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LETTER TO THE EDITORS

Biventricular impella (BiPella) utilization in fulminant COVID-19 myopericarditis-mediated cardiogenic shock during pregnancy

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Sirs,

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a respiratory virus that can present with cardiac involvement such as myopericarditis. Although many cases of myopericarditis are mild, cardiogenic shock is a feared complication and requires hemodynamic support. The impella® (ABIOMED, Danvers, MA) is an axial flow pump and percutaneous assist device that provides continuous circulatory support throughout the cardiac cycle. We report a unique case of cardiogenic shock secondary to COVID-19 myopericarditis in a pregnant patient managed with implantation of impella 5.0® and impella RP®. The biventricular impella approach allows for concurrent mechanical circulatory support to both a failing right and left ventricle.

A 28-year-old woman with no significant medical history presented to the emergency department with subacute onset fatigue, cough, chest pain, and vomiting. The patient was 7 weeks pregnant (G1P0A0). The initial physical exam was only significant for tachycardia with a regular rhythm. An electrocardiogram revealed sinus tachycardia. The initial serum laboratory values were significant for an elevated troponin of 1.45 ng/mL, lactic acid of 2.2 mmol/L (normal: 0.5–2.1), and a normal C-reactive protein of 1.1 mg/dL (normal: < 10). The patient tested positive for SARS-CoV-2 by nasopharyngeal swab in real-time polymerase chain reaction (RT-PCR) and was started on remdesivir and dexamethasone. The patient was previously unvaccinated against COVID-19. A pelvic ultrasound confirmed the presence of a live intrauterine pregnancy. A transthoracic echocardiogram (TTE) showed a severely reduced left ventricular ejection fraction (LVEF) of 15%, impaired right ventricular systolic function, and a moderate sized pericardial effusion with cardiac tamponade. Thus, a pericardiocentesis was completed and a pericardial drain was placed. The patient was subsequently transferred to the cardiac critical care unit. Left heart catheterization did not reveal significant coronary artery stenosis. A low pulmonary artery pulsatility index (PAPi) of 0.3, central venous pressure (CVP) of 16.5 mmHg, and cardiac power output (CPO) of 0.6 W was measured from the pulmonary artery catheter. A multidisciplinary discussion was held by the critical care team and the collective decision was made to initiate mechanical circulatory support. This decision was made based on the patient's deteriorating hemodynamic parameters on inotropes, and Society for Cardiovascular Angiography and Interventions (SCAI) stage C status. The patient had an impella 5.0® implanted. Due to persistent RV failure within 24 h, an impella RP® was implanted (BiPella concept). Figure 1 provides relevant hemodynamic parameters during her course in the ICU. Figure 2 visually depicts the patient's ICU course with dynamic management strategies and critical events. Figure 3 provides a fluoroscopic image of impella 5.0 and impella RP placement.

On the fourth day, the patient acutely deteriorated and a focused assessment with ultrasound for trauma (FAST) revealed gross free fluid throughout the abdomen. A CT angiogram of the abdomen demonstrated hemoperitoneum. The patient required 11 units of packed red blood cells, 4 units of platelets, and 4 units of cryoglobulin for adequate resuscitation. An angiogram revealed blushing of the left phrenic artery which was subsequently embolized. The hemoperitoneum was likely iatrogenic secondary to the pericardiocentesis. In addition to this, the patient's anti-Xa levels were supratherapeutic. Therefore, the heparin purge for both impella CP and RP was reduced by 1/4. After successful embolization and

