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Name of Journal: *World Journal of Clinical Cases*

Manuscript NO: 85940

Manuscript Type: CASE REPORT

Left Atrium Venous-Arterial (LAVA) Extra Corporeal Membrane Oxygenation (ECMO) as Temporary Mechanical Support for Cardiogenic Shock, a Case Study

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Abstract

BACKGROUND

Veno-Arterial Extra Corporeal Membrane Oxygenation (VA-ECMO) support is commonly complicated with Left ventricle (LV) distension in patients with cardiogenic shock. We resolved this problem by transeptally converting VA-ECMO to Left Atrium Venous-Arterial (LAVA) ECMO that functions as a temporary paracorporeal left ventricular assist device to resolve LV distension. In our case LAVA-ECMO was also functioning as a bridge-to-transplant device, a technique that has been scarcely reported in the literature.

CASE SUMMARY

A 65 years-old man suffered from acute myocardial injury that required percutaneous stents. Less than two weeks later, noncompliance to antiplatelet therapy led to stent thrombosis, cardiac shock and cardiac arrest. Femoro-femoral Veno-Arterial Extra Corporeal Membrane Oxygenation (VA-ECMO) support was placed, and the patient underwent a second coronary angiography with re-stenting and Intra-Aortic Balloon Pump (IABP) placement.

The VA-ECMO support was complicated by left ventricular (LV) distension which we resolved via Left Atrium Venous-Arterial (LAVA)ECMO.

Unfortunately, episodes of bleeding and sepsis complicated the clinical picture and the patient passed away 27 days after initiating VA-ECMO.

CONCLUSION

This clinical case demonstrated that LAVA-ECMO is a viable strategy to unload the LV without another invasive percutaneous or surgical procedure. We also demonstrate that LAVA-ECMO can also be weaned to an LVAD system. A benefit of this technique is that the procedure is potentially reversible, should the patient require VA-ECMO support again. A transeptal LV venting approach like LAVA-ECMO may be indicated over ImpellaTM in cases where less LV offloading is required and where a restrictive myocardium could cause LV suctioning. Left ventricular over-distention is a well-known complication of peripheral VA-ECMO in cardiogenic shock and LAVA ECMO through transeptal cannulation offers a novel and safer approach for treating LV overloading, without the need of other percutaneous accesses.

INTRODUCTION

²Cardiogenic shock (CS) is a common cause of mortality and management remains ²challenging despite advances in therapeutic options. CS complicates 5 to 10% of cases of acute myocardial infarction and is the leading cause of death after myocardial infarction ^[1]. When vasopressor and inotropic support are not enough, the next step is often mechanical circulatory support such as Intra- Aortic Balloon Pump (IABP), ImpellaTM, Venous-Arterial Extra Corporeal Membrane Oxygenation (VA-ECMO), and others. When VA-ECMO is chosen, left ventricular (LV) distension with subsequent LV failure can become a main complication that requires LV unloading. Conservative management that includes optimizing volume status, adding inotropes and down-titration of VA- ECMO flow may resolve the LV distension. If conservative measures fail, IABP, ImpellaTM, percutaneous left ventricular assist devices (pLVAD) and transeptal cannulation (such as Tandem HeartTM) are invasive methods of reducing LV distension ^[2,3,4]. In this case report, a patient with CS after a myocardial infarction is placed on VA-ECMO with subsequent LV distension which we manage to resolve by modifying the VA-ECMO into a temporary Left Ventricular Assistance Device (LVAD). This new configuration, called Left Atrial Veno- Arterial ECMO (LAVA-ECMO), unloads the left ventricle without the need of an additional percutaneous procedure

and without the oxygenator. Physiologically, this venous cannula which passes through the intra-atrial septum and into the left atrium reduces the left ventricular end diastolic volume and pressure, helping to reduce preload as well as left ventricular distension. The arterial cannula unloads the volume removed from the venous cannula, thus adding to the ejection fraction of the left heart which improves tissue perfusion.

Once CS has been diagnosed, and treatment has reached the point where mechanical support seems necessary without the hope of de-escalation, the decision for long-term Left VAD support, transplant or other surgical procedures is difficult. In recent years the use of VAD has evolved, and its uses have broadened. Bridge to decision (BTD) describes the temporary use of a VAD until decisions about more definitive therapy are made or until a thorough assessment of cardiac recovery is possible. Patients with insignificant cardiac function but good neurological status may eventually undergo heart transplantation by transitioning from BTD to bridge to transplant (BTT). Very few patients undergo heart transplant while being supported by a short-term VAD because of the lengthy wait time for a suitable donor, therefore one outcome of BTD is the transition to a long-term LVAD to wait for a transplant in an outpatient setting^[5]. Our patient was suitable for heart transplant according to general criteria: having an end-stage heart disease not remediable by other conservative measures and not having major contraindications (irreversible pulmonary hypertension, active systemic infections, active malignancy, cerebrovascular disease, irreversible dysfunction to other organs or inability to comply with medical treatment)^[6].

