

Case Report

# Working Around: The Use of AngioVac and Micra Transcatheter Leadless Pacemaker Implantation in a Critically Ill Patient Receiving Extracorporeal Membrane Oxygenation

Ryan Morse<sup>1,\*</sup>, Mark Joseph<sup>1,2</sup>

<sup>1</sup>Department of Surgery, Virginia Tech Carilion School of Medicine, Roanoke, VA 24016, USA

<sup>2</sup>Carilion Cardiothoracic Surgery, Carilion Clinic, Roanoke, VA 24019, USA

\*Correspondence: [ryanmorse80@vt.edu](mailto:ryanmorse80@vt.edu) (Ryan Morse)

Submitted: 8 July 2023 Revised: 30 August 2023 Accepted: 15 September 2023 Published: 9 January 2024

## Abstract

The use of extracorporeal membrane oxygenation (ECMO) in critically ill patients has been on the rise in recent years. While ECMO has provided substantial benefit to patients who need cardiopulmonary support, its required use of large-bore catheters in major blood vessels often precludes the use of other transcatheter therapies. In this article, we demonstrate that two transcatheter procedures, AngioVac right-sided cardiac thrombus removal and Micra leadless pacemaker placement, both requiring large bore access, can both be safely and effectively implemented in patients who are dependent on ECMO to maintain cardiopulmonary function.

## Keywords

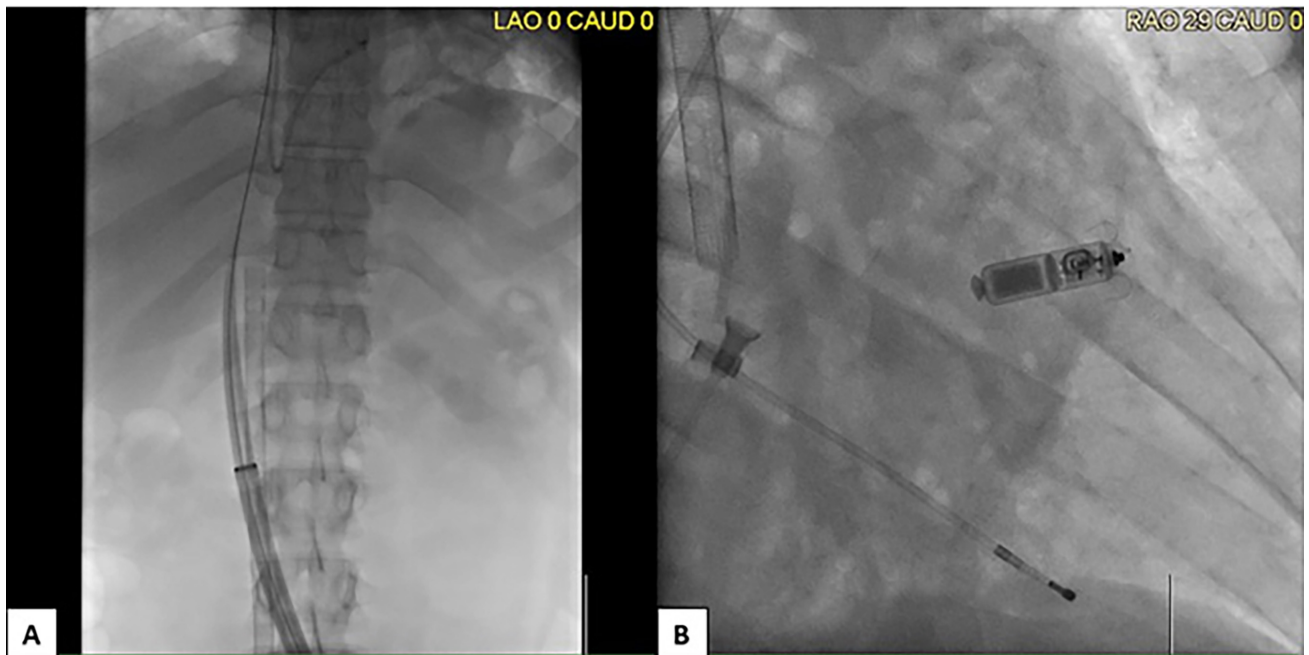
ECMO; AngioVac; COVID-19; pacemaker; thrombus; ESRD

## Introduction

Extracorporeal membrane oxygenation (ECMO) is a life sustaining procedure that allows for continuous oxygenation and circulatory support for critically ill patients. These patients are often complex, with several pathologies requiring invasive therapies to maintain homeostasis. ECMO, while necessary for many patients needing cardiovascular support, requires the placement of large catheters in several of the major blood vessels, which can preclude the use of other intravascular procedures. Here, we present the case of a man who underwent mechanical thrombectomy using AngioVac C20 cannula (AngioDynamics, Latham, NY, USA) for thrombus removal from the right ventricle, as well as Micra transcatheter leadless pacemaker (MedTronic, Minneapolis, MN, USA) placement, both through the left femoral vein, while concurrently cannulated with a 21 Fr right internal jugular catheter and a 23Fr right femoral venous catheter for veno-venous (VV) ECMO.

