

# ECMO support in cardiac intervention of severe pulmonary stenosis

## A case report

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### Abstract

**Rationale:** Patients of critical pulmonary artery stenosis would face severe hypoxemia, cardiac failure as well as massive hemorrhage during percutaneous balloon dilation and pulmonary arterial stent implantation. Here, we present a case in which the elective use of extracorporeal membrane oxygenation (ECMO) support successfully facilitated safe percutaneous balloon dilation of pulmonary artery and stent implantation on a patient with severe pulmonary artery stenosis caused by aorto-arteritis.

**Patient concerns:** A 47-year-old man was hospitalized due to 10 years of post-exercise exhaustion and shortness of breath. Half a month ago the symptoms deteriorated. He also manifested systemic edema and could only sit upright to breath during night time. Computed tomographic angiography (CTA) indicated severe pulmonary stenosis caused by aorto-arteritis.

**Diagnoses:** Right pulmonary artery stenosis, left pulmonary artery occlusion, severe tricuspid regurgitation, right atrium, and ventricle enlargement, atrial fibrillation with rapid ventricular rates, NYHA class IV, pulmonary infection.

**Interventions:** V-A ECMO support was considered during percutaneous balloon dilation of pulmonary artery and stent implantation.

**Outcomes:** The patient remained hemodynamically stable throughout the procedure with no inotropic support. ECMO was successfully weaned off after the intervention, with no procedural complications. Postoperative echocardiography indicated much better heart function, and he was discharged uneventfully 5 days later.

**Conclusion:** V-A ECMO is capable of preventing hypoxemia and providing effective circulation support during cardiac intervention in patients of severe pulmonary stenosis.

**Abbreviations:** ACT = activated clotting time; ECMO = extracorporeal membrane oxygenation; LA = left atrium; LPA = left pulmonary artery; LV = left ventricle; LVEF = left ventricular ejection fraction; RA = right atrium; RPA = right pulmonary artery; RV = right ventricle.

**Keywords:** cardiac catheterization, ECMO, pulmonary artery stenosis

## 1. Introduction

Ever since its first successful application in cardiac catheterization and intervention in 1995 for a 4-year-old patient with pulmonary atresia, ventricular septal defect,<sup>[1]</sup> extracorporeal membrane oxygenation (ECMO) support can help maintain cardiopulmonary function and stabilize the hemodynamics on high-risk cardiac catheterization patients with congenital heart diseases.<sup>[2–5]</sup> Unlike

the pulmonary stent implantation for congenital heart diseases, pulmonary artery stenosis caused by aorto-arteritis has a longer course, and the pulmonary arterial wall is stiffer and less elastic. Therefore, it is more difficult and takes a longer time for intervention. And the patient would be facing risks like impaired cardiopulmonary function as well as massive hemorrhage caused by possible pulmonary artery rupture. Here we present a case in which the elective use of ECMO support successfully facilitated safe percutaneous balloon dilation of pulmonary artery and stent implantation on a patient with pulmonary artery stenosis caused by aorto-arteritis.

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The authors declare that there are no conflicts of interest.

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## 2. Consult for publication

The case was reviewed with the patient's family, and they have provided written consent for the publication of this report.

## 3. Case report

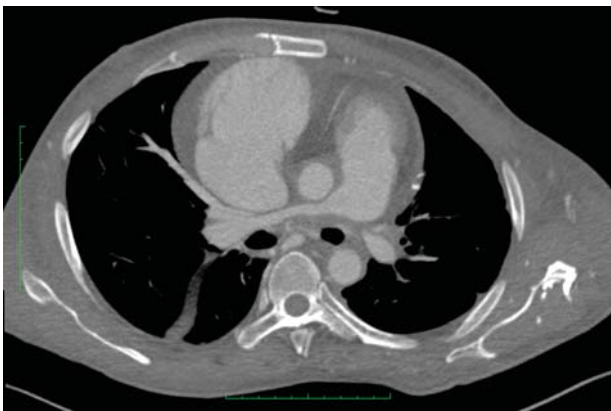
The patient is a 47-year male, who was hospitalized due to 10 years of post-exercise exhaustion and shortness of breath, half a month of aggravated systemic edema. Half a month ago, the symptoms deteriorated. He also manifested systemic edema and could only sit upright to breath during night time. The patient

was checked in the hospital by Emergency Department. His heart rate is 135 to 145 beats per minute (bpm) and blood pressure is 119/65 mmHg. In the condition of nasal cannula oxygen inhalation, respiratory rate is 28 to 35 bpm and SPO<sub>2</sub> was only 95%. The positive signs included marked jugular venous engorgement, acropachy, and edema in both lower limbs.

