Case Reports

Impella RP Support and Catheter-Directed Thrombolysis

to Treat Right Ventricular Failure Caused by Pulmonary Embolism in 2 Patients

Mohamed Shokr, MD
Ahmed Rashed, MD
Ashraf Mostafa, MD
Tamam Mohamad, MD
Theodore Schreiber, MD
Mahir Elder, MD
Amir Kaki, MD

Right ventricular failure secondary to pulmonary embolism is associated with morbidity and death. The Impella RP System has often been used for percutaneous mechanical circulatory support in patients with right ventricular failure from other causes, including myocardial infarction, cardiac surgery, and left ventricular assist device implantation. We report 2 cases of massive pulmonary embolism in which combined Impella RP use and ultrasound-assisted catheter-directed thrombolysis effectively treated shock caused by right ventricular failure and contributed to successful outcomes. To our knowledge, only one other patient with this indication had been treated with the Impella RP device. ***(Tex Heart Inst J 2018;45(3):182-5)***

Key words: *Catheterization, peripheral/instrumentation; combined modality therapy; equipment design; heart-assist devices; pulmonary embolism/complications/therapy; recovery of function; thrombolytic therapy; treatment outcome; ultrasonic therapy/instrumentation; ventricular dysfunction, right/physiopathology/therapy*

From: *Department of Cardiovascular Medicine, Detroit Medical Center/Wayne State University, Detroit, Michigan 48201*

Address for reprints: *Mohamed Shokr, MD, Department of Cardiovascular Medicine, Detroit Medical Center/Wayne State University, Detroit, MI 48201*

E-mail: *mshokr@med.wayne.edu*

The risk of death associated with hemodynamic instability in pulmonary embolism (PE) is 30% to 50%.[1] Management of the resultant acute right ventricular (RV) failure can be challenging because currently available medical and device-based options for hemodynamic support are not always effective and can be technically demanding. The Impella RP® System (ABIOMED) has been used clinically for percutaneous mechanical circulatory support in a variety of cases of RV failure, so we used it to treat 2 patients with RV failure caused by PE. Treatment was facilitated through the use of ultrasound-assisted catheter-directed thrombolysis from the EKOS® EndoWave Infusion Catheter System (EKOS Corporation). We discuss these patients' cases here.

Case Reports

Patient 1

A 52-year-old woman with a history of hypertension and lower-extremity cellulitis presented with acute dyspnea. Her heart rate was 120 beats/min; blood pressure, 85/55 mmHg; and oxygen saturation, 87% on room air. Her brain natriuretic peptide and cardiac troponin I levels were elevated. Echocardiograms revealed a severely dilated and hypokinetic RV, mild tricuspid regurgitation, and an RV systolic pressure of 49 mmHg. A computed tomogram showed bilateral PEs involving the left and right main pulmonary arteries (PAs) and extending to the lobar branches (Fig. 1), and the RV/left ventricular (LV) ratio was 2.2. The patient's Pulmonary Embolism Severity Index (PESI) score[2] was 142.

We performed ultrasound-assisted catheter-directed thrombolysis with use of the EKOS catheter, delivering a total of 11 mg of alteplase (bolus plus infusion) bilaterally into the PAs over 6 hours (Fig. 2). Despite a substantially reduced thrombus burden and maximal doses of dobutamine and milrinone, the patient remained hypotensive and tachycardic secondary to acute RV failure. Her cardiac index was 1.9 L/min/m^2; cardiac output, 4.7 L/min; mixed venous oxygen saturation (MVO_2), 41%; mean right atrial pressure (RAP), 19 mmHg; mean PA pressure, 33 mmHg; and PA pulsatility index, 0.68.

