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CASE REPORT

Two cases of successful treatment of acute right heart failure with Impella RP®

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Abstract

Post-operative right coronary artery occlusion is a serious complication that demands acute coronary revascularization to prevent myocardial infarction. We present two cases with acute right coronary artery obstruction caused by (1) transfemoral aortic valve implantation and (2) acute type A aortic dissection. Although coronary artery bypass grafting was performed intraoperatively, right heart failure was observed in both cases. The Impella RP® device offers temporary right ventricular mechanical support; wherefore, we decided to deploy it in both patients. The devices were uneventfully and successfully implanted to bridge for recovery of the right heart. We report the perioperative course of the patients as well as their condition at 1 year follow-up.

Keywords right ventricular assist device; right ventricular failure; heart failure; cardiogenic shock; mechanical circulatory support; Impella

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Introduction

Occlusion of the right coronary artery is a rare but serious complication of a transcatheter aortic valve implantation (TAVI), occurring in <1% of the interventions.[1] Myocardial ischemia, on the other hand, occurs frequently (19.9%) in type A aortic dissections.[2] Therapeutic options for both complications are percutaneous coronary intervention or coronary artery bypass grafting. However, even after a successful revascularization, the risk for post-interventional or post-operative right heart failure (RHF) remains high.

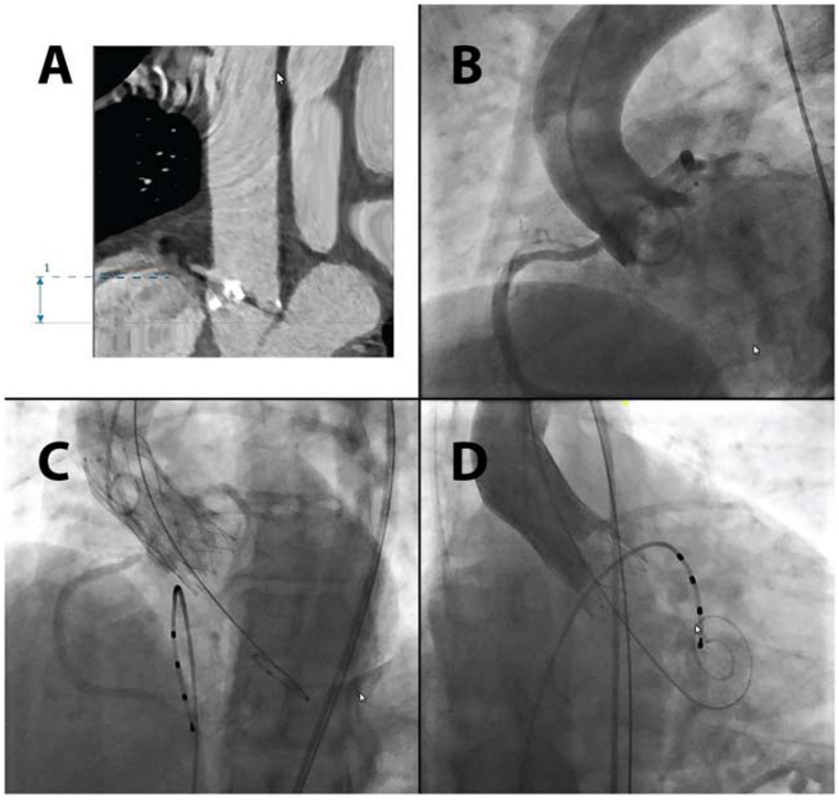
The Impella RP® device (Abiomed Inc, Massachusetts, USA) was designed to provide right ventricular mechanical support in patients with cardiogenic shock. This axial intracardiac blood pump is inserted percutaneously into the right heart via the femoral vein. Venous blood is delivered from the inlet area inside the inferior vena cava through its cannula into the outlet area in the pulmonary artery. We report two cases of patients that were successfully treated with the Impella RP® after post-operative RHF.

Case report

Patient 1

A 73-year-old female patient was hospitalized with severe symptomatic aortic valve stenosis for elective aortic valve replacement (EuroSCORE II: 0.84%). Preoperative workup showed no coronary artery disease. In the preoperative TAVI-CT (ECG triggered, *Figure 1*), the distance from the annulus to the left and the right coronary ostia was 14.4 and 15.5 mm, respectively. The dimensions of the aortic valve were a perimeter derived diameter of 23.7 mm, an area of 409.4 mm^2, and a perimeter of 74.5 mm. Since the patient had been suffering from perinatal brain injury and symptomatic epilepsy, our heart team decided in favour of a transfemoral TAVI approach (Portico 27 mm, PRT 27 mm, Abbott Vascular, Santa Clara, USA). After single post-dilatation, weaning from elevated noradrenaline support was infeasible and a left bundle branch block and increased central venous pressure (CVP) were observed. The peri-interventional