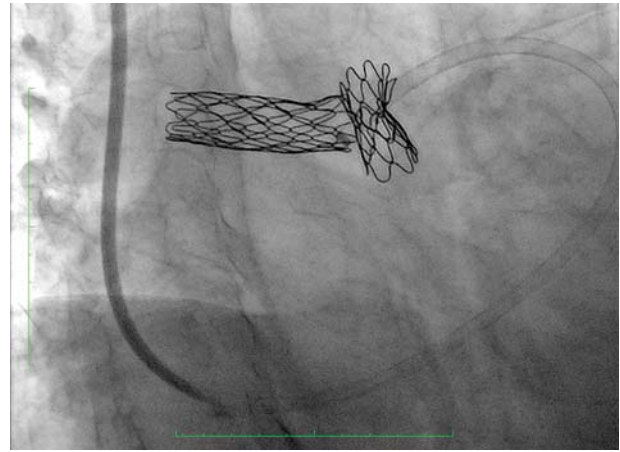
Computed tomographic angiography (CTA) indicated severe right pulmonary artery stenosis with the truncus arteriosus diameter of 0.5 cm, left pulmonary artery occlusion, severe tricuspid regurgitation, and a bunch of aortopulmonary collateral arteries were seen arising from the descending aorta, see Figure 1. Echocardiography data showed right heart was enlarged significantly, especially the right atrium; on the contrary left heart was small (LV38, LA34, RV48, RA87). The Left ventricular ejection fraction (LVEF) was only 27%. Brain natriuretic peptide (BNP) was significantly increased (2062 pg/mL), with mild rise of troponin T (30.9 ng/L). Hepatic congestion and mild liver dysfunction were observed.

**Diagnosis:** Right pulmonary artery stenosis, left pulmonary artery occlusion, severe tricuspid regurgitation, right atrium, and ventricle enlargement, atrial fibrillation with rapid ventricular rates, NYHA class IV, pulmonary infection. Cardiac catheterization as well as percutaneous balloon dilation of pulmonary artery and stent implantation were arranged. Considering the fact that the patient could be facing major risks like severe arrhythmias, acute right ventricular failure, severe hypoxemia, and cardiac hemorrhage during intervention, a multi-discipline discussion was held to come out with the decision to perform the intervention with the support of ECMO.

After general anesthesia was induced, access was obtained by percutaneous puncture of left femoral artery and vein. After the guidewire was put in place, the patient was systemically heparinized (50mg via intravenous injection), and activated clotting time (ACT) was 250seconds. The patient was then placed on femoral V-A ECMO, with the flowrate of 3.5 to 4L/min and BP 101/64 mmHg. Right radial arterial blood gas was checked regularly and the PaO<sub>2</sub> was maintained between 120 and 190 mmHg. After the initial heparinization, ACT was maintained between 150 and 200seconds; therefore, no additional heparin was pumped. Cardiac catheterization was performed via right internal jugular vein. Then percutaneous balloon dilation of the



**Figure 1.** Computed tomographic angiography (CTA) indicated severe right pulmonary artery stenosis with the truncus arteriosus diameter of 0.5 cm, left pulmonary artery occlusion, severe tricuspid regurgitation, and a bunch of aortopulmonary collateral arteries were seen arising from the descending aorta.



**Figure 2.** A pulmonary angiogram demonstrated appropriate placement of the stent and well-functioning of pulmonary artery dilation after the intervention.

left and right pulmonary artery and stent implantation were performed subsequently. The whole operation cost 5 hours. A pulmonary angiogram demonstrated appropriate placement of the stent and well-functioning dilation, see Figure 2. The patient remained hemodynamically stable throughout the procedure with no inotropic support. Bleeding was minimal and did not necessitate blood product transfusion.

After cardiac intervention is done, the right ventricular function would be improved right after the pulmonary arterial stent is implanted. As a result, the evaluation of left ventricular systolic and diastolic function is crucial. Right upper limb blood gas should be checked to evaluate the pulmonary blood improvement and pulmonary function. Echocardiography after operation indicated well-functioning left and right ventricular diastole and systole, with LVEF 55%. The PaO<sub>2</sub> of right radial artery was 150 mmHg. ECMO flowrate was gradually brought down to shut-off, with no procedural complications. Total ECMO support time was 7 hours.