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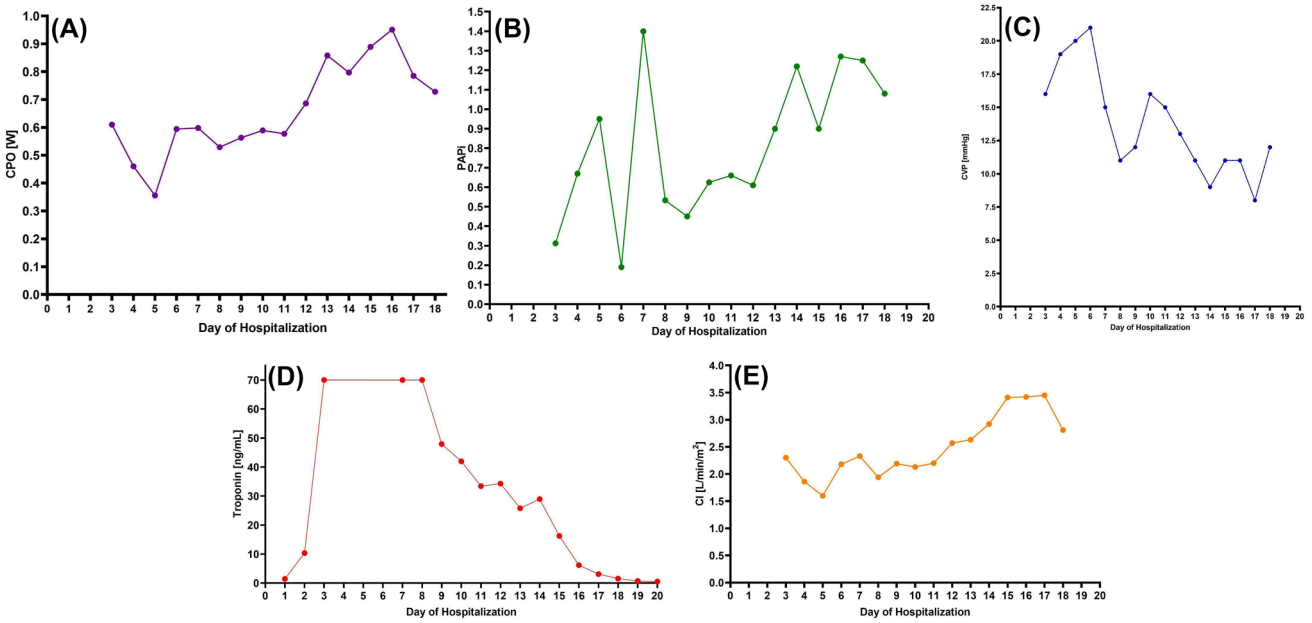

Fig. 1 Hemodynamic parameters recorded using a pulmonary artery catheter during hospitalization. This includes **A** cardiac power output (CPO). **B** Pulmonary artery pulsatility index (PAPi). **C** Central venous pressure (CVP). **D** Serum troponin. **E** Cardiac index (CI)

monitoring, the heparin purge was increased and anti-Xa levels were monitored every 6 h to ensure a therapeutic range. With increased abdominal distension, the transbladder approach was taken to assess intra-abdominal pressure (IAP). The bladder pressure was > 25 mmHg consistent with intra-abdominal hypertension grade IV and highly suspicious of abdominal compartment syndrome. An exploratory laparotomy was completed with successful evacuation of the hemoperitoneum, and negative pressure wound therapy. The patient developed respiratory distress, and a chest radiograph confirmed extensive bilateral alveolar infiltrates consistent with acute respiratory distress syndrome. She was then intubated and mechanically ventilated. On the ninth day of hospitalization, a pelvic ultrasound confirmed the miscarriage.

Her hospital course was further complicated by acute kidney injury from cardiogenic shock that required continuous veno-venous hemofiltration (CVVH). There was steady improvement in the PAPi, cardiac index (CI), and CPO, with stabilization of the central venous pressure (CVP). The patient was successfully managed thereafter with weaning from vasopressors and mechanical circulatory support with explant of both impella RP and impella CP on the 17th day of hospitalization. She was then extubated and discharged to a rehabilitation center with hemodialysis three times a week. A 6-month follow-up echocardiogram showed an LVEF of 62% and normal RV systolic function. At a 1-year follow-up appointment, the patient had recovered from her critical illness and is currently being evaluated for kidney transplantation.

