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Case Report

Percutaneous Left Ventricular Unloading in Cardiogenic Shock During Venoarterial Extracorporeal Membrane Oxygenation: A Radial Approach

Gian Manuel Jiménez-Rodríguez, MD,[a] Daniel Manzur-Sandoval, MD,[a] Ricardo Eduardo Quirazco-Córdova, MD,[a] Luis Antonio Jiménez-Ruán, MD,[b] and Gustavo Rojas-Velasco, MD[a]

[a] *Cardiovascular Critical Care Unit, Ignacio Chávez National Institute of Cardiology, Mexico City, Mexico*

[b] *Cardiology Department, Ignacio Chávez National Institute of Cardiology, Mexico City, Mexico*

Venoarterial extracorporeal membrane oxygenation (VA ECMO) has expanded beyond refractory cardiogenic shock (CS). A 52-year-old patient with electrical storm was assisted with peripheral VA ECMO. He developed left ventricular distension that resolved with the percutaneous placement of a pigtail catheter in the left ventricle accessed through the left radial artery, guided by transesophageal echocardiography (TEE). This article presents a previously undescribed technique that achieved successful unloading of the left ventricle and can be performed at the patient's bedside.

CS is the most severe form of cardiac decompensation and causes end-organ hypoperfusion, multisystem organ failure, and death if a reversible cause is not identified and managed.[1] VA ECMO allows blood to be drained from a central vein and returned to the arterial system, providing both respiratory and circulatory support, and has been established as a management strategy when CS is refractory to usual treatment.[2] Indications for VA ECMO have been expanded to include situations such as support in high-risk interventional procedures and electrical storm. Electrical storm refers to a state of cardiac electrical instability characterized by multiple episodes of ventricular tachycardia (VT) or ventricular fibrillation within a 24-hour period, despite use of antiarrhythmic drugs or electric therapies.[3] Currently, peripheral VA ECMO is preferred over central cannulation, owing to its *lower* incidence of complications and *the possibility* that it can be performed at the patient's bedside, without the need to mobilize the patient to the operating room.[4] During VA ECMO, complications can occur, such as left ventricular distension (LVD). LVD is caused by retrograde flow to the heart, which conditions an increase in the afterload of the left ventricle, an issue magnified in those patients who have very poor residual ventricular function, and in the peripheral cannulation; if not treated in a timely manner, LVD can have a catastrophic outcome. Multiple strategies have been described to achieve adequate discharge of the left ventricle (LV), including the use of an intra-aortic balloon pump (IABP), use of an Impella microaxial flow catheter (Abiomed, Danvers, MA), atrial septostomy, and direct surgical drainage of the LV, left atrium, or pulmonary artery.[5] In this article, we describe the case of a patient with electrical storm who was supported by peripheral VA ECMO. The patient developed LVD that was resolved percutaneously by the placement of a pigtail catheter in the LV through the radial artery, guided by TEE, achieving a successful unload of the LV. This procedure has not been reported previously in the medical literature.

Case History

A 52-year-old man with a medical history of ischemia and dilated cardiomyopathy, with a left ventricular ejection fraction of 30%, arrived in the emergency department due to multiple episodes of syncope. He carried an implantable cardioverter-defibrillator for secondary prevention, and a MitraClip (Abbott, Chicago, IL) for secondary severe mitral regurgitation in the context of symptomatic heart failure (in New York Heart Association functional class III) with favourable anatomy for transcatheter edge-to-edge repair 2

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Ethics Statement: The local institutional research and ethics committees waived approval for this study. Written informed consent for patient information and images to be published were provided by the patient or a legally authorized representative.

Corresponding author: Dr Daniel Manzur-Sandoval, Instituto Nacional de Cardiología Ignacio Chávez, Juan Badiano 1, Belisario Domínguez - Sección XVI, Tlalpan, Mexico City, PO 14080, Mexico. Tel.: 011-52-55-5573 x2911

E-mail: drdanielmanzur@gmail.com

See page 88 for disclosure information.

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Novel Teaching Points

- One of the complications of peripheral VA ECMO is LVD.
- LVD can cause pulmonary edema, thrombosis, and refractory arrhythmias.
- Drainage of the LV with a pigtail catheter accessed through the radial artery is technically feasible.

