

# BiPella: Mini Review on a Novel Method to Treat Cardiogenic Shock Patients

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## INTRODUCTION

Despite medical advancements in treatment of cardiogenic shock, it still remains as a condition with high-morbidity and mortality. There are many treatment modalities to help the heart's pumping function and perfusion in compromised states, such as inotrope & vasopressor application, intra-aortic balloon pump (IABP) counterpulsation, percutaneous left ventricular assist devices, which are Tandem Heart and Impella (Abiomed, MA, USA); and lastly, surgically placed left ventricular assist devices (LVAD).<sup>1-7</sup> In severe cases where pharmacologic treatment and percutaneous options are not enough to stabilize hemodynamic status and where surgery is not applicable, novel approaches should be applied.

Benefits of Impella devices in supporting left ventricle (LV) in cardiogenic shock are well established,<sup>1,2,5,8,9</sup> but few studies on percutaneous assist device use in right ventricle (RV) dysfunction exist. In addition, a novel method called BiPella (biventricular Impella) has been reported. It consists of simultaneous deployment of a percutaneously inserted left ventricle assist Impella device (either Impella 2.5, Impella 5.0 or Impella CP) and Impella RP, which is suitable for RV support. Until now, there are only 7 case reports and one retrospective

analysis on the BiPella method in treatment of refractory cardiogenic shock in adult patients<sup>6,10-15</sup> (Table 1). Our article reviews the current literature regarding BiPella use in refractory cardiogenic shock and presents a case of a post-acute myocardial infarction (AMI) cardiogenic shock patient who has been treated with BiPella, successfully weaned off every assist device and discharged to home.

## CASE REPORT

A 53-year-old woman presented to emergency room with sudden onset chest pain that had started 1 hour earlier. During further evaluation, the patient developed complete heart block, hypotension and cardiogenic shock, blood pressure being 72/48 mmHg. A central venous catheter was placed in the right femoral vein. The patient was resuscitated with atropine and dopamine, orotracheal intubated and urgently taken into the catheterization laboratory.

Angiography was performed and revealed a patent stent in the middle to proximal segment of the left anterior descending artery (LAD), a stable hazy lesion of 70% stenosis in the distal LAD, proximally occluded left circumflex artery (LCx) – which was found to be large and supplying the right ventricle as well – and nondominant right coronary artery with moderate stenosis (Figure 1).

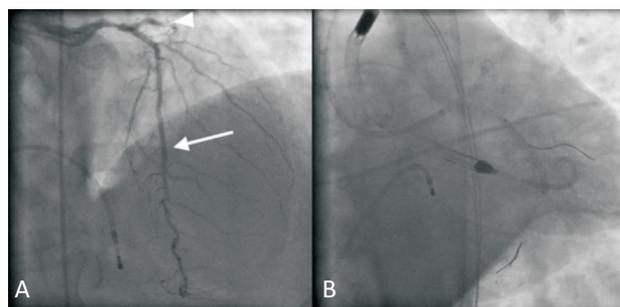
A temporary transvenous pacemaker was inserted via the left femoral vein and placed to the RV apex with good capture, but the patient remained in cardiogenic shock. Right heart catheterization was performed (Table 2). The decision to insert an LV Impella was made in an attempt to improve hemodynamics, the Impella CP device was deployed successfully and the patient was stabilized. The patient's pulmonary artery pulsatility index (PAPi) was calculated as 0.88 after the implantation. Afterwards, a 3.0 × 28 mm Multi-Link Vision stent (MLV;

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Abbott Vascular) was placed to the LCX artery. Revascularization was successful with thrombolysis in myocardial infarction (TIMI) flow grade improving from 0 to 3. Despite the successful revascularization of the LCX coronary artery the cardiac power output was calculated to be less than 0.7, a decrease in which is associated with increased mortality.<sup>16</sup> We proceeded with insertion of another central venous catheter through the right internal jugular vein (IJV) under ultrasonography. During the procedure, the right heart function worsened, the patient experienced multiple ventricular fibrillations (VF) and cardiac arrest. After the resuscitation, a second angiography was performed and stent patency was observed. It was decided to proceed with support the patient with an Impella RP, due to the unavailability of the extracorporeal membrane oxygenation (ECMO) device in our hospital (Figure 2). Having inserted the second central venous line to the right IJV, the first central venous catheter was removed and the Impella RP device was inserted with success. Following insertion, pulmonary artery pressure was measured as 31/15 mmHg and