CASE PRESENTATION

Chief complaints

A 65 years-old man suffered from acute myocardial injury with coronary angiography showing a 90% stenosis of the CFX. He underwent immediate percutaneous transluminal coronary angioplasty (PTCA) plus one stent on each of the following coronary arteries: left main, left anterior descending, and left circumflex. On day +9 after admission, he started double anti-platelets therapy (DAPT) anticoagulation (ASA+

Ticagrelor) and was discharged from the hospital. At the same time, he was found to be positive for Sars-CoV-2 on a nasal swab but was asymptomatic. On day +12 he experienced a new ischemic episode (he was apparently uncompliant with the DAPT therapy due to Ticagrelor unavailability) so he came back to the emergency department with an ECG showing an anterolateral ischemia. He underwent a cardiac arrest that did not respond to standard ACLS so he received femoro-femoral VA-ECMO support

History of present illness

A 65 years-old man suffered from acute myocardial injury with coronary angiography showing a 90% stenosis of the CFX. He underwent immediate percutaneous transluminal coronary angioplasty (PTCA) plus one stent on each of the following coronary arteries: left main, left anterior descending, and left circumflex. On day +9 after admission, he started double anti-platelets therapy (DAPT) anticoagulation (ASA+ Ticagrelor) and was discharged from the hospital. At the same time, he was found to be positive for Sars-CoV-2 on a nasal swab but was asymptomatic. On day +12 he experienced a new ischemic episode (he was apparently uncompliant with the DAPT therapy due to Ticagrelor unavailability) so he came back to the emergency department with an ECG showing an anterolateral ischemia. He underwent a cardiac arrest that did not respond to standard ACLS so he received femoro-femoral VA-ECMO support

History of past illness

A 65 years-old man suffered from acute myocardial injury with coronary angiography showing a 90% stenosis of the CFX. He underwent immediate percutaneous transluminal coronary angioplasty (PTCA) plus one stent on each of the following coronary arteries: left main, left anterior descending, and left circumflex. On day +9 after admission, he started double anti-platelets therapy (DAPT) anticoagulation (ASA+ Ticagrelor) and was discharged from the hospital. At the same time, he was found to be positive for Sars-CoV-2 on a nasal swab but was asymptomatic. On day +12 he experienced a new ischemic episode (he was apparently uncompliant with the DAPT

therapy due to Ticagrelor unavailability) so he came back to the emergency department with an ECG showing an anterolateral ischemia. He underwent a cardiac arrest that did not respond to standard ACLS so he received femoro-femoral VA-ECMO support

Personal and family history

A 65 years-old man suffered from acute myocardial injury with coronary angiography showing a 90% stenosis of the CFX. He underwent immediate percutaneous transluminal coronary angioplasty (PTCA) plus one stent on each of the following coronary arteries: left main, left anterior descending, and left circumflex. On day +9 after admission, he started double anti-platelets therapy (DAPT) anticoagulation (ASA+ Ticagrelor) and was discharged from the hospital. At the same time, he was found to be positive for Sars-CoV-2 on a nasal swab but was asymptomatic. On day +12 he experienced a new ischemic episode (he was apparently uncompliant with the DAPT therapy due to Ticagrelor unavailability) so he came back to the emergency department with an ECG showing an anterolateral ischemia. He underwent a cardiac arrest that did not respond to standard ACLS so he received femoro-femoral VA-ECMO support

Physical examination

At the same time, he was found to be positive for Sars-CoV-2 on a nasal swab but was asymptomatic. On day +12 he experienced a new ischemic episode (he was apparently uncompliant with the DAPT therapy due to Ticagrelor unavailability) so he came back to the emergency department with an ECG showing an anterolateral ischemia. He underwent a cardiac arrest that did not respond to standard ACLS so he received femoro-femoral VA-ECMO support

Platelet count reduced progressively due to the extracorporeal circuit. Other complications included bleeding and sepsis. Anticoagulation was constantly monitored through ACT (every 2 h) and aPTT twice daily.

Laboratory examinations

Platelet count reduced progressively due to the extracorporeal circuit. Other complications included bleeding and sepsis. Anticoagulation was constantly monitored through ACT (every 2 h) and aPTT twice daily. Despite such monitoring, the patient experienced multiple bleeding episodes, first in cannula insertion sites and then in the airway. We managed bleeding through blood transfusions (4 units of packed red blood cells) and strict monitoring of coagulation markers. Pneumonia was also diagnosed, and antibiotics were started.