years prior to decompensation. On admission, hypotension and tissue hypoperfusion were noted. A diagnosis of CS was established, and management with inotropes (levosimendan) and a vasopressor (norepinephrine) was started. During the clinical evaluation, he developed multiple episodes of unstable VT requiring amiodarone, lidocaine, beta-blockers, and multiple electrical shocks from the implantable cardioverter-defibrillator. Despite this therapy, the patient continued with episodes of VT, and electrical storm was diagnosed. Our centre was consulted, and our recommendation to start therapy with peripheral VA ECMO was accepted. With previous placement of an IABP through the right femoral artery, a double cannulation strategy with a femorofemoral configuration was decided. A 25-French extraction venous cannula (Medtronic, Minneapolis, MN) was inserted through the right femoral vein directed toward the mid—right atrium, and a 15-French arterial return cannula (Medtronic) was inserted through the left common femoral artery into the mid—abdominal aorta. The pulmonary flotation catheter was not placed, as we try to avoid stimulation of the right ventricle with the catheter, which could trigger more ventricular arrhythmias in a very irritable myocardium in the context of an electrical storm. Hemodynamic stability was achieved, so the patient was able to be subjected to bilateral stellate ganglion block and a VT ablation procedure. Automated isochronal late activation mapping with ablation catheter via a transseptal approach identified deceleration zones in the septum and anterior wall, and radiofrequency ablation was performed successfully in these zones. He remained stable during the procedure. Then, 12 hours later, the patient required a higher fraction of oxygen in the gas mixer, showed congestion of the vascular bed in the chest X-ray (Fig. 1), and developed LVD (despite management with inotropes and an IABP) with spontaneous echo contrast (Fig. 2A), an absence of opening of the aortic valve (Fig. 2B; Video 1, view video online), and pulmonary edema. At that time, his systemic blood pressure was 80/30 mm Hg, and the blood flow of the ECMO had to be decreased to 2.3 liters per minute to limit afterload and LVD. An Impella device was not available at that moment in our centre. Because the patient could not be transferred to the catheterization laboratory, because of extreme hypotension, a 6-French pigtail catheter (Cordis US, Miami Lakes, FL) was introduced through the left radial artery with a 6-French sheath introducer (Fig. 2C). Its passage through the aorta toward the LV cavity was guided in real time with TEE (Fig. 2D). The transgastric long-axis view in the transesophageal echocardiogram allowed us the visualization of

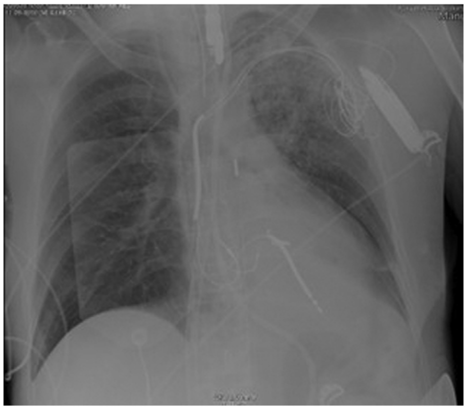

Figure 1. Chest X-ray showing congestion of the vascular bed.

the subvalvular mitral valve apparatus, including the chordae tendineae, so we were able to ensure the placement of the catheter in the mid-ventricular region without injuring these structures. The correct position of the tip was confirmed with a portable chest X-ray (Fig. 2E). Then, the pigtail catheter was connected to the extraction cannula (Fig. 2F). TEE showed resolution of LVD as well as the spontaneous echo contrast and opening of the aortic valve (Fig. 2G; Video 2, view video online). In addition, the LV end-diastolic pressure was measured, giving a value of 7 mm Hg (Fig. 2H). An increase in systemic blood pressure to 100/70 mm Hg was documented, and the blood flow of the ECMO was able to be increased to 3 liters per minute, without evidence of hemolysis. We anticoagulated the patient, with unfractioned heparin and a partial thromboplastin time target of 70—80 seconds, while using the pigtail. We used it for only 48 hours before removing it without any evidence of catheter thrombosis, limb ischemia, or neurologic issues. After 5 days of mechanical circulatory support, the patient was able to be weaned off the VA ECMO.

Discussion

One of the most feared complications that can occur during VA ECMO is LVD. VA ECMO generates increased afterload, and the LV may not be able to eject blood sufficiently. The aortic valve remains closed, and LVD may result, giving rise to elevated pulmonary artery pressures, pulmonary edema, thrombosis, and arrhythmias and hindered LV recovery.[6] Direct percutaneous drainage of the LV via the interatrial septum, or transaortically, has been described; the latter is conducted via an axillary or femoral artery approach.[7] Important to mention is that, frequently, the 2 common femoral arteries are occupied (by the IABP and the arterial cannula of the ECMO), and axillary access can be difficult to achieve percutaneously, and often requires surgical assistance.