The case of a 28-year-old woman with severe biventricular cardiogenic shock secondary to COVID-19 myopericarditis during pregnancy with successful BiPella support is described. Her hospital course was complicated by spontaneous abortion, hemorrhagic shock, compartment syndrome, and acute kidney injury. The prognosis of patients with biventricular cardiogenic shock is poor. They might benefit from cardiac support with biventricular impella; however, evidence is lacking [1]. Until now, only one case of BiPella use for COVID-19-mediated cardiac disease has been reported in the literature and only a few cases with a single impella device [2, 3]. There is a paucity of evidence on the mechanism by which SARS-CoV-2 causes cardiac infiltration and disease. However, histopathological examination of the myocardium in COVID-19 patients in autopsy reports show multifocal lymphocytic myocarditis and interstitial macrophage infiltration [4, 5].

The CPO [CPO = MAPxCO/451] is measured in watts (W) and is a measure of tissue perfusion [6]. The PAPi is a correlation between the pulmonary artery pulse pressure and right atrial pressure and is a predictor of RV failure. Poor RV dysfunction is characterized by a PAPi < 0.9 and CPO < 0.6 and consideration for RV mechanical circulatory support (MCS) should be given, especially in the context of ongoing LV support [7]. A CPO < 0.53 is associated with a mortality rate of approximately 50% [6]. Similarly, a low