## Case Report

The patient was a 35-year-old man with respiratory failure secondary to coronavirus disease (COVID-19) pneumonia. He was initially treated with a course of dexamethasone and baricitinib, but due to worsening hypoxemia underwent endotracheal intubation. Despite mechanical ventilation and high positive end expiratory pressure, his hypoxemia continued to worsen with evidence of acute respiratory distress syndrome (ARDS). Subsequently, chest X-ray revealed pneumomediastinum, subcutaneous emphysema, and a small right pneumothorax. The patient was initiated on VV ECMO with catheterization of the right femoral vein with a 23 Fr catheter for drainage and right internal jugular vein with a 21 Fr catheter for return. A heparin infusion with a goal of an activated partial thromboplastin clotting time (aPTT) of 60–80 seconds was initiated for ECMO anticoagulation, which was changed to bivalirudin with the same aPTT goal for long-term anticoagulation 5 days after initiation of VV ECMO due to severe thrombocytopenia and the suspicion of heparin induced thrombocytopenia. During his course in the hospital, he developed several episodes of sinus bradycardia and complete heart block causing profound hypotension requiring the insertion of a temporary venous pacemaker. Due to intermittent capture, it was determined that the temporary pacemaker would need to be replaced with a permanent transcatheter leadless pacemaker (Micra AV) or a traditional screw in lead as a possible alternative. Given the need for additional venous access and the potential of infectious issues associated with a traditional screw in lead, the placement of a leadless pacemaker was chosen. In addition, thrombus was found on trans-esophageal echo in the right ventricle as well as adhered to the ECMO circuit. Despite increase in dosing of bivalirudin to a goal aPTT of 120–140 over the course of a week, the thrombi failed to resolve. Due to the mobility of the thrombus in the right ventricle and the potential for embolization, AngioVac removal and circuit replacement was completed at the time of pacemaker placement. This procedure occurred 22 days after initiation of VV ECMO.



**Fig. 1. Fluoroscopic imaging during procedure.** (A) Fluoroscopic imaging of AngioVac and venous circuit of ECMO in the inferior vena cava simultaneously. (B) Fluoroscopic imaging of transcutaneous leadless pacemaker positioned in the right ventricle. ECMO, Extracorporeal membrane oxygenation.

The patient was placed under anesthesia and the left common femoral vein was accessed using an 8 Fr sheath. Heparin was administered to reach activated coagulation time (ACT) greater than 250, at which point the sheath was removed and the left femoral vein was closed using two Perclose ProGlide (Abbott Laboratories, Chicago, IL, USA) sutures in a “preclose” fashion. The left femoral vein was then dilated to accommodate a 26 Fr Gore Dry-Seal sheath under fluoroscopic guidance. A wire was then used through this sheath to insert the AngioVac cannula alongside the ECMO cannula, as seen in Fig. 1A. In order to maintain the ECMO circuit, a Y connector was used to attach the return catheter from the AngioVac system into the venous return of the ECMO circuit. This application was performed with a short pause in the ECMO circulation. This allowed the AngioVac and ECMO pumps to run in series, with the ECMO pump adequately regulating and maintaining blood flow at approximately 3 liters. In order to accommodate both the AngioVac cannula and the ECMO cannula in the right atrium, the ECMO cannula was pulled back to the level of the diaphragm. The AngioVac was then guided across the tricuspid valve using fluoroscopic and trans-esophageal echocardiography (TEE) guidance, at which point the thrombus was extirpated from the right ventricle, with a small amount of thrombus remaining adhered to the apex after several passes. The AngioVac cannula was then withdrawn, with the return attaching this circuit to the ECMO being clamped, restoring venous return from the original right femoral 23 Fr catheter. The DrySeal sheath was then removed and replaced with a Medtronic 27