Figure 1 Pre-interventional and peri-interventional images of the TAVI procedure. (A) In the CT-scan, the distance between the aortic annulus and the right coronary ostium was 15.5 mm. (B) Angiography of the right coronary artery prior to the TAVI procedure. (C) After deployment of the aortic prosthesis, stenosis of the right coronary ostium is visible. (D) Post-dilatation caused total occlusion of the right coronary artery (Patient 1).



coronary angiogram revealed an occluded ostium of the right coronary artery (right coronary dominance). The aortic valve prosthesis was not oversized, but a heavily calcified leaflet occluded the right ostium, which could not be intubated. Therefore, the patient was transferred to the operating theatre and underwent uneventful off-pump coronary artery bypass grafting (CABG) with *in situ* right internal mammary artery (flow 79 mL/min, pulsatility index 0.9). Post-operative transesophageal echocardiography (TEE) showed moderately to severely reduced right ventricular (RV) function with septal and inferior hypokinesia. At the intensive care unit (ICU), the patient developed RHF with severely reduced function (*Table 1*) with repeated ventricular fibrillation and cardiopulmonary resuscitation despite extensive catecholamine support (norepinephrine 16 γ/min, milrinon 600 micrograms/h). Therefore, an Impella RP® was implanted under X-ray guidance by our cardiologists on the ICU, which re-established hemodynamic stability (cardiac index before Impella: 1.0 L/min/m^2, after weaning: 3.7 L/min/m^2), and norepinephrine support was reduced to 10 γ/min. The arterial lactate (before Impella: 11.6 mmol/L, at weaning: 0.6 mmol/L) and the central venous pressure (before Impella: 21 mmHg, after weaning: 14 mmHg) were also reduced. Lactate dehydrogenase levels (1413 U/L) peaked on the second and high sensitive troponin-T levels (9128 ng/L) on the third day after implantation. Weaning

Table 1 Echocardiography data of Patient 1

Patient 1	Before Impella	13th POD	6 month FUP
RV function	severely reduced	Normal	Normal
LV function	Normal (60%)	Mildly reduced (52%)	Mildly reduced (53%)
Tricuspid valve regurgitation	Mild	Mild	Mild
TAM, mm	n/a	19	21
EDA/BSA, cm^2/m^2	n/a	12.33	n/a
Fractional area change, %	n/a	43	41
Comments	Dilated RV (46 mm)	Dilated right and left atria	Normal right atrium, dilated left atrium

Echocardiography data right before Impella RP implantation, on the 13th post-operative day (POD) and at 6 month follow-up (FUP). RV, right ventricular; TAM, tricuspid annular motion; n/a, not available; EDA, end-diastolic area; BSA, body surface area; RA, right atrium.

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Table 2 Echocardiography data of Patient 2

Patient 2	Perioperative	4th POD	1 year FUP
RV function	Severely reduced	Moderately reduced	Moderately reduced
LV function	Moderately severely reduced	Mildly reduced (45%)	Normal (59%)
Tricuspid valve regurgitation	n/a	Moderate	Mild
TAM, mm	n/a	10	12
EDA/BSA, cm^2/m^2)	n/a	11.4	8.7
Fractional area change, %	n/a	n/a	28
Atrium	Atrial septum deviation to the left	Atrial septum deviation to the left	Dilated RA

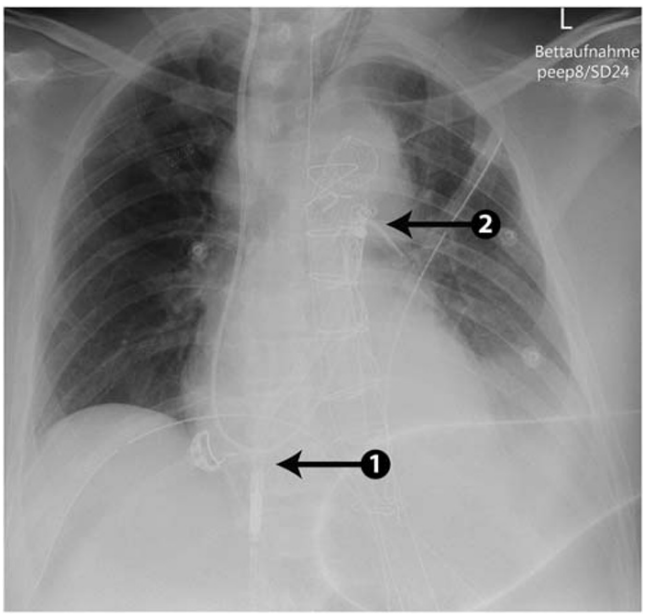
Echocardiography data right before Impella RP® implantation, on the 4th post-operative day (POD) and at 1 year follow-up (FUP). RV, right ventricular; TAM, tricuspid annular motion; EDA, end-diastolic area; BSA, body surface area; n/a, not available, RA, right atrium.