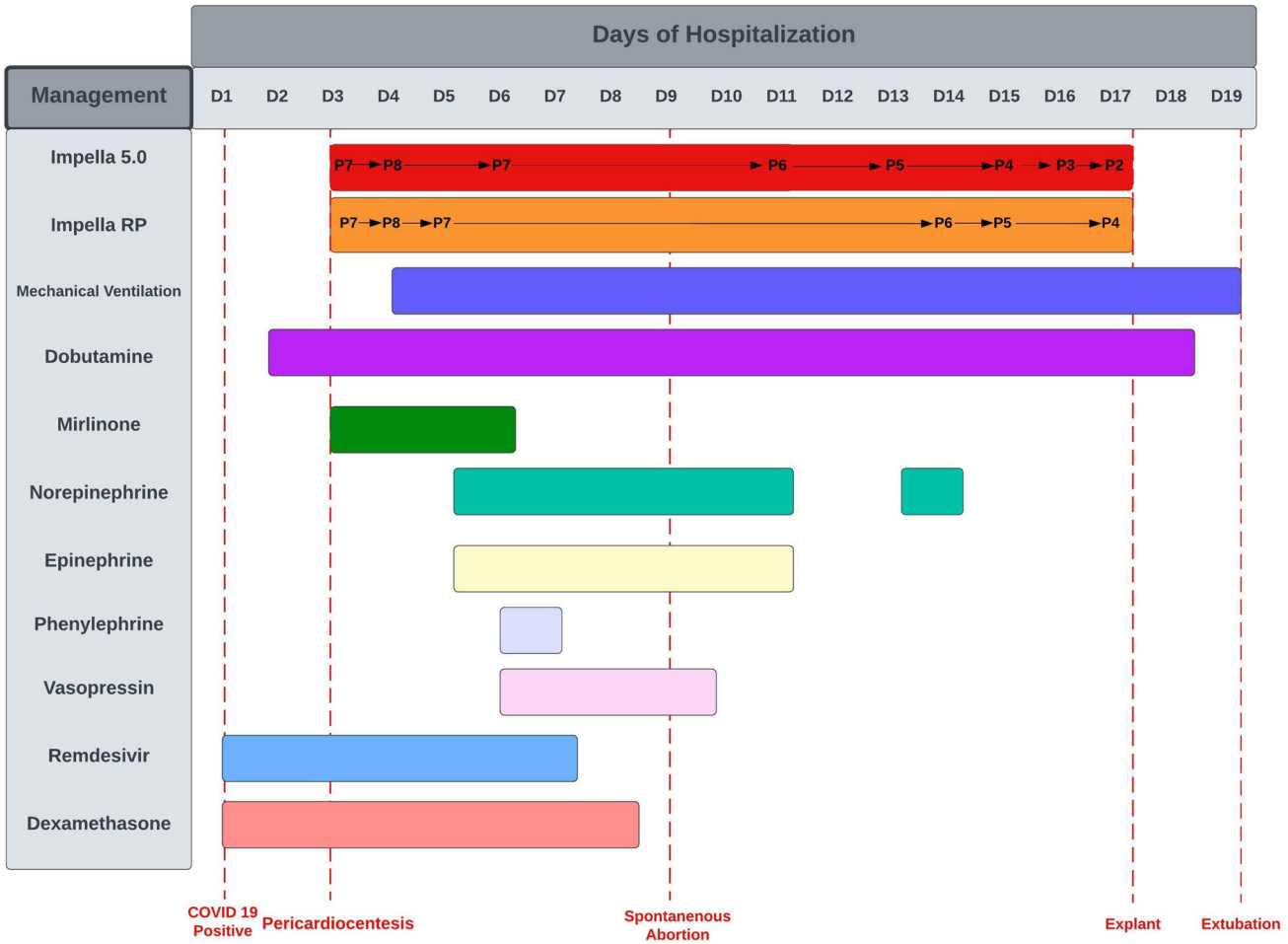

Fig. 2 Visual depiction of the patient's hospital course. Interventions include mechanical circulatory support, ventilation, and vasopressors utilized. Key events including positive test result for SARS-CoV-2 on presentation, pericardiocentesis on day 3, spontaneous abortion on day 9, explant of biventricular impellas on day 17, and extubation on day 19. Relevant power settings for impella 5.0 and impella RP are included

PAPi is closely associated with an increase in all-cause mortality and adverse cardiac events [8]. In our patient, the CPO trough was measured during the third and fourth days of hospitalization, and low PAPi measurements (< 0.9) were recorded during the first 2 weeks. A gradual improvement in hemodynamic parameters was observed with continued MCS. Depending on local expertise, an alternative approach with VA-ECMO was also an option in this patient which has the advantage to provide oxygen. As a possible disadvantage, VA-ECMO might increase the afterload of the LV while impella unloads the ventricle. Bleeding, ischemic, and thrombotic complications can occur in both situations. [9]. Major strengths of our case include the reporting of longitudinal hemodynamic data during ICU admission. Limitations include the lack of myocardial biopsy. In conclusion, this case highlights that severe cardiogenic shock can occur due to myopericarditis secondary to COVID-19. The BiPella concept can be successfully utilized in these patients.

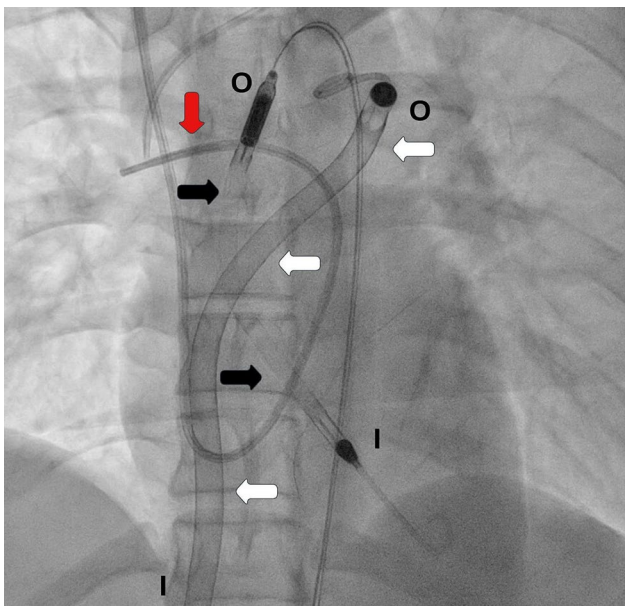

Fig. 3 Fluoroscopic image showing pulmonary catheter (red arrow). The impella 5.0 (black arrows) and impella RP (white arrows). I = inlet, and O = outlet for each respective impella device

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Data availability Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Declarations

Conflict of interest On behalf of all the authors, the corresponding author states that there are no competing or conflicts of interest.

Consent to publish The participant has consented to the submission of the case report to the journal.

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