We report a case of VV-ECMO usage during tracheal stent exchange and airway management in a patient with severe tracheal stenosis and significant cardiopulmonary risk factors.

Case Description: An 80-year-old female with extensive cardiopulmonary history including aortic stenosis and mitral valve regurgitation requiring aortic and mitral valve replacement complicated by prosthetic endocarditis and root abscess requiring re-do sternotomy and had developed tracheal stenosis requiring metal stent placement at an outside hospital after a prolonged period of mechanical ventilation for pneumonia. On this presentation, near-total proximal tracheal obstruction was identified on imaging with metal stent fractures in multiple places epithelialized into the airway with significant granulation tissue. Due to her increased risk of peri-operative cardiac complications and inability to tolerate hypoxemia, VV-ECMO was electively used during therapeutic rigid bronchoscopy with stent extraction and new stent replacement to maintain adequate oxygenation and the procedure was completed without complications.

Conclusions: Elective peri-operative usage of VV-ECMO for respiratory support can be an effective approach for safely performing high risk and complex airway procedures in select patients with significant cardiopulmonary risk.

Keywords: Case report; veno-venous extracorporeal membrane oxygenation (VV-ECMO); tracheal stenosis; rigid bronchoscopy

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Introduction

Tracheal stenosis is a complication commonly arising from prolonged endotracheal intubation, with estimates of reported incidence ranging from 6–21% (1,2). Endotracheal cuff pressure on the tracheal mucosa can cause interruption of blood flow leading to necrosis, scarring, and disruption of tracheal anatomy. Management of tracheal stenosis typically involves surgical intervention through dilation, stenting, resection, or other procedures focused on relieving the point of narrowing (1). Establishing a safe airway and maintaining oxygenation during procedures under general anesthesia while providing surgical access can prove especially difficult in cases of tracheal stenosis depending on the location and severity (3).

^ ORCID: 0000-0002-2904-6745.

Extracorporeal membrane oxygenation (ECMO) is an advanced form of cardiopulmonary support traditionally reserved for critically ill patients and procedures with high risk of hemodynamic instability (4). ECMO utilizes an external circuit in which blood is removed from the patient, gas exchange is facilitated, and then subsequently returned to the patient. Veno-venous ECMO (VV-ECMO) has recently seen increased usage as intraoperative pulmonary support to ensure sufficient oxygenation in airway procedures with potential for respiratory compromise (4-7). Few cases of elective VV-ECMO for surgical management of severe tracheal stenosis have been previously described, with only nine cases found in the literature by a systematic review in 2018 by Malpas *et al.* (5), an additional case described by Martinod *et al.* (8) in 2020, and a series of eight cases reported by Meyer *et al.* in 2021 (9).

We present a case of elective VV-ECMO usage during tracheal stent exchange for severe tracheal stenosis through rigid bronchoscopy in an 80-year-old female patient at significant risk for cardiopulmonary complications. We present the following case in accordance with the CARE reporting checklist (available at https://shc.amegroups.com/article/view/10.21037/shc-22-4/rc).

Case presentation

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). As determined by the University of Southern California institutional review board, written informed consent was not required as the study involved no more than minimal risk to the subject and the waiver would not adversely affect the rights and welfare of the subject.

An 80-year-old female with extensive cardiopulmonary history including tracheal stenosis requiring stent placement presented with worsening respiratory status and chronic productive cough. Her medical history included aortic stenosis and mitral valve regurgitation requiring aortic and mitral prosthetic valve replacement complicated by endocarditis and aortic root abscess requiring revision sternotomy and coronary artery bypass graft. She had recurrent pneumonias requiring prolonged mechanical ventilation and tracheostomy with development of tracheal stenosis after decannulation requiring tracheal stent placement.

Computed tomography (CT) imaging showed redemonstration of proximal tracheal stenosis with significant granulation tissue and multiple tracheal stent fractures causing airway obstruction. The decision was made to electively initiate VV-ECMO prior to therapeutic rigid bronchoscopy with granulation tissue debridement, fractured and epithelialized stent extraction, and new stent replacement due to her increased risk of peri-operative cardiac complications and inability to tolerate hypoxemia.