from Impella RP® was successful on the fourth post-operative day. The patient was transferred from the ICU to the ward on the seventh post-operative day, and the RV function was already fully restored in echocardiography on the thirteenth post-operative day (*Table 1*). At the 6 month follow-up, the RV function was still preserved and the aortic bioprosthesis showed normal function in echocardiography (Table 1).

Patient 2

A 55-year-old male patient was diagnosed with type A aortic dissection and disruption of the RCA. The patient was taken to the operating theatre in stable condition and without neurological deficits. Before initiation of a cardiopulmonary bypass (CPB), the patient went into ventricular fibrillation and was successfully defibrillated with a single shock. Under deep hypothermic circulatory arrest with selective antegrade cerebral perfusion, we performed a David operation with replacement of the ascending aorta, the hemiarch, and antegrade TEVAR. Due to a tear of the right coronary ostium, a venous CABG to the posterior descending artery was performed (flow 14 mL/min, pulsatility index 6). Consecutively, the patient went into acute RHF; wherefore, a second venous bypass graft to the main right coronary artery was implanted (flow 28 mL/min, pulsatility index 4.7). Since RHF persisted with severely reduced RV function (Table 2) despite of inhaled nitric oxide (20 ppm), and inhalation of iloprost, adrenaline, norepinephrine, and milrinone, an Impella RP® device was implanted X-ray guided by our cardiologists, and the patient was weaned from CPB (crossclamp time: 190 min, CPB: 346 min, CVP 12 mmHg, pH 7.12, lactate 7.4, norepinephrine 10 γ/min, adrenaline 10 γ/min, nitric oxide 20 ppm, iloprost 20 mcg) and transferred to the ICU. Under cautious reduction of medical cardiac support and under TEE surveillance, the patient could be weaned from Impella RP® on the fourth post-operative day (cardiac index: 3.6 $L/min/m^2$, CVP: 12 mmHg, moderately reduced RV function, *Table 2*). Arterial

Figure 2 This X ray shows correct placement of the Impella RP device. The venous blood is delivered from the inlet area in the inferior vena cava at the level of the diaphragm (Arrow 1). The pigtail end of the Impella RP® is placed inside the left pulmonary artery with the 'silver ball' (Arrow 2) of the outlet 2–4 cm distal to pulmonic valve.



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lactate peaked peri-operatively (before Impella: 8.7 mmol/L, after weaning: 0.8 mmol/L) and lactate dehydrogenase levels (613 U/L, after weaning: 433 U/L) and high sensitive Troponin-T levels (4673 ng/L, after weaning 1358 ng/L) on the first post-operative day. The patient was extubated on the sixth post-operative day and transferred to the ward on the ninth post-operative day. Echocardiography revealed a moderately impaired right ventricular function (TAM: 10 mm) and a mildly impaired left ventricular function. After 16 days, the patient was discharged to a cardiac rehabilitation unit. At the 1 year follow-up, the patient presented in good condition with a mildly impaired right ventricular function (*Table 2*).

Discussion

Data on Impella RP® application in patients with post-cardiotomy shock are scarce. We report two cases of implantation of the Impella RP® device, which resulted in a beneficial outcome. A recent prospective randomized trial yielded promising short-term results of Impella RP® in post-cardiotomy RHF (30 day survival: 69%, 180 day survival: 62.4%).[3] Since only 14% of all implanted Impella devices are currently type RP® models in post-cardiotomy shock patients,[4] further long-term results are needed. We experience Xray as helpful for guidewire positioning,[5,6] although echocardiography-guided introduction is feasible as well.

If the patient is not already under fully heparinization, anticoagulation is initiated with 5000 IU of heparin just before implantation, and maintained with therapeutic heparin levels (target anti-factor Xa activity of 0.5 U/mL). Weaning consists of stepwise reduction of pump performance to around 2 L/min while monitoring clinical evolution, cardiac output, and pulmonary artery pressures. Apart from clinical parameters (stable CVP, systemic hemodynamics, and perfusion), improvement of RV function in echocardiography should also be evaluated. After 15–20 min of reduced flow rate without any records of hemodynamic instability or adverse effects, the device is set to the lowest pump level (P1), pulled back into the inferior vena cava and removed after the motor has been turned off (P0).