Fr sheath to provide a longer sheath for delivery of the leadless pacemaker to the right ventricle. The Micra device was then deployed on the right ventricular septum by crossing the tricuspid valve. Initial placement failed to achieve capture, but repositioning lower on the septum wall resulted in adequate capture threshold. The device was then released and the catheter was removed. The final deployment location of this device can be seen in Fig. 1B. Since the venous ECMO catheter had to be pulled back in order to accommodate the DrySeal sheath and due to clot within the circuit, the decision was made to switch to a new circuit and cannulas. This was done by attaching a 19 Fr arterial cannula to the circuit and placing it through the Medtronic sheath, which allowed for wire access through the right femoral system in order to place a new 23 Fr venous ECMO cannula without disrupting the ECMO flow. The Y connector allowed for continuous VV support while the original femoral venous cannula was replaced by replacing the AngioVac circuit with a 19 Fr arterial cannula placed inside the 27 Fr Medtronic cannula as a temporary drainage cannula. The 27 Fr cannula was then removed and flow on the new circuit was brought back up to normal without issue. Total procedure time was 3.5 hours, and the patient was placed on bivalirudin with a goal aPTT of 70–90 seconds for post-surgical anticoagulation. The patient continued to have a complicated hospitalization course, but experienced complete resolution of his intermittent heart block and gradually regained pulmonary function. He was successfully weaned off of ECMO seven days later and was discharged from the hospital 40 days after admission. On discharge, he was able

to ambulate independently after an additional three weeks of supplemental oxygen and continued anticoagulation with warfarin for 10 months due to chronic deep vein thrombosis (DVT). His ejection fraction was mostly preserved at 45–50% at time of follow up seven months after discharge with restoration of normal intrinsic rhythm.

## Discussion

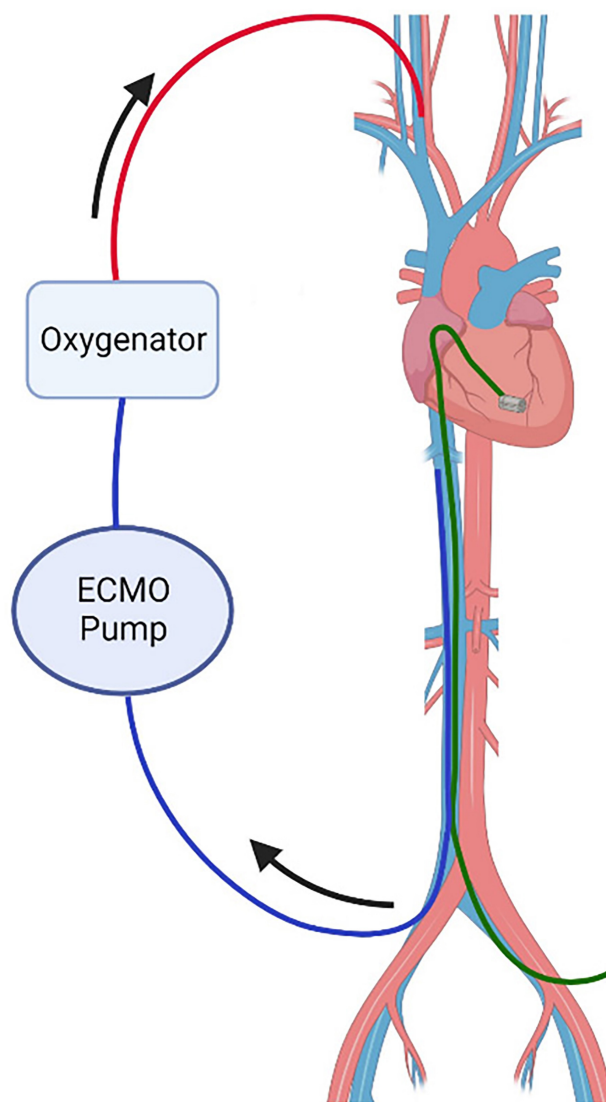
This case demonstrates the transcatheter placement of a leadless pacemaker, as well as the use of the AngioVac system to remove a right venous thrombus can both be successfully achieved while the patient is concurrently treated with VV ECMO.