**Figure 1.** (A) Anteroposterior Cranial angiographic view of the patient demonstrating left anterior descending artery with good flow (arrow) and occluded left circumflex artery (arrowhead). (B) Anteroposterior Caudal angiographic view of Impella CP (arrowhead) and revascularized left circumflex artery (arrow).



**Figure 2.** Chest X-ray showing in situ Impella CP and RP.

**Table 1.** Literature on BiPella approach

Author	Year	Type of publication	Number of patients	Description
Hunziker P, et al. <sup>12</sup>	2013	Case report	1	54-year-old patient presenting with CS due to AMI.
Kapur NK, et al. <sup>14</sup>	2015	Case report	1	45-year-old patient with CS due to ischemic cardiomyopathy.
Aghili N, et al. <sup>10</sup>	2016	Case report	1	30-year-old patient presenting with CS due to fulminant myocarditis, unresponsive to pulse steroids.
Kamioka N, et al. <sup>13</sup>	2017	Case report	1	30-year-old patient with CS due to ischemic cardiomyopathy, BiPella implanted via caval-aortic approach.
Pappalardo F, et al. <sup>6</sup>	2017	Case report	1	30-year-old patient with myocarditis and acute onset atrial fibrillation developed CS.
Kuchibhotla S, et al. <sup>15</sup>	2017	Retrospective analysis	20	Retrospective analysis on 20 patients with CS due to biventricular failure. Outcomes of survivors and non survivors were compared.
Chiu CY, et al. <sup>11</sup>	2018	Case report	1	67-year-old patient presenting with CS due to inferior non-ST segment elevation AMI.
Dalal PK, et al.	2019	Case report	1	61-year-old patient presented with CS due to AMI.

AMI, acute myocardial infarction; CS, cardiogenic shock.

**Table 2.** Hemodynamics

	Dopamine + Pacing + Impella CP	Dopamine + Pacing + BiPella
Right atrial pressure (mmHg)	17	8
Right ventricle pressure (mmHg)	40/19	31/7
Pulmonary artery pressure (mmHg)	40/25	31/15
Pulmonary capillary wedge pressure (mmHg)	26	16
Cardiac index (L/min/m <sup>2</sup> )	1.8	2.4
Pulmonary artery pulsatility index	0.88	2

hemodynamic status improved rapidly. Furthermore, the patient's PAPI was calculated as 2, increase in which predicts the improvement in the RV function.<sup>17,18</sup> During the procedure, the patient received a total of 7 electroshocks due to recurrent VFs. Her hemoglobin concentrations were 14.1 g/dl before and 11.1 g/dl after the procedure, indicating that there was not any blood loss and hemolysis requiring transfusion.

The patient remained hemodynamically stable throughout admission. She was extubated and weaned off inotropic support on day 2. On day 3, she was successfully weaned off the right and the left Impella devices sequentially. Echocardiography on day 4 revealed an left ventricular ejection fraction (LVEF) of 55-60% without any valvular leaks. The patient was uneventfully discharged to home on day 4.

## DISCUSSION

### Efficacy of percutaneous right ventricular assist devices: Impella RP

Percutaneous mechanical assist devices have recently started being used for right ventricular support in many conditions such as acute decrease in cardiac output due to right ventricular failure and bridging patients to heart failure interventions. One of the currently used percutaneously inserted right ventricle assist devices is Impella RP. The LV Impella devices have been studied well, but case reports and investigations for Impella RP are few.<sup>19-23</sup>