Using an Impella RP, we instituted percutaneous support through the right femoral vein into the left PA. The device's inflow was in the proximal inferior vena cava to unload the RV, ensure adequate LV preload, and optimize tissue perfusion. Subsequently, the patient's pulmonary and hemodynamic function improved: MVO_2, 70%;

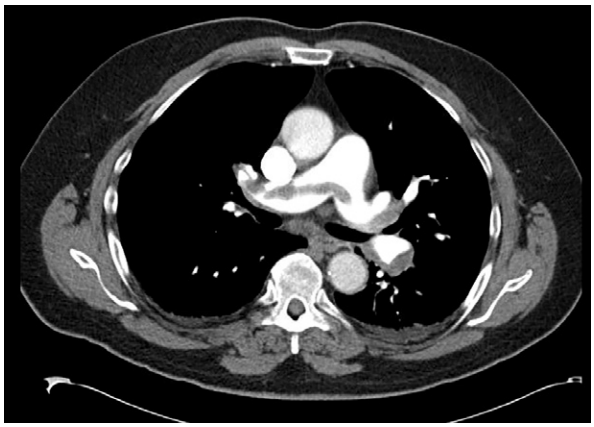

Fig. 1 *Patient 1. Computed tomographic angiogram shows a pulmonary embolus extending into the right and left pulmonary arteries.*

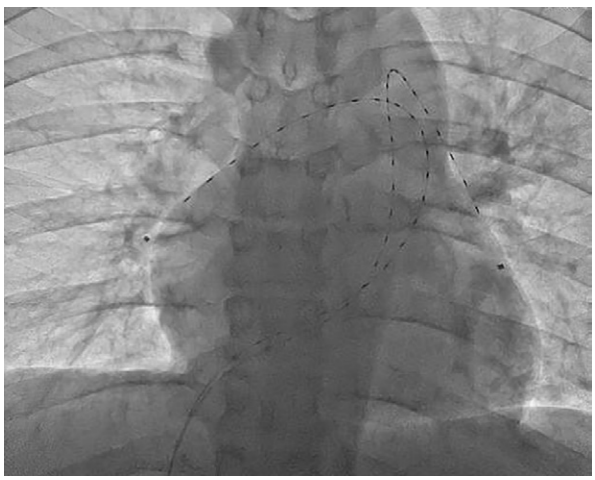

Fig. 2 *Patient 1. Fluoroscopic image (anteroposterior view) shows bilateral EKOS catheters extending into the right and left pulmonary arteries.*

cardiac output, 7.9 L/min; cardiac index, 3.5 L/min/m^2; mean RAP, 12 mmHg; and PA pulsatility index, 1.5. Her mean PA pressure remained 33 mmHg.

During the next 5 days, the patient was weaned from the device and inotropic support. A final echocardiogram showed substantially improved RV systolic pressures and modestly improved RV function and size. She was discharged from the hospital in stable condition, with apixaban prescribed.

Patient 2

A 72-year-old man with a history of hypertension presented with dyspnea and right-lower-extremity swelling. He was hemodynamically stable. Venous duplex ultrasonograms confirmed right femoral vein thrombosis. At the bifurcation of the pulmonary trunk, a computed tomogram showed a filling defect extending into both main PAs, consistent with saddle embolism.

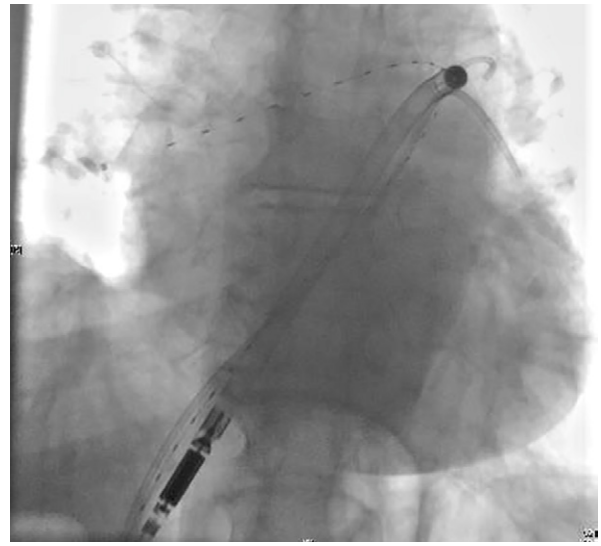

Fig. 3 *Patient 2. Fluoroscopic image (left anterior oblique view) shows the EKOS catheter extending into the right pulmonary artery. Also seen are the right ventricle, the Impella RP, and a Swan-Ganz catheter.*