The patient was brought to the operating room and VV-ECMO was pre-operatively established via bifemoral access using a 21-Fr multi-port catheter and a 17-Fr venous catheter under local anesthesia. Bifemoral access was chosen due to history of internal jugular thromboembolism. After VV-ECMO was started, general anesthesia was initiated. The patient was intubated with a 13 mm rigid tracheoscope and jet ventilation was initiated in order to facilitate instrumentation. Significant granulation tissue was visualized causing near-total obstruction of the proximal trachea with epithelialized portions of fractured tracheal stent fragments (*Figure 1A-1C*). Endotracheal balloon dilation was performed with the CRE™ Single-Use Pulmonary Balloon Dilation Catheter, separating the stent from the tracheal wall. Granulation tissue along with embedded stent fragments was removed via debridement with argon laser coagulation. The remaining fractured stent was removed en bloc (*Figure 1D,1E*) and a new BONASTENT 14×60 mm tracheal metal covered stent (Thoracent, Long Island, NY, USA) was placed (*Figure 1F,1G*). A metal stent rather than a silicone stent was placed given proximity to the vocal cords with increased risk of stent migration associated with silicone stents. Oxygenation was adequately maintained throughout the procedure with saturations measuring between 94–100%. The patient was extubated and was decannulated from VV-ECMO without any complications at the conclusion of the case. The patient was subsequently followed up with multiple surveillance bronchoscopies at a 2-month interval without issue.

Discussion

ECMO has been widely used in emergent rescue settings for patients with respiratory or cardiovascular failure (4). By nature of the procedure, ECMO can lead to a significant rate of complications including thrombosis, coagulopathy, and infection (10). Intraoperative ECMO usage has been extensively documented as a critical component of cardio-thoracic procedures. Due to its invasiveness and risk for adverse events, the elective usage of ECMO has only recently been explored as an adjunctive form of