The first study to investigate safety and efficacy of Impella RP in right ventricle failure (RVF) was "RECOVER RIGHT", which was a cohort consisting of 30 patients.<sup>19</sup> The investigators compared cardiac indices (CI) and central venous pressures of the patients with RVF who were unresponsive to pharmacotherapy. The mean post-implantation & on-device CIs were significantly higher and CVPs were significantly lower than pre-implantation values.<sup>19</sup> 180-day overall survival rate was 70%, which is satisfactory considering the mortality of refractory RV failure.<sup>19</sup> A major problem of the study was that it could not differentiate the patients who really benefitted from the percutaneous RV assist device and who were to recover with only medical therapy (without any intervention) despite hemodynamic instability, given the resili-

ence of RV, which is better than the LV in terms of recovering from failure without treatments.<sup>19,23</sup> Moreover; hospital stay, inotrope weaning and overall survival of those who received a percutaneous RV assist device and those who did not cannot be compared due to lack of a control group. The authors also mentioned these limitations and emphasized the need for a randomized controlled trial on this matter. Overall, the conclusion of the article was that percutaneous RV assist devices might give the RV a break to recover by providing rapid restoration of hemodynamics and thus improve long-term survival.<sup>19</sup>

In January 2018, Elder et al. published a case series of 5 patients with acute pulmonary embolism complicated with hemodynamic instability despite intravenous saline infusion, adequate inotropic support and thrombectomy.<sup>20</sup> All had normal LVEF, confirming RVF as the cause of hemodynamic instability. They reported that all of the patients were weaned off the Impella RP device in a mean of 3.2 (1-6) days; mortality rate was 0% at 30 days, major complications were a patient with septicemia who recovered during admission and a patient with hemolysis requiring no treatments.<sup>20</sup> Although this case series consists of only 5 patients, it provides an insight into how Impella RP can be useful in cases with refractory cardiogenic shock due to RVF.

Efficacy and safety of Impella for LV support has been studied well yet reports on its benefits on RVF cases are still limited. However, it can still be considered as an alternative treatment method, especially for refractory cases. The question whether RV assistance affects long term outcomes still remains unanswered and further investigations are necessary on this topic.

### Literature on BiPella: is the BiPella method feasible, safe and efficacious?

Percutaneous assist devices are commonly used in cases where left ventricular function is not enough for tissue perfusion. Moreover, they can even be used in patients with isolated RVF that causes cardiogenic shock.<sup>19-23</sup> However, biventricular compromise is still a challenge. In such conditions, LV assistance mostly remains insufficient; biventricular support is needed and can be achieved by combinations of inotropic support, IABP counterpulsation, venoarterial ECMO, Tandem Heart or Impella.<sup>1-5,7,24</sup> Given the promising results of Impella de-

vices on RVF cases, biventricular Impella implantation (BiPella) can be considered as an effective method.

In the literature, there are only 6 case reports on BiPella. The first report was on a 54-year-old patient presenting with AMI and cardiogenic shock refractory to intravenous fluid support, high dose inotropes and coronary angioplasty.<sup>12</sup> Impella CP was implanted and it resolved the pulmonary edema, yet failed to resolve right heart failure and congestion related multi-organ dysfunction. Following the implantation of the Impella RP, the patient was stabilized and weaned off both devices in 8 days.<sup>12</sup>

The BiPella method is reported to be useful not only in cardiogenic shock due to AMI, but also in congestive heart failure decompensation. In 2015, Kapur et al., presented a 45-year-old man with stage D ischemic cardiomyopathy and worsening dyspnea for 1 month, without chest pain.<sup>14</sup> The patient was supported initially with milrinone. Coronary angiography was free of significant coronary artery disease. Echocardiography revealed biventricular failure. After a trial of IABP insertion, the hemodynamics did not improve. Due to clinical instability, surgical implantation of LVAD was not feasible. In order to bridge the patient to surgery, the BiPella method was undertaken. The patient was operated and LVAD was implanted 5 days later, upon hemodynamic stabilization. The patient was discharged to home without any inotropic support on day 15.<sup>14</sup> In 2017, another case of a 30-year-old woman presenting with cardiogenic shock due to ischemic cardiomyopathy was reported.<sup>13</sup> However, in this case, peripheral arterial access was not suitable for Impella 5.0, thus Impella implantation was done by caval-aortic access as previously described for transcatheter aortic valve replacement procedures.<sup>25</sup> Even with this method, the patient was successfully stabilized by BiPella and bridged to surgery for permanent LVAD placement.<sup>13</sup>