Conclusion

In this case, we present for the first time a proposal for direct unloading of the LV by the placement of an intraventricular catheter through a radial route. Access for this method is easy to achieve and has the advantage that it can be

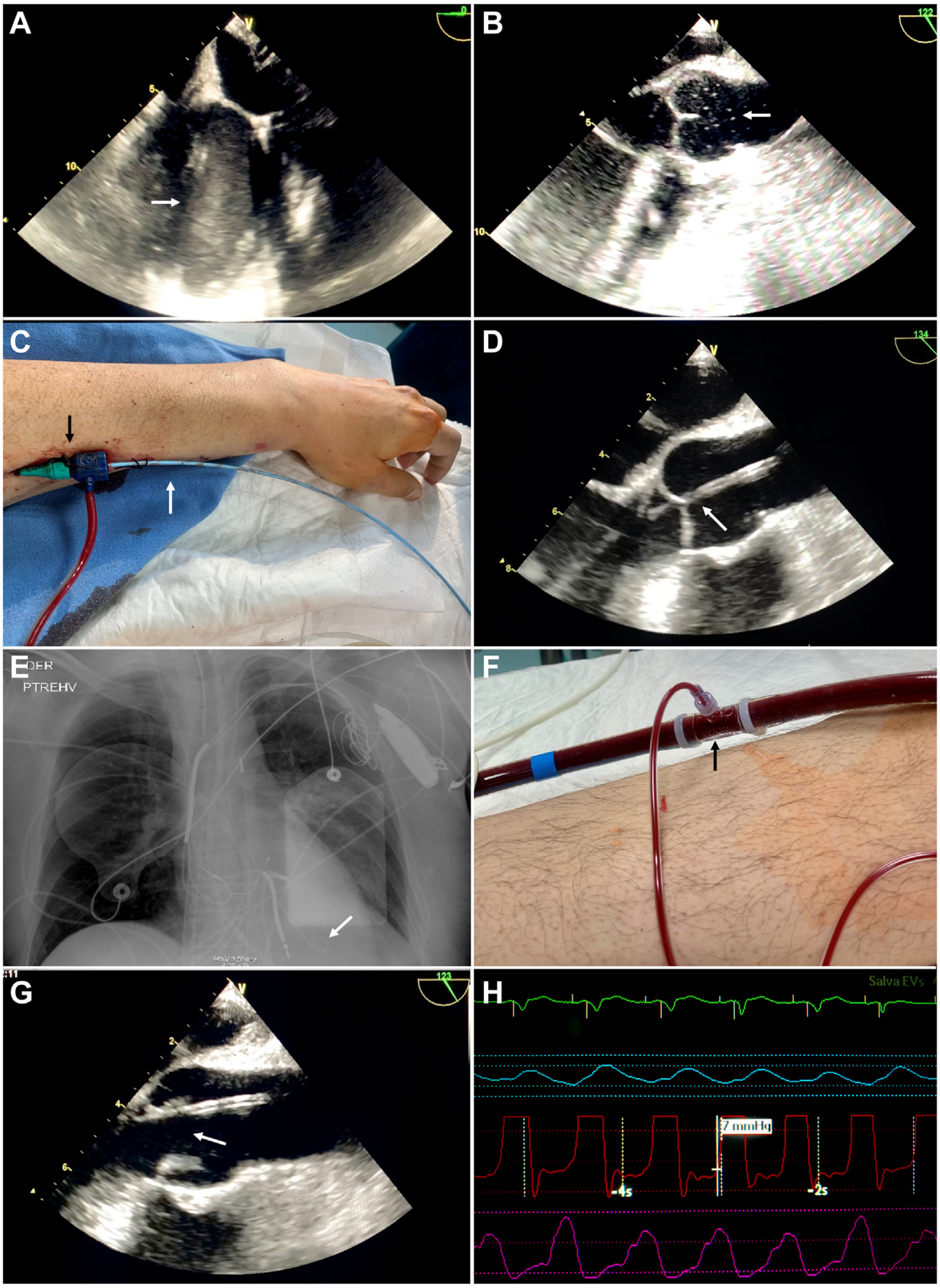

Figure 2. (**A**) Transesophageal echocardiography (TEE) 4-chamber view. Dilated left ventricle with spontaneous echo contrast (**white arrow**). (**B**) Absence of opening of the aortic valve and spontaneous echo contrast in the aortic root (**white arrow**). (**C**) Through a 6-French sheath introducer in the left radial artery (**black arrow**), a 6-French pigtail catheter is introduced to the left ventricular (LV) cavity (**white arrow**). (**D**) Real-time TEE guidance showing the catheter passage through the aortic valve (**white arrow**) into the LV cavity (3-chamber view). (**E**) Chest X-ray showing the tip of the catheter at the LV cavity (**white arrow**). (**F**) The pigtail catheter is connected directly to the extraction cannula (**black arrow**). (**G**) Real-time TEE showing the opening of the aortic valve (**white arrow**) after the drainage is initiated (3-chamber view). (**H**) LV end-diastolic pressure of 7 mm Hg is registered.

performed at the patient's bedside with echocardiographic guidance, achieving adequate discharge of the LV, using both image and hemodynamic measurements. This strategy is especially applicable in centres with limited resources or where the usual cannulation devices for LV unloading are unavailable or scarce.

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Disclosures

The authors have no conflicts of interest to disclose.

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Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at https://www.cjcopen.ca/ and at https://doi.org/10.1016/j.cjco.2022.11.003.