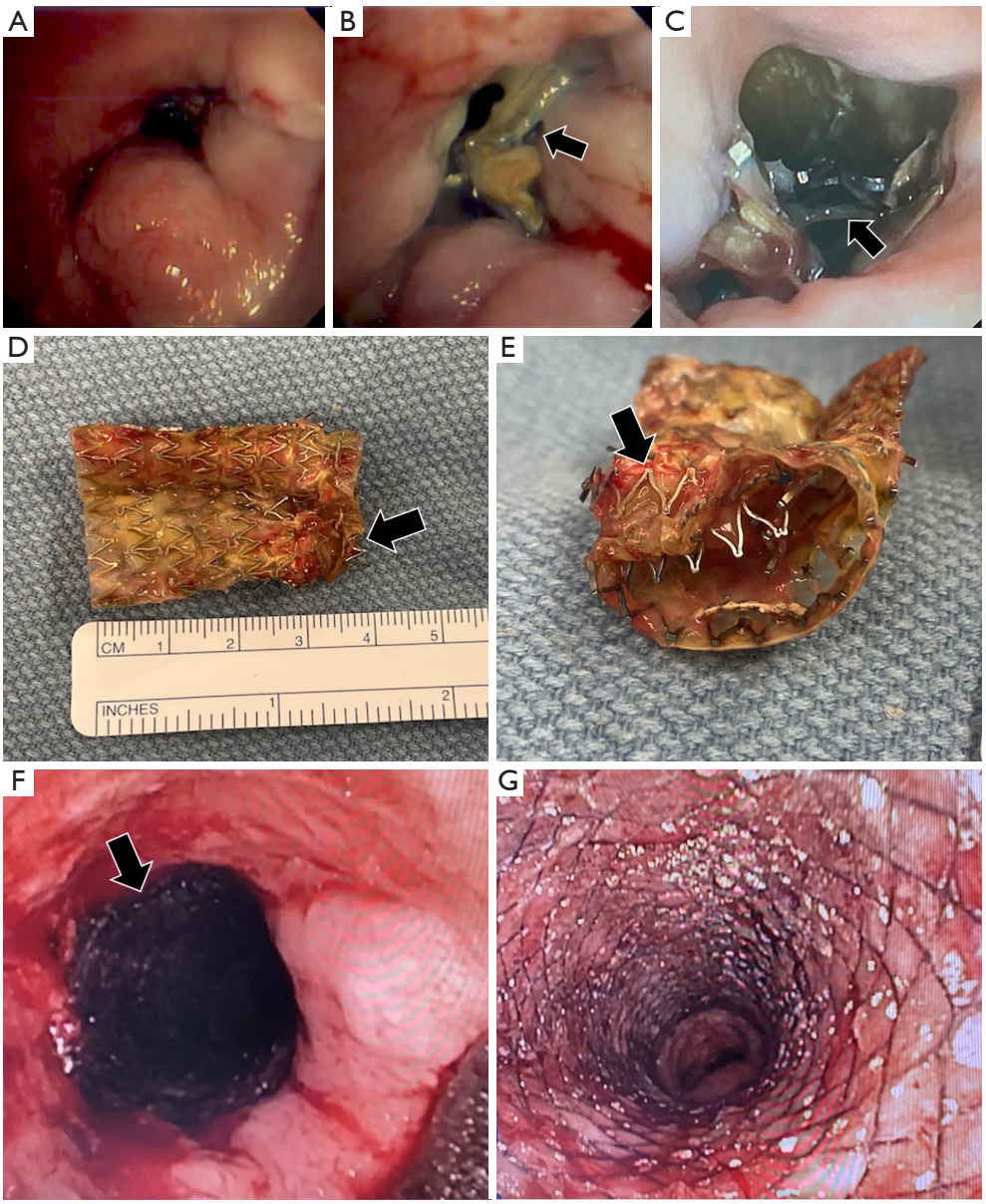

Figure 1 Bronchoscopic images. Tracheal stenosis causing (A) near-complete airway obstruction of the proximal trachea visualized during rigid bronchoscopy. (B,C) Fractured metal tracheal stent embedded within the proximal tracheal mucosa (black arrows). (D,E) The metal tracheal stent was successfully removed during the procedure. Fractured segments of the stent are visible (black arrows). (F,G) The replacement tracheal stent was successfully positioned in the proximal trachea without evidence of airway obstruction at the conclusion of the procedure. The stent is pictured (F) proximally (black arrow) and (G) distally. The carina is visible distally in the center of the image.

perioperative respiratory support in complicated airway procedures (4-6,8).

In VV-ECMO, blood circulated from the patient undergoes gas exchange in the ECMO circuit. Oxygenated blood is returned into the patient's venous system rather than bypassing the heart like in veno-arterial (VA) ECMO. By relying on the heart to provide adequate circulation, VV-ECMO primarily provides pulmonary support. Additionally, VV-ECMO requires minimal anticoagulation and has a lower risk of hemodynamic complications than VA-ECMO.

Management of severely obstructed airways during surgical procedures under general anesthesia can prove

challenging due to the risk of complete obstruction and respiratory decompensation (5,11). In situations where endotracheal intubation is not appropriate, conventional options such as bag-mask ventilation or jet ventilation may be insufficient in high-risk patients. In our case, the patient's tenuous respiratory status and severe obstruction may have precluded surgical management with traditional ventilation options without VV-ECMO support. Pre-operative bifemoral cannulation and initiation of VV-ECMO under local anesthesia provided assurance of safe oxygenation status prior to general induction in a difficult airway at risk for respiratory decompensation. In conjunction with manual jet ventilation, VV-ECMO allowed for safe oxygenation levels throughout the procedure, minimizing the risk of excessive cardiopulmonary stress and peri-operative complications in a patient with significant risk factors.

A few similar cases of elective ECMO utilization to facilitate a variety of airway procedures have been recently reported in the literature. Dunkman *et al.* (12) reported the usage of VV-ECMO during distal endotracheal tumor resection in a 37-year-old male without complications. Kim and colleagues (13) described their successful case series of four patients undergoing tracheal resection and end-to-end anastomosis for tracheal stenosis with VV-ECMO support. Martinod *et al.* (8) review their series of five patients who underwent rigid bronchoscopy with VV-ECMO. Our report contributes to the expanding literature that VV-ECMO can be safely used in combination with other ventilation techniques to facilitate difficult airway procedures in a patient with extensive cardiopulmonary risk factors. VV-ECMO has rarely been used in an elective manner for airway procedures, but we suggest it can be considered an effective adjunctive option in cases where conventional ventilation alone is not sufficient to maintain stable respiratory status.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://shc.amegroups.com/article/view/10.21037/shc-22-4/rc

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Helsinki Declaration (as revised in 2013). This study has approval from the University of Southern California institutional review board with study ID #HS-16-0003 and was determined to not require written informed consent as the study involved no more than minimal risk to the subject and the waiver would not adversely affect the rights and welfare of the subject.

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