### *Leadless Catheter Implantation with Concurrent ECMO*

The Micra transcatheter pacemaker system represents a great advancement in the care of complete heart block. Patients who are candidates for intravascular pacemaker implantation typically would require a pacemaker to be surgically implanted subcutaneously with transvenous lead placement. These implanted leads are the major source of complications such as infection, hematoma, pericardial effusion/tamponade, pneumothorax, and coronary sinus dissection [1]. Leadless pacemaker systems were designed to reduce the complications associated with both subcutaneous device implantation as well as transvenous lead placement [2]. While there are substantial advantages to leadless pacemaker systems, the concurrent presence of a large bore catheter in the vena cava, such as in a patient on VV ECMO, complicates its placement as the Micra transcatheter pacemaker must travel through the vena cava to reach the right ventricle. This is an uncommon procedure, although a recently published case report describes a similar method to the one reported here [3]. In this case, both a 23 Fr cannula and a 27 Fr sheath were present in the vena cava simultaneously, as depicted in Fig. 2. Despite the use of two large bore devices in the vena cava, the patient experienced no complications related to this procedure and capture was achieved. There were no issues with deployment of the delivery sheath or positioning of the pacemaker. In addition, placement of leadless pacemaker allowed freeing up of a potential access site in this patient, who required multiple venous lines including dialysis access, central lines and ECMO cannulas. This can be problematic in critically ill patients in the ICU.

### *AngioVac Use with Concurrent ECMO*

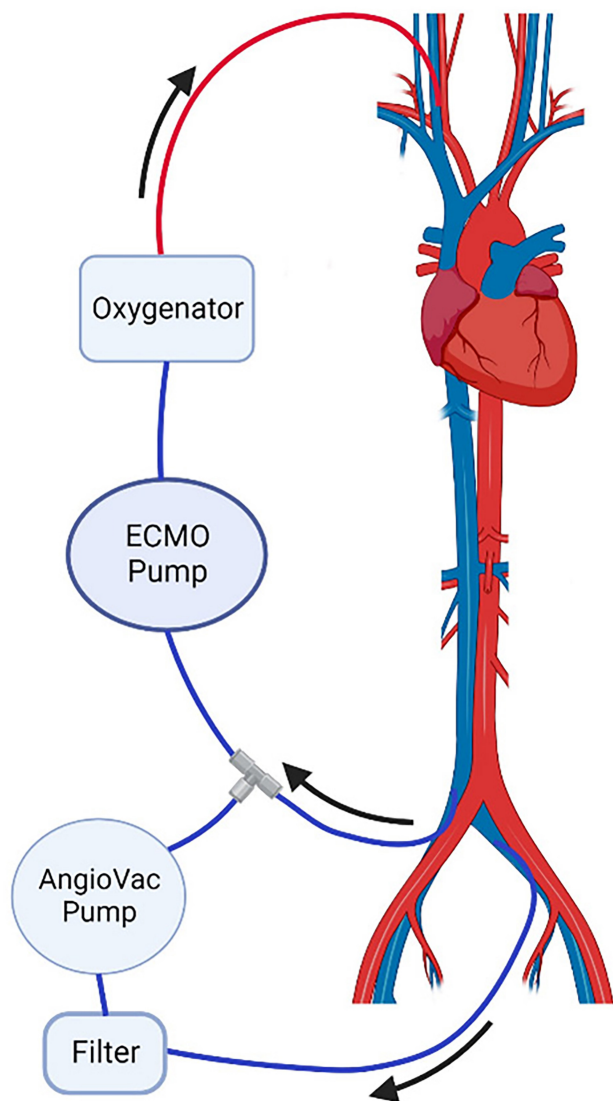
The COVID-19 pandemic has resulted in a large increase in the utilization of VV ECMO for the treatment of respiratory failure [4]. With an increase in use, however, has come an increase in reporting of thrombotic events. These thrombotic events are one of the major causes of



**Fig. 2. The common pathway of the ECMO circuit and of the pacemaker to the right ventricle.**

mortality in patients on ECMO [5]. In addition, COVID infection itself tends to be a prothrombotic state [6]. The treatment of ventricular thrombus in patients on ECMO is complex, and there are currently no guidelines available [7]. The AngioVac system is an extracorporeal circuit system which is intended for the removal of fresh, soft thrombi or emboli. This system provides an ideal solution for the treatment of thrombi in patients who are on ECMO, as thrombolytic therapy increases the risk of bleeding, which is already a leading cause of mortality in this patient population [8]. The AngioVac provides suction through a 22 Fr coil reinforced aspiration cannula. A centrifugal pump withdraws blood and thrombi from the body, which are then passed through a blood filter and returned to the patient through a reinfusion cannula. In this patient, the standard venous return for the AngioVac circuit was connected to the ECMO circuit, allowing for continuous oxygenation while the right

ventricular thrombus was being removed and thus avoiding an additional venous access. Similar to the leadless catheter implantation, however, this also required working around the 23 Fr ECMO cannula. A detailed graphical representation is depicted in Fig. 3.