The patient was then transferred to CCU, with stable hemodynamics (BP 98/65 mmHg, HR 106 bpm). The patient reported to be experiencing significant improvement from cardiac exhaustion and shortness of breath the following day. Bedside echocardiography indicated much better heart function (LV43 RV43 LVEF 55%) compared with that of preoperative; the diameters of RPA and LPA were 6 mm and 4 mm respectively; reduced right ventricle systolic function (TAPSE=14 mm, TDI-S=8.5 cm/s). He was referred for treatments such as anti-infection, anti-coagulation, Betocloc, diuresis, and cardiotonic. The patient was discharged uneventfully 5 days later.

#### 4. Discussion

ECMO, which performs as a temporary substitute for cardiopulmonary function, can help ensure oxygen supply and stabilize the hemodynamics.<sup>[7]</sup> It provides extra time for cardiopulmonary rescue and treatment, and is widely used as a bridge to recovery in treating cardiopulmonary failure, heart and lung transplantation.<sup>[8-13]</sup> In recent years, there are reports of ECMO application to maintain cardiorespiratory stability during cardiac intervention in patients of coronary artery stent implantation and complex congenital heart diseases.<sup>[2-6,14]</sup>

In this patient of severe RPA stenosis and LPA occlusion caused by aorto-arteritis, the NYHA class was only IV, with the lowest LVEF of 27%. ECMO was a necessity in his interventional treatment, given the following considerations. During the percutaneous balloon dilation, with no blood flow passing through the pulmonary artery, the right ventricle would be facing the risk of overload, even malignant arrhythmia and acute heart failure.<sup>[1,3]</sup> Meanwhile, limited pulmonary blood flow would also cause aggravated hypoxemia. In this case when intervention was performed, the almost occluded LPA was dilated first, then the RPA. We conducted in this order to prevent the risk of aggravated right ventricular overload and hypoxemia.<sup>[1,3]</sup> Even there have been reports of V-V ECMO support in pulmonary arterial stent implantation on children with congenital heart diseases to provide intraoperative oxygenation,<sup>[3]</sup> V-A ECMO support has the advantages of decreasing right ventricular backflow and cardiac preload, as well as pulmonary pressure and flowrate. Therefore V-A ECMO is capable of preventing right heart failure and hypoxemia. Moreover, because the patient suffered from left ventricular disuse atrophy due to chronic pulmonary oligoemia, a sudden increase of left ventricular preload after the stent was positioned in place might cause acute left ventricular failure, V-A ECMO should be considered the optimal option to provide effective circulation support.

There are some necessary considerations in the management of ECMO support in cardiac intervention. ECMO requires anticoagulation which increases the risk of hemorrhage during intervention.<sup>[15]</sup> This as a result will cause a bigger risk of hemorrhage. Therefore, it is imperative to obtain vascular access prior to ECMO establishment.<sup>[3]</sup> At the same time, ECMO arteriovenous puncture guidewire should be put in place prior to systemic heparinization and femoral vessel cannulation.<sup>[3]</sup> Because of the heparin coating of ECMO support circuit, apart from the initial heparin addition during ECMO establishment, there is no need to pump heparin constantly throughout the whole ECMO procedure. In this case the ACT was maintained between 150 and 200 seconds, with no hemorrhage complication. It is very important to point out that, the patient of pulmonary artery stenosis caused by aorto-arteritis would be facing more risks of bleeding and pulmonary artery rupture than congenital heart diseases. Therefore, it is more difficult and takes a longer time for intervention, and it took 5 hours for this patient.

The retrograde perfusion of femoral V-A ECMO has the drawbacks of upper body hypoperfusion.<sup>[7,16,17]</sup> Right radial arterial blood gas should be monitored intraoperatively, so that upper body hypoxemia could be noticed immediately. Otherwise, the alternative cannulation configurations in peripheral ECMO is a concern, that is, a combined usage of veno-arterial and veno-venous ECMO (V-A-V ECMO).<sup>[17]</sup> Moreover, femoral arterial retrograde perfusion would increase the left ventricular afterload.<sup>[7,16]</sup> And in this particular case of small left ventricle, it might even cause aggravated left ventricular dysfunction when perfusion flowrate is high. On the other hand, when the flowrate is low, the conflicting plane under femoral arterial retrograde perfusion might not reach the aortic arch, which would in turn cause upper body hypoperfusion. Therefore, intraoperative ECMO flowrate titration is crucial.<sup>[7]</sup> Upper limbs blood gas

as well as echocardiography should be checked and considered to calibrate the optimal ECMO support flowrate.<sup>[7]</sup> Constant surface echocardiography is recommended if possible.

## Author contributions

**Data curation:** Xiang Yu.

**Supervision:** Rong-Hua Zhou.

**Writing – original draft:** Xiang Yu, Rong-Hua Zhou.

**Writing – review & editing:** Rong-Hua Zhou.

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