Time is a key factor in RHF; the delay between incipient RHF and implantation of right ventricular support should be as short as possible.[7] In Patient 1, catecholamine support could not be reduced after the TAVI, as it would be expected post-operatively after coronary artery bypass grafting; wherefore, the team decided to immediately implant an Impella RP® device, which resulted in consecutive increase in cardiac index, reduction of CVP, and, as a result, almost bisection of inotropic demand.

In Patient 2, weaning from CPB was infeasible after type A aortic dissection due to RHF, but became possible with the additional mechanical support of the Impella RP®.

Under sufficient X-ray guidance (*Figure 2*), the implantation via femoral vein puncture is possible in cath labs,[5] operating theatres,[8] and ICUs. We have not observed any major complications in our small case series of Impella RP®; however, we are aware that bleeding complications should be investigated in the future.[8]

In centres where the Impella RP® is not yet available, the alternative approach to unload the right heart would be extracorporeal membrane oxygenation (ECMO), which is more invasive and comes along with high mortality and morbidity. Furthermore, these cases underline the future tendency towards a closer and more congruent joint therapeutic approach of cardiac surgeons and cardiologists. Implantation of the Impella RP® device is feasible in equipped centers[5,6] and improves the hemodynamic management in selected patients with post-cardiotomy RHF. These two cases would have qualified for Cohort B of the RECOVER RIGHT protocol, and our positive results are in line with the 58.3% survival data in the premarket clinical study.[8] Further trials are urgently needed to assess survival benefit and improve patient selection since overall 30 day mortality is still high (22.6–31%)[9] after Impella RP® implantation.

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Conflict of interest

Patrick Hunziker has received lecture fees and research grants from Abiomed.

References

1. Sultan I, Siki M, Wallen T, Szeto W, Vallabhajosyula P. Management of coronary obstruction following transcatheter aortic valve replacement. *J Card Surg* 2017; **32**: 777–781.
2. Trimarchi S, Nienaber CA, Rampoldi V, Myrmel T, Suzuki T, Mehta RH, Bossone E, Cooper JV, Smith DE, Menicanti L, Frigiola A, Oh JK, Deeb MG, Isselbacher EM, Eagle KA. International registry of acute aortic dissection I. Contemporary results of surgery in acute type A aortic dissection: The International Registry of Acute Aortic Dissection experience. *J Thorac Cardiovasc Surg* 2005; **129**: 112–122.
3. Cheung AW, White CW, Davis MK, Freed DH. Short-term mechanical circulatory support for recovery from acute right ventricular failure: clinical outcomes. *J Heart Lung Transplant* 2014; **33**: 794–799.

4. Jensen PB, Kann SH, Veien KT, Moller-Helgestad OK, Dahl JS, Rud CS, Jensen MK, Jensen LO, Schmidt H, Moller JE. Single-centre experience with the Impella CP, 5.0 and RP in 109 consecutive patients with profound cardiogenic shock. *Eur Heart J Acute Cardiovasc Care* 2018; **7**: 53–61.
5. Elder M, Blank N, Kaki A, Alraies MC, Grines CL, Kajy M, Hasan R, Mohamad T, Schreiber T. Mechanical circulatory support for acute right ventricular failure in the setting of pulmonary embolism. *J Interv Cardiol* 2018; **31**: 518–524.
6. Gramegna M, Beneduce A, Bertoldi LF, Pagnesi M, Marini C, Pazzanese V, Camici PG, Chieffo A, Pappalardo F. Impella RP support in refractory right ventricular failure complicating acute myocardial infarction with unsuccessful right coronary artery revascularization. *Int J Cardiol* 2019.
7. Haddad F, Elmi-Sarabi M, Fadel E, Mercier O, Denault AY. Pearls and pitfalls in managing right heart failure in cardiac surgery. *Curr Opin Anaesthesiol* 2016; **29**: 68–79.
8. Anderson MB, Goldstein J, Milano C, Morris LD, Kormos RL, Bhama J, Kapur NK, Bansal A, Garcia J, Baker JN, Silvestry S, Holman WL, Douglas PS, O'Neill W. Benefits of a novel percutaneous ventricular assist device for right heart failure: the prospective RECOVER RIGHT study of the Impella RP device. *J Heart Lung Transplant* 2015; **34**: 1549–1560.
9. Anderson M, Morris DL, Tang D, Batsides G, Kirtane A, Hanson I, Meraj P, Kapur NK, O'Neill W. Outcomes of patients with right ventricular failure requiring short-term hemodynamic support with the Impella RP device. *J Heart Lung Transplant* 2018; **37**: 1448–1458.