**Fig. 3. AngioVac system run in series with ECMO circuit.**

Modifications to the AngioVac device to include an oxygenator in the extracorporeal circuit have been described in the literature [9–11], although this represents a novel use of the AngioVac system to temporarily replace the venous component of a preexisting ECMO circuit intraoperatively. A similar use to the one described here has been achieved previously, although this represents the first reported case in which this method was used to treat thrombosis in an adult, and the second overall in which the patient survived to discharge from the hospital [12,13].

## Conclusions

This case demonstrates that the presence of a large bore femoral venous cannulation, such as VV ECMO, should not be considered a contraindication to the use of other large bore intravenous treatment modalities such as transcatheter pacer placement and use of mechanical thrombectomy devices such as the AngioVac system. Similarly, this case demonstrates that the AngioVac system can be incorporated into an existing circuit for with VV ECMO with only minor modification to the original circuit.

## Availability of Data and Materials

The data generated for use in this study are available from the corresponding author on reasonable request.

## Author Contributions

This case report was prepared by RM and MJ. RM drafted and prepared the manuscript. MJ provided patient care, performed the procedure described in this report, and provided guidance and edits to the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of their work.

## Ethics Approval and Consent to Participate

All subjects gave their informed consent prior to participation. This protocol was reviewed by the Carilion Clinic Institutional Review Board (IRB-23-2028).

## Acknowledgment

Not applicable.

## Funding

This research received no external funding.

## Conflict of Interest

The authors declare no conflict of interest.

## Supplementary Material

A completed checklist following the 2013 CARE guidelines on case reports can be found in **Supplementary Table 1**. Supplementary material associated with this article can be found, in the online version, at <https://doi.org/10.59958/hsf.6223>.

## References

- [1] Dalia T, Amr BS. Pacemaker Indications. StatPearls Publishing: USA. 2022.
- [2] Lee JZ, Mulpuru SK, Shen WK. Leadless pacemaker: Performance and complications. *Trends in Cardiovascular Medicine*. 2018; 28: 130–141.
- [3] Cunn G, Goldner B, Epstein LM. Will it fit? Leadless pacemaker implantation in a patient on extracorporeal membrane oxygenation. *HeartRhythm Case Reports*. 2022; 8: 805–806.
- [4] Supady A, Combes A, Barbaro RP, Camporota L, Diaz R, Fan E, *et al*. Respiratory indications for ECMO: focus on COVID-19. *Intensive Care Medicine*. 2022; 48: 1326–1337.
- [5] Murphy DA, Hockings LE, Andrews RK, Aubron C, Gardiner EE, Pellegrino VA, *et al*. Extracorporeal membrane oxygenation-hemostatic complications. *Transfusion Medicine Reviews*. 2015; 29: 90–101.
- [6] Wool GD, Miller JL. The Impact of COVID-19 Disease on Platelets and Coagulation. *Pathobiology: Journal of Immunopathology, Molecular and Cellular Biology*. 2021; 88: 15–27.
- [7] Sangalli F, Greco G, Galbiati L, Formica F, Calcinati S, Avalli L. Regional thrombolysis with tenecteplase during extracorporeal membrane oxygenation: a new approach for left ventricular thrombosis. *Journal of Cardiac Surgery*. 2015; 30: 541–543.
- [8] Combes A, Hajage D, Capellier G, Demoule A, Lavoué S, Guervilly C, *et al*. Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome. *The New England Journal of Medicine*. 2018; 378: 1965–1975.
- [9] Tarzia V, Ponzoni M, Tessari C, Evangelista G, Zanella F, Pittarello D, *et al*. Navigating the Heart. The Evolution of the AngioVac System in a Single-center Experience. *Current Problems in Cardiology*. 2023; 48: 101543.
- [10] Renew JR, Wittwer ED, Robb TM, Fritock MD. AngioVac Removal of a Saddle Pulmonary Embolus Using TEE Guidance and Venoarterial ECMO Support. *Journal of Cardiothoracic and Vascular Anesthesia*. 2016; 30: 749–752.
- [11] Shanmugasundaram M, Chatterjee A, Lee K. Percutaneous Large Thrombus and Vegetation Evacuation in the Catheterization Laboratory. *Interventional Cardiology Clinics*. 2022; 11: 349–358.
- [12] Griffith KE, Jenkins E, Copenhaver W, Williams DM. Novel use of the AngioVac® system to remove thrombus during simultaneous extracorporeal membrane oxygenation life support. *Perfusion*. 2016; 31: 164–168.
- [13] Priest JR, Brown M, Choi D, Thiagarajan R, Roy N, Esch J, *et al*. Modified AngioVac System use With Extracorporeal Membrane Oxygenation in a Child With Fontan Thrombosis. *ASAIO Journal*. 2022; 68: e48–e52.