Case Report

Fatal pulmonary hemorrhage due to severe mitral regurgitation during venoarterial extracorporeal membrane oxygenation

ABSTRACT

Pulmonary hemorrhage (PH) during venoarterial extracorporeal membrane oxygenation (VA-ECMO) has been primarily reported in pediatric patients. We report a case of fatal PH during VA-ECMO for cardiogenic shock after myocardial infarction (MI). PH, in this case, was secondary to a triad of aortic insufficiency, left ventricle distension, and severe laminar mitral regurgitation. This case scenario, previously unreported in adults, illustrates the need for the echocardiographic assessment of left-sided heart valves prior to VA-ECMO initiation after MI as well as management considerations for massive PH in this context.

Key words: Echocardiography; pulmonary hemorrhage; venoarterial extracorporeal membrane oxygenation

Introduction

Pulmonary hemorrhage (PH) during venous-arterial extracorporeal membrane oxygenation (VA-ECMO) is a potentially catastrophic event. Outside the pediatric context, there is a paucity of any literature involving adults with PH during VA-ECMO. We present such a case for two purposes: 1) to highlight the importance of echocardiography, especially of the left-heart valves, prior to ECMO initiation and 2) discuss management options for PH due to severe MR during VA-ECMO.

Case History

A 64-year-old woman with a past medical history significant only for hypertension was brought to the hospital due to altered mental status. On examination, heart rate was 69 beats-per-minute, respiratory rate 32 breaths-per-minute, blood pressure 129/115 mmHg, and oxygen saturation 83% on 100% FiO_2. Initial laboratory studies were normal including a troponin-I of 0.017 ng/mL (reference <0.06 ng/mL). The only abnormal initial laboratory finding was an elevated N-terminal pro-brain natriuretic peptide of 324 pg/mL (normal lab reference <125 pg/mL). Electrocardiogram demonstrated possible septal infarction. 10 min after arrival, she lost consciousness and pulses were unpalpable. Initial cardiopulmonary resuscitation (CPR) management included tracheal intubation, epinephrine, amiodarone, bicarbonate, magnesium, and calcium. She was defibrillated with 200 biphasic joules for ventricular fibrillation with the subsequent rhythm pulseless electrical activity. Following <5 min of CPR, preparation for VA-ECMO was

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made, a single 5000 unit bolus of unfractionated heparin was administered, and 4-French venous sheaths were placed in the right common femoral artery and left common femoral vein. The left common femoral vein was cannulated with a 27-French venous cannula and the right femoral artery was cannulated with a 15-French arterial cannula. Cannulas were connected to the ECMO circuit under crystalloid flush and pump flow was increased to 3.5 L/min. The venous cannula terminated at the inferior cavoatrial junction and the arterial cannula terminated in the right common iliac artery, both confirmed by abdominal computed tomography (CT). Chest CT revealed no potential etiology for the cardiac arrest; however, lung findings included severe diffuse interstitial thickening with alveolar ground-glass appearance. The patient required multiple vasopressors to maintain a mean arterial pressure >65 mmHg and within 30–60 min of ECMO initiation, hemoptysis was noted in the ventilator circuit.

Despite adjustments to cannulas, ECMO flow rates declined and she concurrently developed massive PH. Her endotracheal tube (ETT) was clamped and disconnected from ventilation with oxygenation provided entirely by the VA-ECMO circuit. Due to the ongoing PH, no additional anticoagulation was given other than the initial 5000 units of heparin. Activated clotting time was 361 and 186 s at 3 and 6 h after cannulation, respectively. 6 h after presentation troponin-I peaked at 36.0 ng/mL. Transesophageal echocardiography (TEE) demonstrated a left ventricle (LV) ejection fraction of 10%, anterior and lateral wall akinesis, severe mitral regurgitation (MR) [Figure 1], and moderate aortic insufficiency (AI) [Figure 2]. 12 h after the presentation, the patient's family decided on comfort care measures only.

