ESC European Society of Cardiology

European Heart Journal - Case Reports (2023) **7**, 1–5
https://doi.org/10.1093/ehjcr/ytad402

CASE REPORT
Coronary intervention

Unexpected deformation of the right coronary artery during percutaneous coronary intervention with venoarterial extracorporeal membrane oxygenation combined with Impella: a case report

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Received 30 December 2022; revised 3 August 2023; accepted 15 August 2023; online publish-ahead-of-print 17 August 2023

Background The establishment of cautionary notes regarding percutaneous coronary intervention (PCI) with venoarterial extracorporeal membrane oxygenation combined with Impella (ECMELLA) is still lacking.

Case summary A 68-year-old man was transferred to our hospital with cardiac arrest. ECMELLA insertion was performed via the bilateral femoral artery and vein for refractory ventricular fibrillation. Coronary angiography revealed an occluded lesion in the right coronary artery (RCA). Contrast injection was administered after confirming backflow through the guide catheter (GC) to avoid coronary dissection because the artery pressure was non-pulsatile during total circulation support. Prudent coronary angiography revealed a couple of accordion phenomena. Additionally, coronary angiography showed a shorter distance from the right border of the cardiac silhouette to the RCA and the venous line of extracorporeal membrane oxygenation than before PCI. This drastic change in the cardiac silhouette suggested that ECMELLA induced the collapse of the right heart system. Subsequently, a drug-eluting stent was implanted successfully. Final coronary angiography confirmed severe bending in the proximal segment of the RCA, which was absent in the reference coronary angiography. The patient had an uneventful course except for mild cognitive impairment. The computed tomography coronary angiography after ECMELLA removal indicated the RCA without deformation.

Discussion In the present case, the collapse of the right heart system caused by ECMELLA resulted in RCA deformation. This case also underscored that contrast injection to the coronary artery in total circulation support should be administered after confirmation of backflow through a GC.

Keywords ECMELLA • ECPELLA • Cardiac arrest • Extracorporeal membrane oxygenation • Impella • Case report

ESC curriculum 3.2 Acute coronary syndrome • 2.4 Cardiac computed tomography • 3.4 Coronary angiography • 5.6 Ventricular arrhythmia • 7.3 Critically ill cardiac patient

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Handling Editor: Dimitrios Vrachatis
Peer-reviewers: Claudio Picariello; David Blusztein
Compliance Editor: Franca Morselli
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Learning points

- The collapse of the right heart system due to venoarterial extracorporeal membrane oxygenation combined with Impella, known as ECMELLA, could lead to the deformation of the right coronary artery.
- During total circulation support, contrast injection into the coronary artery should be performed only after backflow through a guiding catheter has been confirmed in order to prevent coronary dissection.

Introduction

Recently, the combination of venoarterial extracorporeal membrane oxygenation (VA-ECMO) with Impella (Abiomed Inc., Danvers, MA, USA), known as ECMELLA, has gained attention for the management of refractory cardiac arrest or cardiogenic shock.[1–3]