Another case of a 30-year-old woman presenting with acute cardiogenic shock due to fulminant myocarditis proven by endocardial biopsy was reported by Aghili et al.<sup>26</sup> The patient was unresponsive to inotropic support and pulse steroids; therefore, was considered a potential candidate for orthotopic heart transplantation. To stabilize the patient, BiPella was deployed, the patient recovered hemodynamically and was successfully weaned off BiPella by day 3. Her repeat echocardiogra-

phy revealed a LVEF of 50% and properly functioning RV, thus the patient no longer needed heart transplantation.<sup>26</sup>

In 2018, two more cases of the BiPella approach were reported. The first was a 37-year-old man presenting with dyspnea and tachycardia.<sup>6</sup> On examination, the patient had atrial fibrillation and an LVEF of 10%. Antiarrhythmic pharmacotherapy was initiated and during treatment, the patient developed aphasia, cardiogenic shock refractory to inotropes and hemiparesis of right extremities. Ischemic stroke was diagnosed with computed tomography, the patient underwent endovascular cerebral thrombectomy, and transferred to intensive care unit after the procedure.<sup>6</sup> The progress of the patient was complicated with bilateral pleural effusions that required drainage. Echocardiography revealed biventricular failure and it was decided to proceed with BiPella implantation, which stabilized the hemodynamics within 24 hours. Endocardial biopsy revealed myocarditis. Intravascular hemolysis was observed, thus pumping power of the Impella devices was reduced (lactate dehydrogenase > 1240 U/L). Impella RP and CP were explanted on day 7 and day 9, respectively. LVEF was 35% on day 22.<sup>6</sup> The patient had few neurologic deficits on discharge at day 22, but managed to survive.<sup>6</sup>

The second case report published in 2018 was a 67-year-old patient presenting with inferior non-ST segment elevation AMI and cardiogenic shock.<sup>11</sup> After revascularization, the patient developed bradycardia and a severely reduced CI was calculated, necessitating temporary pacemaker and Impella CP implantation. After successful implantation, the patient developed pulseless electrical activity and resuscitation was performed. Despite all measures, RVF persisted and Impella RP was also inserted. Upon insertion, lactate levels decreased and the patient stabilized without other complications. Impella CP and RP were weaned off on day 6 and day 9 respectively. EF of 65% was measured on control echocardiography on day 22.<sup>11</sup>

In addition to the case reports, the first extensive study was a retrospective analysis of 20 patients with cardiogenic shock due to biventricular failure, which was confirmed by cardiac catheterization.<sup>15</sup> All patients in the study were treated with BiPella, pre and post procedural cardiac pressures are noted. Statistically significant increase in cardiac output and rapid decrease in both RV and LV filling pressures were observed.<sup>15</sup> Based

on the results, the authors concluded that the amount of time between the onset of the shock and deployment of BiPella, along with the severity of the shock, is associated with decreased survival rates. One other result was that high baseline pulmonary artery pressures were inversely related with survival, probably because of the chronicity of left ventricular dysfunction.<sup>15</sup> Although the mortality rate was 50% in the series, this study is the first extensive analysis to demonstrate the clinical feasibility of BiPella as a method to treat biventricular failure.

## LEARNING POINTS

Cardiogenic shock remains a condition with high morbidity and mortality. When the left ventricle is compromised, methods such as inotropes & vasopressors and pLVADs are the available options for compensation. However, these methods may not be sufficient to ensure hemodynamic stabilization in case of biventricular failure. BiPella, which is a combination of LV and RV Impella devices, is a novel approach and can be considered as a salvage treatment modality for refractory biventricular failure. Nevertheless, randomized controlled trials with adequate sample sizes should be conducted to prove the efficacy and safety of the BiPella approach for treatment of this condition.

## CONFLICT OF INTEREST

All the authors declare no conflict of interest.

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