Discussion

PH after initiation of ECMO is well-described in pediatric patients; however, similar reports are lacking in the adult population.[1-3] Typically related to anticoagulation management, commonly reported bleeding sites during ECMO aside from the pulmonary system, include brain, retroperitoneum, gastrointestinal tract, cannulation insertion sites, and recent surgical sites.[2,4] Harrison *et al.* presented a PH case during VA-ECMO; however, the etiology in this instance was related to pulmonary-artery catheter manipulation.[2] The etiology of the fatal PH in our presented case was attributed to an aggregate of multiple issues beginning with her initial underlying AI leading to retrograde ECMO flow and LV distension. It is unknown the degree of any preexisting MR but based on the limited TEE, her left atrium was not dilated; hence, it was unlikely that chronic severe MR was present prior to her presentation. The severe MR was likely acute and a result of LV and papillary muscle dysfunction in the context of a large acute myocardial infarction (MI). Ultimately, the triad of AI, distended LV, and severe MR all led to the pulmonary system being exposed to retrograde ECMO flows.

Echocardiography

During VA-ECMO, significant MR may be associated with PH but may also lead to pulmonary edema and alveolar disruption without hemorrhage.[5] In a review of echocardiography for ECMO, Doufle *et al.* advocate for a complete echocardiographic examination prior to ECMO initiation. The need for VA-ECMO implies the presence of severe LV systolic dysfunction and in the context of an acute MI implies a high likelihood of concomitant mitral valve dysfunction.[5] The reported incidence of new MR during an acute MI depends on the method of evaluation, preexisting cardiac pathology, treatments instituted during MI evolution, and timing of the MR evaluation. The incidence of acute MR in patients with an acute MI ranges from 1.6% when assessed by ventriculography to as high as 74% when assessed by echocardiography.[6] In terms of the aortic valve, initiation of VA-ECMO increases LV afterload and predictably

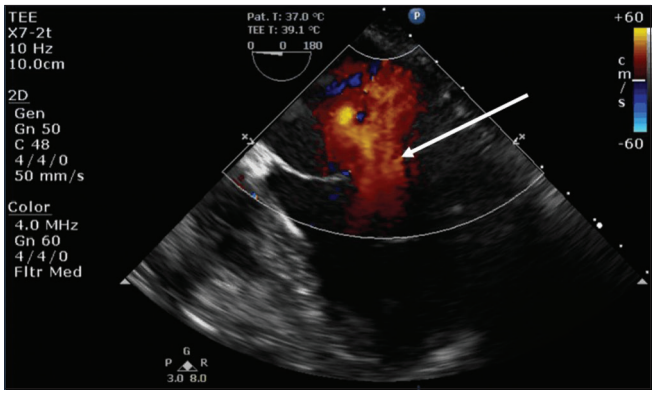

Figure 1: Mid-esophageal four-chamber transesophageal echocardiography still image demonstrating severe mitral regurgitation (arrow)

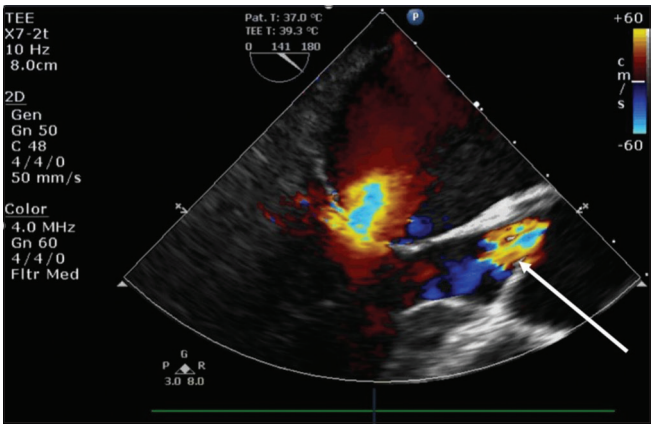

Figure 2: Mid-esophageal long-axis transesophageal echocardiography still image demonstrating a moderate degree of aortic insufficiency (arrow)