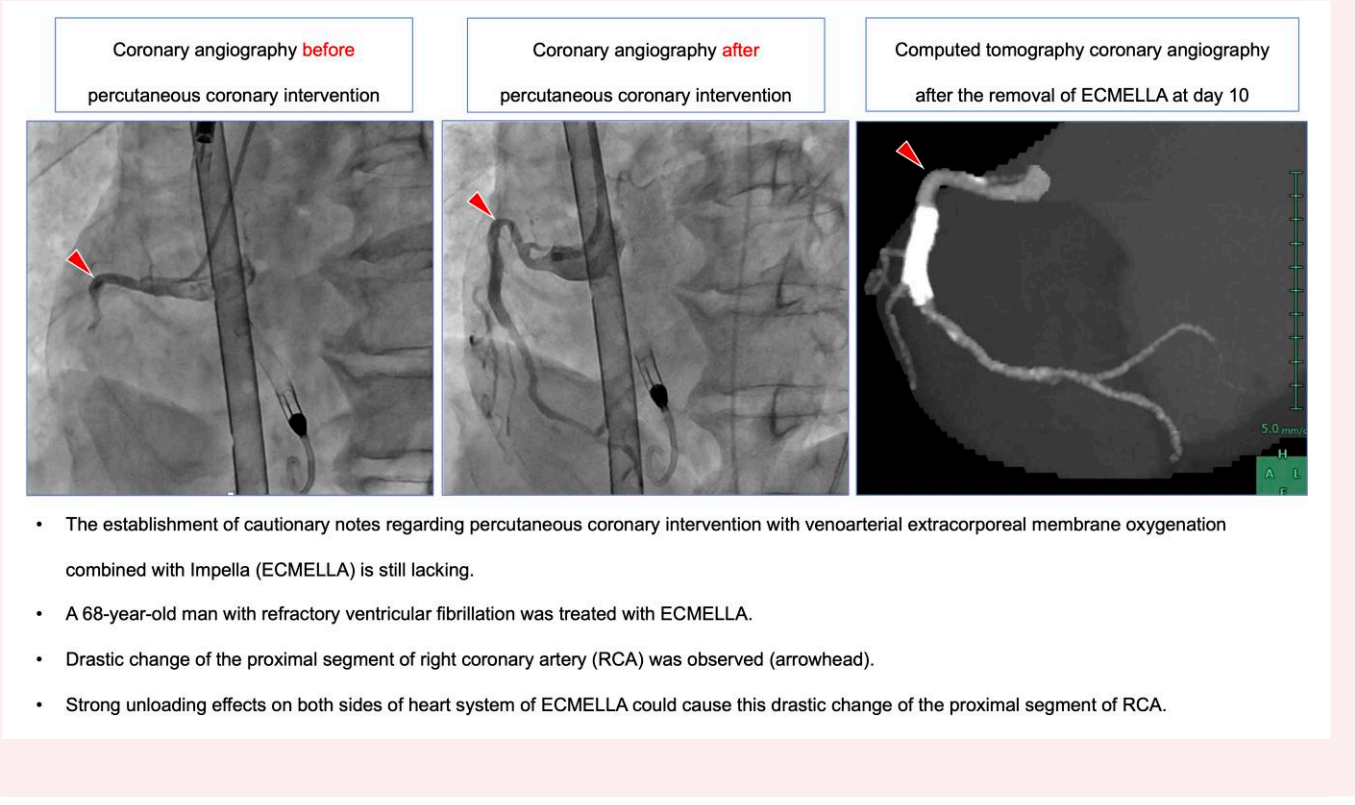
ECMELLA has demonstrated the ability to provide adequate organ perfusion and total circulation support.[4,5] Previous studies have indicated that total circulation support can reduce the size of infarctions in cases of myocardial infarction.[6–8] However, to the best of our knowledge, no studies have described the effects of the dynamic circulatory changes achieved through ECMELLA on the percutaneous coronary intervention (PCI) procedure. In this report, we present a novel case of refractory out-of-hospital cardiac arrest caused by acute myocardial infarction, during which an unexpected deformation of the right coronary artery (RCA) occurred during PCI with ECMELLA.

Summary figure

Case presentation

A 68-year-old man who had been healthy all his life was transferred to our hospital's emergency room with ventricular fibrillation following acute chest pain. Despite implementing advanced cardiovascular life support for 20 min, spontaneous circulation could not be restored. Consequently, the shock team, consisting of two interventional cardiologists, performed the insertion of peripheral VA-ECMO through the right femoral artery and vein in the catheter laboratory. After confirming that the mean atrial pressure remained above 65 mmHg with VA-ECMO, cardiopulmonary resuscitation ceased. Subsequently, an Impella CP (Abiomed Inc., Danvers, MA, USA) was inserted via the left femoral artery. The pump flow of VA-ECMO was set at 4.0 L/min, and the Impella support level was P2 without suction. During this time, ~2500 mL of normal saline was administered to maintain venous tone. Despite the insertion of ECMELLA, the patient remained in a comatose state. Therefore, target temperature management was initiated.

Following the insertion of ECMELLA, coronary angiography was performed, which revealed an occlusive lesion in the middle segment of the RCA and intact left coronary arteries (*Figure 1A* and Supplementary