The patient's RV/LV ratio was 1.2, and his PESI score was 132. Echocardiograms revealed severely increased RV size, an RV ejection fraction of 0.10, dilated and akinetic mid-apical free-wall segments, and an RV systolic pressure of 47 mmHg. He underwent ultrasound-assisted catheter-directed thrombolysis with use of an EKOS catheter (Fig. 3); a total of 35 mg of alteplase was infused over 14 hours. One day later, he became hypotensive and tachycardic; his oxygen saturation was 86% on 4 L of oxygen. Despite a 10-μg/kg/min dobutamine infusion, he remained hypotensive and had a cardiac index of 2 L/min/m^2; cardiac output, 4.4 L/min; MVO_2, 59%; mean RAP, 15 mmHg; mean PA pressure, 41 mmHg; and PA pulsatility index, 1.06. We inserted an Impella RP through the patient's right femoral vein into the left PA with the inflow in the proximal inferior vena cava (Fig. 3). Subsequently, his pulmonary and hemodynamic function improved: MVO_2, 68%; cardiac output, 7.1; cardiac index, 3.1; mean RAP, 22 mmHg; mean PA pressure, 33 mmHg; and PA pulsatility index, 1.27.

During the next 4 days, the patient was weaned from the device and inotropic support. A final echocardiogram revealed substantially improved RV size and systolic pressure, and mildly improved systolic function. He was discharged from the hospital in stable condition, with apixaban prescribed.

Discussion

Right ventricular failure can complicate cardiac surgery, heart transplantation, LV assist device implantation, acute myocardial infarction, myocarditis, and PE.[3]

Pulmonary emboli, especially massive and submassive, can lead to increased RV afterload and failure; the associated morbidity and mortality rates are substantial.[4] Management options include thrombolysis, cautious fluid resuscitation, inotropic support, vasodilators, and vasopressors. The use of extracorporeal membrane oxygenation (ECMO), surgically implanted RV assist devices, and the TandemHeart® Percutaneous Ventricular Assist Device (LivaNova PLC) has also been reported.[5] To our knowledge, percutaneous RV support through use of the Impella RP has been reported only once in the presence of PE.[6] Our 2 patients benefited from combined Impella RP support and ultrasound-assisted catheter-directed thrombolysis in the treatment of their massive PEs.

Medical therapy for severe RV failure often has poor outcomes.[7] Short-term percutaneous mechanical support devices are a potential alternative. Pumps that generate continuous flow with a minimal, low-amplitude pulsatile component may more closely mimic native RV function.[8]

The Impella RP is a catheter-mounted microaxial pump designed for temporary RV support through single-vein access. Its 23F pump head contains an electric motor, axial blood pump, and outflow cannula mounted on an 11F catheter. It is inserted percutaneously through the femoral vein and advanced across the pulmonary valve into the PA under fluoroscopic guidance. The inflow portion of the catheter resides in the inferior vena cava, and a flexible nitinol cannula traverses the right atrium, tricuspid valve, and pulmonary valve. The outflow portion of the catheter resides in the main PA. It provides flow of up to 5 L/min for as long as 14 days.[3]

In 2015, the RECOVER RIGHT investigators concluded that use of the easily deployable Impella RP was safe in cases of RV failure and provided immediate hemodynamic improvement. Conducted at 15 United States centers, the study included 30 cases of RV failure.[7]

Impella RP use in such cases has improved hemodynamic status and enabled RV recovery with improved PA resistance. Furthermore, it has lessened the need for vasoactive medications and their potentially harmful coronary and peripheral vasoconstrictive effects.[9] According to a 2015 clinical expert consensus statement,[9] percutaneous mechanical circulatory support devices—particularly the TandemHeart and Impella—provided superior hemodynamic support when compared with pharmacologic therapy. Advantages of the Impella RP device over ECMO include a smaller access site[10] and relatively easier deployment.

The EKOS EndoWave Infusion Catheter System was approved in May 2014 for treating PE by means of ultrasound-assisted catheter-directed thrombolysis. Its use improved RV function[11] and enabled faster restoration of RV size than did anticoagulation alone.[9,12] Patients undergoing treatment need just 15% to 25% of the thrombolytic dose typical for systemic thrombolysis. The lower risk of bleeding[13] is advantageous when large-sized peripheral venous access is needed, such as that for the Impella RP.

Percutaneous circulatory support with use of the Impella RP can facilitate RV recovery in cases of acute RV failure. Catheter-directed thrombolysis has emerged over the past few years as an attractive, potentially safer alternative to systemic thrombolysis in the treatment of massive and submassive PE. Combined, these modes show promise in the management of PE.

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