LETTER TO THE EDITOR

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Venoarterial extracorporeal membrane oxygenation as a bridge to surgery in ischemic papillary muscle rupture

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The prognosis of papillary muscle rupture (PMR) leading to acute mitral regurgitation and cardiogenic shock remains dismal, with survival dependent on prompt recognition and surgical intervention [1]. Papillary muscle rupture surgical repair is one of the higher-risk operations done in cardiac surgery and its outcome is poor in the presence of decreased cardiac output, hepato-renal failure and metabolic acidosis [2].

The acute hemodynamic consequences of PMR lead to rapidly progressive acute respiratory failure and severe cardiogenic shock, often refractory to conventional management, such as mechanical ventilation, inotropic support treatment and intra-aortic balloon pump (IABP) [3]. The ideal time of surgery for these patients remains unclear, and in fact a significant portion of these patients are considered too risky for immediate operative stress due to multi-organ failure (MOF).

Mortality without surgery reaches 80%, and operative mortality within 30 days of surgery ranges from 20% to 40% [4].

Venoarterial-extracorporeal membrane oxygenation (VA-ECMO) provides circulatory and/or respiratory support and immediate hemodynamic stabilization in these critically ill patients, and can be used as a bridge to surgery.

We present 2 cases of refractory cardiogenic shock due to PMR successfully supported with VA-ECMO initiated before surgical intervention.

Case series: Patient 1. A 50-year-old male patient was admitted to a peripheral hospital due to posterior wall myocardial infarction. He underwent an emergency coronary angiography and percutaneous coronary intervention (PCI) to the left circumflex (LCX) and right coronary artery (RCA) with drug-eluting stents. Transthoracic echocardiography revealed severe mitral valve regurgitation due to posteromedial PMR. Owing to refractory cardiogenic shock despite maximal conventional treatment (mechanical ventilation, inotropic support), the patient was transferred to our institute for further treatment. Upon arrival at the intensive care unit, blood pressure was 100/60 mm Hg, heart rate 150 bpm, lactate level was 4.9 mmol/l, and peripheral VA-ECMO (femoral artery cannula 17F, femoral vein cannula 22F) for hemodynamic support and clinical stabilization was initiated. Within VA-ECMO support, clinical stabilization (drop of lactate to 1.3 mmol/l) allowed cardiac surgery to be performed 4 days later, consisting in mitral valve replacement (MVR) with an ATS 27 mm mechanical valve (Medtronic, Minneapolis MN USA). During the procedure the peripheral VA-ECMO was converted to central VA-ECMO with cannulation of the ascending aorta, right atrium and left ventricular venting through the right superior pulmonary vein.

On postoperative day (POD) 4 the central VA-ECMO was explanted. The postoperative course of the patient was complicated with several re-explorations due to severe postoperative bleeding (diffuse mediastinal bleeding) and tamponade, renal replacement therapy, tracheostomy due to respiratory insufficiency, herpes simplex infection, postoperative atrial fibrillation, and postoperative stroke with subacute infra- and supra-tentorial ischemic lesions. On POD 34, after neurologic recovery, the patient was transferred to a peripheral hospital for further treatment and rehabilitation.

Patient 2. A 63-year-old patient with progressive dyspnea and week-long angina pectoris symptoms was transferred to our hospital for further treatment. From the medical history, the patient in the past had a lateral wall myocardial infarction with implantation of a bare metal stent in the obtuse marginal artery. Upon arrival the patient was in cardiogenic shock with mechanical ventilation and maximal inotropic support, blood pressure 75/45 mm Hg, heart rate 123 bpm and a lactate value of 8.4 mmol/l. Urgent coronary angiography showed a 65% stenosis of the left anterior descending artery (LAD) and occlusion of the first obtuse marginal artery. Transesophageal echocardiography showed severe mitral valve regurgitation due to anterolateral PMR. Owing to refractory cardiogenic shock despite maximal conventional treatment, a peripheral VA-ECMO (femoral artery cannula 17F, femoral vein cannula 22F) was implanted for hemodynamic stabilization. Within VA-ECMO support, there was hemodynamic stabilization and gradual

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decrease of the lactate levels to 2 mmol/l; the next day, the patient underwent MVR with a mechanical valve ATS 29 mm (Medtronic, Minneapolis MN USA). Three days later, due to harlequin syndrome (the upper part of the body was poorly oxygenated due to impaired native pulmonary oxygenation, while the lower part of the body was oxygenated retrogradely by the VA-ECMO circuit) anterograde axillary cannulation with a 20F cannula through a Gelsoft (Terumo Aortic, Renfrewshire UK) 8 mm graft was established. On POD 6 the VA-ECMO was explanted. The postoperative course was complicated with a re-exploration due to severe postoperative bleeding (diffuse mediastinal bleeding) and tamponade, tracheostomy due to respiratory insufficiency that required renal replacement therapy, and postoperative ischemic stroke with quadriparesis. Moreover, during his hospitalization the patient needed enteral and parenteral feeding. On POD 78 after neurologic recovery, he was discharged to a rehabilitation center for further treatment in a stable condition.