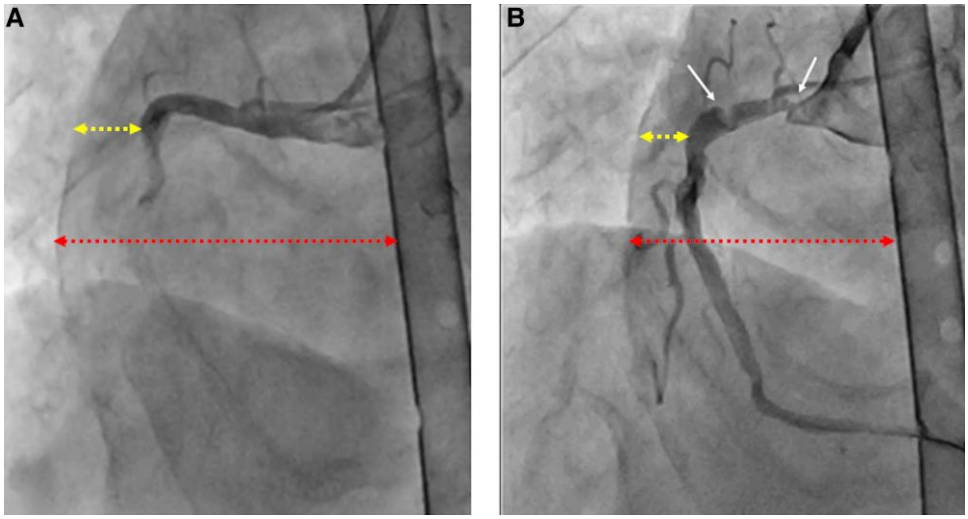


Figure 1 (*A*) Coronary angiography prior to percutaneous coronary intervention (PCI). An occlusive lesion is identified in the middle segment of the right coronary artery (RCA). The distance from the right border of the cardiac silhouette to the RCA (upper two-sided arrow) and venous line of extracorporeal membrane oxygenation (lower two-sided arrow) is clear. (*B*) Coronary angiography after guide wire crossing. A couple of accordion phenomena are observed in the proximal segment of the RCA (one-sided arrows). This coronary angiography showed a shorter distance from the right border of the cardiac silhouette to the RCA (yellow two-sided arrow) and venous line of extracorporeal membrane oxygenation (red two-sided arrow) than that prior to PCI.

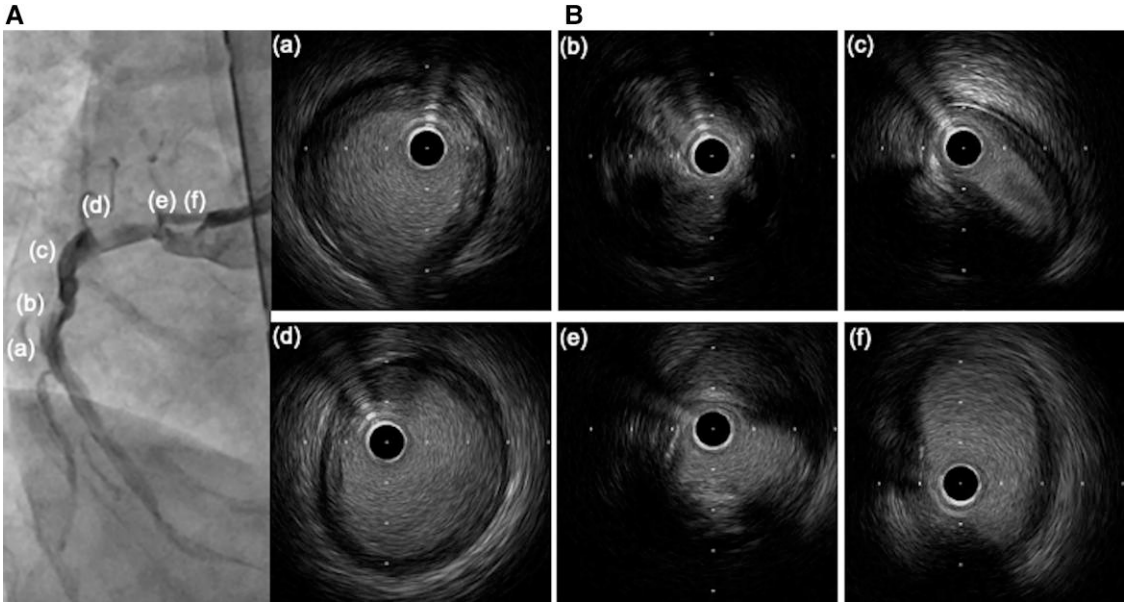


Figure 2 (*A*) Coronary angiography before intravascular ultrasound imaging. (*A–F*) Correspond to the intravascular ultrasound images (*B*). (*B*) Intravascular ultrasound images. Culprit lesion (*B*) exhibited lipid-rich plaque and thrombus. A couple of accordion phenomena are observed (*C*, *E*).

material online, *Video S1*). Subsequently, defibrillation successfully restored the normal sinus rhythm (heart rate = 78/min) with ST-segment elevation in leads II, III, and aVF. During this time, the arterial pressure remained non-pulsatile at 85 mmHg without the administration of any vasopressors or inotropes, which suggested that successful total circulation support was achieved by ECMELLA.