Imaging examinations

*See Figure 1

FINAL DIAGNOSIS

A 65 years-old man suffered from acute myocardial injury with coronary angiography showing a 90% stenosis of the CFX.

severe LV dysfunction

Other complications included bleeding and sepsis

TREATMENT

A 65 years-old man suffered from acute myocardial injury with coronary angiography showing a 90% stenosis of the CFX. He underwent immediate percutaneous transluminal coronary angioplasty (PTCA) plus one stent on each of the following coronary arteries: left main, left anterior descending, and left circumflex. On day +9 after admission, he started double anti-platelets therapy (DAPT) anticoagulation (ASA+ Ticagrelor) and was discharged from the hospital. At the same time, he was found to be positive for Sars-CoV-2 on a nasal swab but was asymptomatic. On day +12 he experienced a new ischemic episode (he was apparently uncompliant with the DAPT therapy due to Ticagrelor unavailability) so he came back to the emergency department with an ECG showing an anterolateral ischemia. He underwent a cardiac arrest that did

not respond to standard ACLS so he received femoro-femoral VA-ECMO support (ECMOLIFE, Eurosets S.r.l., Medolla (MO), Italy; HLS venous cannula 23 Fr and HLS arterial cannula 19 Fr, Getinge, Germany). He then underwent a second coronary angiography with PTCA and stents on the same vessels and **placement of an** intra-aortic balloon pump (IABP, CARDIOSAVE hybrid, Maquet Getinge Group, Germany) with 1:1 ratio assistance. Afterwards, the patient was admitted to the ICU and a trans-esophageal echocardiography (TEE) was performed with the following findings: severe LV dysfunction with interventricular hypokinesia of the septum, left atrial smoke, minimal aortic valve opening with mild aortic insufficiency, and severe reduction of right ventricle longitudinal and concentric function. The IABP was ineffective in unloading the left heart so, on day +20, a transeptal left atrial cannulation was performed and VA-ECMO was converted to Left Atrial Veno-Arterial Extracorporeal Membrane Oxygenation (LAVA-ECMO, with Protek-Solo 21Fr, Livanova, USA) (*Figure A*). TEE demonstrated improvement in the right ventricular, anterior septum and posterior wall **movement** with a permanent and concomitant severe left ventricular dysfunction. On day +21 the patient underwent a cycle of levosimendan infusion. Because of the permanent LV dysfunction and overdistension, on day +22, he was transferred to the cardiothoracic ICU. After progressive weaning from VA-ECMO with a reduction of venous return on the ECMO device (via a Hoffmann clamp on the venous branch of the tube), the patient was definitively shifted to a total left ventricular assistance. The oxygenator was removed from the circuit, making an LVAD. Vasopressor and inotropic support were decreased as cardiac function improved (*Graph 1*). Platelet count reduced progressively due to the extracorporeal circuit. Other complications included bleeding and sepsis. Anticoagulation was constantly monitored through ACT (every 2 h) and aPTT twice daily. Despite such monitoring, the patient experienced multiple bleeding episodes, first in cannula insertion sites and then in the airway. We managed bleeding through blood transfusions (4 units of **packed red blood cells**) and strict monitoring of coagulation markers. Pneumonia was also diagnosed, and antibiotics were started. Regular fibro-bronchoscopies were also done with the aim of

maintaining adequate ventilation, removing clots, and clearing secretions. Renal failure (AKI 3) developed, requiring continuous renal replacement therapy (CRRT).

OUTCOME AND FOLLOW-UP

Our patient passed away on day +39 due to an uncontrolled airway bleed, 27 days after starting VA-ECMO.

DISCUSSION

ECMO requires the blood to be continuously anti-coagulated, which poses a constant risk for hemorrhagic complications. In addition, prolonged ICU admissions increase the likelihood of septic complications. To our knowledge, the LAVA-ECMO configuration does not seem to pose any additional risk of hemorrhage or sepsis, in comparison to the normal VA or VV-ECMO. No specific studies have been designed to evaluate this comparison, however

CONCLUSION

This clinical case demonstrated that LAVA-ECMO is a viable strategy to unload the LV without another invasive percutaneous or surgical procedure. We demonstrate the ability to use LAVA-ECMO and the ability for its conversion to an LVAD system, as has been demonstrated in the literature [4,7]. One downside is that LAVA-ECMO requires a transeptal percutaneous cannulation that, when removed, could result in a small residual atrial septal defect, that could be repaired through a minimally invasive procedure. A benefit of this technique is that the procedure is potentially reversible, should the patient require VA-ECMO support again. A transeptal LV venting approach like LAVA-ECMO may be indicated over Impella™ in cases where less LV offloading is required and where a restrictive myocardium could cause LV suctioning [4]. Left ventricular over-distention is a well-known complication of peripheral VA-ECMO in cardiogenic shock and LAVA-ECMO through transeptal cannulation offers an

undervalued and potentially safer approach for treating LV overloading, without the need of other percutaneous accesses.

ORIGINALITY REPORT

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SIMILARITY INDEX

PRIMARY SOURCES

1	Timothy J. Myers. "Temporary Ventricular Assist Devices in the Intensive Care Unit as a Bridge to Decision", AACN Advanced Critical Care, 2012 <small>Crossref</small>	74 words — 3%
2	www.ncbi.nlm.nih.gov <small>Internet</small>	36 words — 1%