Concerning the use of IABP, it is a policy of the center to skip its adoption in the setting of post-MI mechanical complications. It was used until the year 2018. Since then, peripheral VA-ECMO has been the first choice as a bridge to definite treatment because it offers better hemodynamic support than IABP and allows improvements in end-organ failures.

Moreover, a femoral shunt was not used in these 2 patients. In our opinion the use of smaller cannulae (both patients had 17F arterial cannulae) is safe, provides adequate flow and prevents the limb ischemia complications that are caused by larger cannulae. We closely monitor limb perfusion and, in the event of ischemia, a distal perfusion cannula is immediately inserted.

Both patients during VA-ECMO support received intravenous inotropic treatment. Initially, after full VA-ECMO support, in the postoperative period daily weaning trials took place. The weaning process was monitored using hemodynamic assessment and application of transthoracic and transesophageal echocardiogram studies. Studies were performed with full and 50% reduced support. After a reduction of 50%, if the left ventricle showed any signs of recovery (maintaining mean arterial pressure (MAP), ejection fraction (EF) > 30%) a bolus of heparin was given, and the VA-ECMO flow was reduced to a minimum of 1 l and then was stopped. The patient is considered weanable if the following criteria are fulfilled: MAP > 65 mm Hg, EF > 30%, central venous pressure < 18 mm Hg and minimal inotropic support.

The patient's written consent was obtained to present this report.

Papillary muscle rupture is a rare but often fatal mechanical complication of acute myocardial infarction. It causes acute severe mitral regurgitation, frequently resulting in acute pulmonary edema, cardiogenic shock, or both.

In our case series, peripheral VA-ECMO support allowed immediate respiratory and circulatory support by restoring hemodynamics, providing time and hemodynamic stability for the necessary diagnostic workup and surgical intervention, while reversing organ damage and metabolic acidosis. Furthermore, these patients are at a particularly high risk for post-cardiotomy shock and remain dependent upon mechanical circulatory support in the first postoperative days.

The use of VA-ECMO as a bridge to cardiac surgery in critical cardiac surgical illness is certainly gaining traction and there is evidence that is an efficacious strategy in a significant portion of patients, as demonstrated by quite a number of case reports.

The literature relating to the use of peripheral VA-ECMO in the context of PMR is limited to isolated successful case reports [5, 6] and as a part of case series [7–10].

Obadia *et al.* and Alam *et al.* [5, 6] reported the use of preoperative peripheral VA-ECMO in 65- and 69-year-old male patients who presented with cardiogenic shock after ischemic posteromedial PMR. In both patients the VA-ECMO was explanted on POD 5 after MVR with a biologic valve.

Dobrilovic *et al.* [7] reported the outcome of 12 consecutive candidates for various cardiac procedures (1 with ischemic PMR), placed on peripheral VA-ECMO as a bridge to definite surgery. The preoperative support of the patient with ischemic PMR was 91 hours. He underwent MVR and coronary artery bypass grafting (CABG) to the LCX. The peripheral VA-ECMO was successfully explanted 22 hours after the operation with no hospital mortality. In a cohort of 12 patients with cardiogenic shock requiring surgical treatment (4 of whom had ischemic PMR), Watkins *et al.* [8] demonstrated the benefit of preoperative peripheral VA-ECMO in patients with prohibitive risk of mortality. The mean VA-ECMO duration was 6.7 ±4.3 days.

Pinto *et al.* [9] observed in a series of 4 patients with severe mitral valve regurgitation and cardiogenic shock, 3 of whom had ischemic PMR, the beneficial effect of preoperative peripheral VA-ECMO. The age of the 3 patients was 65 (posteromedial PMR), 73 (anterolateral PMR) and 38 (anterolateral PMR) years. Two patients underwent MVR with a biologic valve and CABG, while the third patient underwent isolated MVR with a mechanical valve. The peripheral VA-ECMO was explanted on day 3, day 8, and day 20 respectively. Recently, DiVita *et al.* [10] reported in a case series of 2 patients (1 with ischemic PMR) the successful use of TandemHeart (TH) ECMO (LivaNova, London, UK) as a bridge to reparative surgery, in a 49-year-old male patient who presented with severe mitral valve regurgitation and cardiogenic shock due to posteromedial PMR. The patient underwent successful re-implantation of the ruptured papillary muscle, mitral annuloplasty and CABG.

Peripheral cannulation through the femoral vessels is the preferred implantation technique in our institute, and based on our experience we prefer smaller arterial cannulae in order to prevent distal limb ischemia. Anticoagulation, left ventricular unloading and weaning strategies were discussed thoroughly previously [11, 12].

In conclusion, the use of peripheral VA-ECMO as a bridge to surgical repair allowed us to successfully man-

age these 2 patients with no hospital mortality, and despite the complicated postoperative course, mainly neurologic complications, they were both discharged.

Disclosure

The authors declare no conflict of interest.

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