A guide wire (GW) was successfully advanced to the distal part of the RCA. However, backflow through the guide catheter (GC) was not confirmed. Subsequently, a contrast injection was administered in the ascending aorta after confirmation of backflow through the GC. Prudent coronary angiography revealed three findings. Firstly, thrombolysis in myocardial infarction grade 3 flow was achieved. Secondly, the proximal segment of the RCA exhibited a couple of accordion phenomena, defined as pseudo-stenotic lesions caused by straightening of the tortuous coronary artery by the GW.[9] Thirdly, the distance between the right border of the cardiac silhouette and the RCA and venous line of VA-ECMO was shorter than that before PCI (*Figure 1B* and Supplementary material online, *Video S2*).

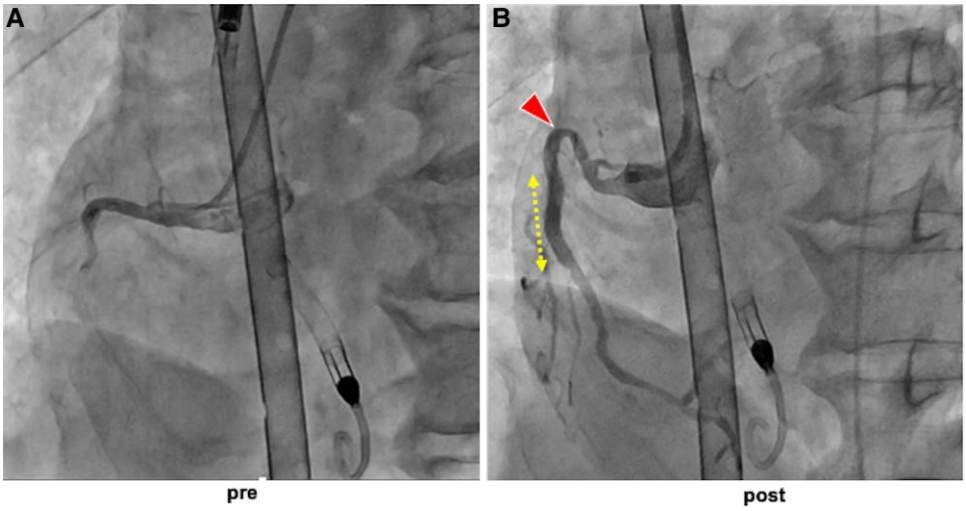


Figure 3 (*A*) Coronary angiography before percutaneous coronary intervention (PCI). The proximal segment of the right coronary artery (RCA) is straight. (*B*) Coronary angiography after PCI. A 3.5 × 20 mm everolimus-eluting stent is successfully implanted (yellow two-sided arrow). Severe bending in the proximal segment of the RCA is observed (red arrowhead).

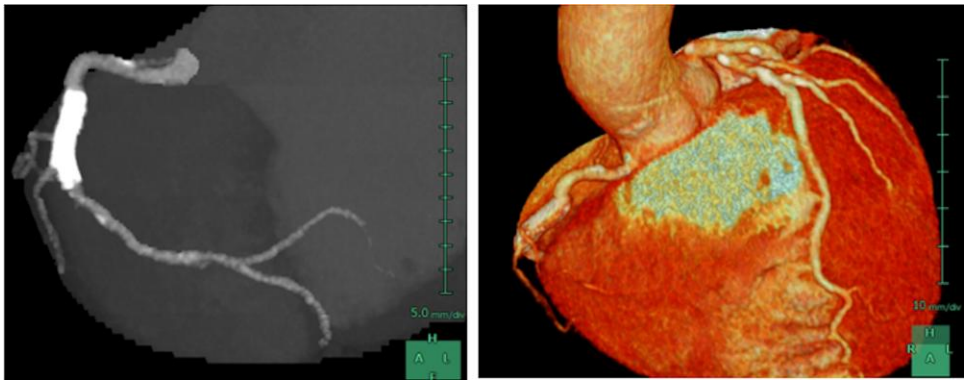


Figure 4 Computed tomography coronary angiography after the removal of the venoarterial extracorporeal membrane oxygenation and Impella. Severe bending of the proximal part of the right coronary artery improved.

Intravascular ultrasound imaging (Alta View, Terumo, Tokyo, Japan) showed the culprit lesion in the middle part of the RCA and a couple of accordion phenomena in the proximal part of the RCA (*Figures 2A and B*; Supplementary material online, *Video S3*). Finally, a 3.5 × 20 mm Synergy everolimus-eluting stent (Boston Scientific, Marlborough, MA, USA) was successfully implanted. A final coronary angiography confirmed the presence of severe bending in the proximal segment of the RCA, which was not evident in the reference coronary angiography (*Figure 3* and Supplementary material online, *Videos S1* and *S4*). Throughout the PCI, the patient's vital signs remained stable with ECMELLA support, and no vasopressors or inotropes were required. An electrocardiogram upon admission showed resolution of ST-segment elevation and T-wave inversion in leads II, III, and aVF.