exacerbates preexisting AI causing LV distention. Increasing LV pressure and distension worsen existing ischemic severe MR which risks exposing the pulmonary system to excess pressure with resultant pulmonary edema or PH. Moreover, LV distention leads to increased LV myocardial wall stress and risks worsening subendocardial ischemia due to increased myocardial oxygen consumption.[5] Hence, at a minimum and hemodynamics permitting, all acute MI patients being considered for VA-ECMO need both mitral and aortic valves assessed by echocardiography to mitigate against pulmonary injury and PH.

Pulmonary hemorrhage

PH is a life-threatening condition of bleeding from pulmonary or bronchial vasculature with a mortality rate exceeding 50%.[7] In our case, the patient was on VA-ECMO when massive hemoptysis was observed in her ETT and ventilator circuit. This treatment of PH by tamponade with a clamped ETT with ventilation and oxygenation by ECMO alone has been reported.[8] However, clamping or occluding an ETT in order to manage PH implies that intra-airway and intravascular pressures will ultimately equalize. Until pressure equalization occurs, continued PH may significantly reduce the ECMO circuit preload resulting in reduced arterial circuit flow, a scenario that may have contributed to the refractory hypotension in our case. Moreover, this tamponade process may be prolonged and ultimately lead to no ability for pulmonary gas exchange. Alternatively, the use of high positive-end expiratory pressures (PEEP) in lieu of ETT clamping may be attempted as a means to mitigate against both lungs becoming completely fluid- or clot-filled lowering the chances for recovery without potential lung transplantation.

Other treatment options include minimizing the use of systemic anticoagulation during ECMO as a means of minimizing bleeding that was extant (i.e. Goodpasture syndrome-related PH) or de-novo during the ECMO period.[9] Arterial embolization, cold saline irrigation, bronchial and vasoconstrictor medication lavage have also been reported.[7] These were not attempted in our case as the hemoptysis was massive and the patient too hemodynamically unstable for any transport.

Left ventricle distension

As previously discussed, AI during VA-ECMO leads to LV distension with resultant worsening of underlying MR, potentially contributing to PH and increased myocardial oxygen demand. Furthermore, the bronchial circulation and aortopulmonary collateral vasculature both return a significant volume of blood to the heart further contributing to LV distension.[5] Therefore, decompression is required when LV distension is associated with complications as demonstrated in our case; however, some of these strategies are contraindicated in the context of AI. For example, the use of mechanical assist devices such as an intra-aortic balloon pump or Impella (Abiomed, Danvers, MD), a miniaturized rotary pump which moves blood from the LV-outflow tract to ascending aorta, are contraindicated in more than mild AI. Hence, these options were not suitable for our patients. Another strategy includes decompression at the level of the left atrium (LA) by way of an interatrial septostomy or interatrial device placement. Balloon septostomy has been used in severe heart failure and hypoxemia and there are reports of using devices such as a fenestrated Amplatzer occluder (Abbott Vascular Inc., Santa Clara, CA) to create a Fontan-like fenestration and interatrial connection to decrease LA pressure.[10] Balloon septostomy and interatrial cannula have both been successfully used to wean ECMO patients with severe LV dysfunction and concomitant pulmonary edema or PH.[11] The V-Wave device (V-Wave Ltd, Caesarea, Israel), approved for pulmonary arterial hypertension and heart failure, is one of the newest iterations of these devices engineered to act as "transseptal stent" creating a restrictive left-to-right shunt.[12]

In summary, consideration for VA-ECMO after acute MI warrants a pre-cannulation echocardiographic examination to evaluate for significant left-sided valvular pathology. Should significant PH occur during VA-ECMO, management options include minimizing or eliminating systemic anticoagulation, ETT clamping or ventilation with high PEEP, and possible left atrium decompression

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Conflicts of interest

There are no conflicts of interest.

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