The patient had an uneventful course after PCI, except for mild cognitive impairment, and was discharged on Day 13. Computed tomography coronary angiography after ECMELLA removal showed the RCA without deformation (*Figure 4*).

Ten months after discharge, he was doing well without recurrent cardiac events.

Discussion

ECMELLA is a novel treatment approach; however, studies reporting cautionary notes on PCI with ECMELLA are limited.

This case report highlights two important issues. The first clinical suggestion is that unexpected deformation of the RCA may occur during PCI with ECMELLA.

This deformation can be attributed, in part, to three mechanisms. First, VA-ECMO has an unloading effect on the right heart system, and Impella has an unloading effect on the left heart system. Therefore, ECMELLA has an unloading effect on both sides of the heart system, unlike other mechanical circulatory support devices.[4,5] In the present case, fluoroscopic imaging depicted a shorter distance from the right border of the cardiac silhouette to the RCA and the venous line of VA-ECMO than that before PCI following ECMELLA insertion. This drastic fluoroscopic change suggested an extraordinary collapse of the right heart system. In the present case, this extraordinary collapse of the right heart system occurred even though a large amount of normal saline was administered before ECMELLA insertion. Normally,

high-flow VA-ECMO support without Impella could cause pulmonary hypertension and pressure elevation of the right heart system as a consequence of pressure elevation of the left heart system induced by retrograde flow from VA-ECMO, which could prevent the extraordinary collapse of the right heart system. However, as aforementioned, ECMELLA has strong unloading effects on both sides of the heart system, which could cause an extraordinary collapse of the right heart system such as that in the present case.

Second, the connection between the RCA and the surrounding tissue is not tight because the RCA runs in the epicardial fat at the atrioventricular groove.[10] This vulnerability suggests that the running pattern of the RCA could be affected by the size and shape of the right heart system.

Third, in our case, the proximal part of the RCA was relatively long and devoid of calcified plaque. These characteristics of the proximal RCA could cause high mutability of the vasculature.

Hence, it is conceivable that the extraordinary collapse of the right heart system induced by ECMELLA could lead to an unexpected deformation of the RCA. The finding that computed tomography coronary angiography after ECMELLA removal shows the RCA without deformation supports this hypothesis (*Figure 4*).

The second clinical suggestion is that contrast injection in total circulation support should be performed after confirmation of backflow through a GC. The arterial pressure wave from the tip of the GC in total circulation support could be non-pulsatile.[6,7] In this situation, PCI operators cannot assess whether the GC is occlusive within the proximal vessel. Therefore, in total circulation support, confirmation of backflow through a GC may be a safe and necessary step to avoid coronary dissection induced by the contrast injection.

Further studies are required to elucidate the conditions under which RCA deformation occurs. Though some studies have demonstrated the efficacy of biventricular Impella in refractory cardiogenic shock,[11,12] more studies are required to evaluate whether biventricular Impella could cause RCA deformation.

In conclusion, our case suggests that unexpected deformation of the RCA may occur during PCI with ECMELLA and contrast injection into the coronary artery during total circulation support should be performed after confirming backflow through a GC to avoid coronary dissection. Further studies are needed to provide cautionary notes regarding PCI with ECMELLA.

Lead author biography

Hiroki Sugane was born in Chiba, Japan, in 1987. He graduated from Kochi Medical University and received the MD degree in 2012. He was working as a cardiology fellow at Chikamori Hospital from 2014. Then, he became a cardiovascular interventional fellow at Department of Cardiovascular Medicine, National Cerebral and Cardiovascular Center, Japan, from 2017. He experienced a large number of PCI cases as well as analysis of intravascular imaging. From 2019, he serves as a staff cardiologist at Chikamori Hospital, Kochi, Japan. His research interest is percutaneous coronary intervention and intravascular imaging.

Supplementary material

Supplementary material is available at *European Heart Journal – Case Reports*.

Consent: The authors confirm that written consent for the submission and publication of this case report, including images and associated text, has been obtained from the patient in line with the COPE guidance.

Conflict of interest: None declared.

Funding: None declared.

Data availability

The data underlying this article are available in the article and its online *supplementary material*.

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