Impella RP Flex as a Rescue for the Failing Right Ventricle after Heart Transplantation

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Case Report

Keywords:

Posted Date: September 7th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-3232413/v1

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Abstract

Right ventricular dysfunction (RVD) after orthotopic heart transplantation (OHT) is a common cause of morbidity and mortality in the early post-transplant phase. As its pathophysiology is multifactorial, management is challenging. Recently, Impella RP Flex was approved for RV support as a mechanical circulatory device. We hereby present the first case of its use in managing RV failure in a patient after OHT.

Introduction

Right ventricular dysfunction (RVD) after orthotopic heart transplantation (OHT) is a common cause of morbidity and mortality in the early post-transplant phase.\(^1\) Post-OHT RVD pathophysiology is multifactorial, encompassing donor and recipient selection and certain procedural risk factors (Fig. 1). As such, management of post-OHT RVD is challenging, and early recognition is crucial to achieving the best patient outcomes. Other principles of management include inotropic support, avoiding volume overload, decreasing RV afterload, maintaining adequate blood pressure to maintain coronary perfusion, and timely intervention with mechanical circulatory device for RV support when necessary.\(^1,2\) In October 2022, ABIOMED’s Impella RP Flex with SmartAssist was approved by the US Food and Drug Administration for temporary RV support for up to 14 days.\(^3\) Impella RP Flex is a percutaneous device implanted via the internal jugular vein, and it has a much smaller caliber than the currently available RV support devices. These characteristics facilitate ease of insertion and increase patient mobility while providing support without the need for extracorporeal blood circulation.\(^3\) Here, we present the first case of its use in managing RVD in a patient after OHT.

Case Report

A 40-year-old male with familial dilated cardiomyopathy and Factor V Leiden mutation presented with SCAI stage C cardiogenic shock. Admitting hemodynamics were a right atrial pressure (RAP) of 9 mmHg, pulmonary arterial pressure (PAP) of 53/21 mmHg, pulmonary capillary wedge pressure (PCWP) of 24 mmHg, cardiac output (CO) of 2.5 L/min/m\(^2\), cardiac index (CI) of 1.5 L/min/m\(^2\), systemic vascular resistance (SVR) of 1926 dynes-sec-cm\(^{-5}\), and pulmonary vascular resistance (PVR) of 4 WU. The patient was started on milrinone with intra-aortic balloon pump (IABP) support. Hemodynamics improved, with a central venous pressure (CVP) of 9 mmHg, PAP 47/19 mmHg, PCWP 18 mmHg, CO 4.64 L/min/m\(^2\), CI 2.76 L/min/m\(^2\), SVR 977 dynes-sec-cm\(^{-5}\), and PVR 2 WU. Patient status was listed as 2 and subsequently underwent OHT with a 46-year-old female heart, with a donor-recipient predicted heart mass mismatch of -10% and total ischemic time of 238 minutes. The donor cause of death was intracranial hemorrhage, and the donor left ventricular ejection fraction (LVEF) was 55–60% with normal RV function and a septal wall thickness 0.8 cm. The transport of the donor organ was in a SherpaPak case with DelNido preservative solution.

Although no left ventricular (LV) dysfunction (LVD) was noted during the operation, the IABP was left in place per surgeon’s preference due to mild RVD, and the patient was on a medical therapy of epinephrine 0.02 mcg/kg/min, milrinone 0.5 mcg/kg/min and dobutamine 2.5 mcg/kg/min. Epinephrine was weaned within 24 hours, and a post-operative day (POD) 1 transthoracic echocardiogram (TTE) demonstrated normal LV function and mildly reduced RV function. The dobutamine dose was therefore increased to 5 mcg/kg/min and the IABP was removed. Hemodynamics subsequently deteriorated including a CVP of 22 mmHg, PAP of 37/21 mmHg, PCWP of 21 mmHg, as well as CO 3.14 L/min/m\(^2\), CI 1.84 L/min/m\(^2\), SVR 1535 dynes-sec-cm\(^{-5}\), PVR 1.7 WU) (Table 1). These changes necessitated increased dosage of dobutamine (7.5 mcg/kg/min) and epinephrine (0.03 mcg/kg/min), and initiation of inhaled nitric oxide (iNO). TTE continued to reveal normal LV function but moderately reduced RV function and dilatation (TAPSE 1.2 cm), and the intrinsic rhythm showed complete atrioventricular (AV) dissociation (Fig. 2). Despite aggressive diuresis, CVP remained > 20 mmHg with worsening cardiorenal syndrome requiring initiation on continuous renal replacement therapy (CRRT). Given the sinus node dysfunction and low mixed venous oxygen saturation, isoproterenol was added in addition to dobutamine, milrinone and epinephrine. However, the isoproterenol was not well tolerated by the patient, who developed nausea and vomiting side effects. The patient received immunosuppression (IS) therapy, including induction with thymoglobulin, and remained on triple IS therapy with mycophenolate mofetil, tacrolimus, and prednisone; endomyocardial biopsy revealed no rejection.
Table 1
Laboratory and hemodynamic parameters of the patient at different time intervals during the hospital stay.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Transplant</th>
<th>Immediate Post-Transplant</th>
<th>POD 1</th>
<th>POD 2</th>
<th>Pre-Impella RP-Flex (POD 11)</th>
<th>Post Impella RP-Flex (POD 12)</th>
<th>Prior to Impella RP-Flex removal (POD 25)</th>
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<tbody>
<tr>
<td>Hemoglobin (g/dL)</td>
<td>12.8</td>
<td>10.6</td>
<td>10</td>
<td>9.4</td>
<td>7.4</td>
<td>7.8</td>
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<tr>
<td>Hematocrit (%)</td>
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<td>33.5</td>
<td>32.3</td>
<td>29</td>
<td>22.5</td>
<td>22.8</td>
<td>24.7</td>
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<td>pH</td>
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<td>7.41</td>
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<td>7.40</td>
<td>7.42</td>
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<tr>
<td>Creatinine (mG/dL)</td>
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<td>1.7</td>
<td>1.8</td>
<td>1.9</td>
<td>3.4</td>
<td>2.8</td>
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<td>GFR (mL/Min/1.73 M²)</td>
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<td>60</td>
<td>55</td>
<td>45</td>
<td>31</td>
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<td>AST (u/L)</td>
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<td>1509</td>
<td>1201</td>
<td>83</td>
<td>21</td>
<td>19</td>
<td>27</td>
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<td>ALT (u/L)</td>
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<td>2281</td>
<td>885</td>
<td>110</td>
<td>66</td>
<td>46</td>
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<td>3</td>
<td>1.4</td>
<td>0.7</td>
<td>0.6</td>
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<td>Lactate (mmol/L)</td>
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<td>Milrinone 0.25 mcg/kg/min</td>
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<tr>
<td>Dobutamine 2.5 mcg/kg/min</td>
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<td>Dobutamine 5 mcg/kg/min</td>
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<td>MCS</td>
<td>IABP 1:1</td>
<td>IABP 1:1</td>
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<td></td>
<td>Impella RP-Flex at p7</td>
<td>Impella RP-Flex weaning</td>
<td></td>
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<tr>
<td>SvO2%</td>
<td>70</td>
<td>71</td>
<td>50</td>
<td>63</td>
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<td>CVP (mmHg)</td>
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<td>9</td>
<td>22</td>
<td>7</td>
<td>24</td>
<td>10</td>
<td>6</td>
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<tr>
<td>PAP (mmHg)</td>
<td>47/19</td>
<td>25/9</td>
<td>37/21</td>
<td>26/9</td>
<td>40/27</td>
<td>32/18</td>
<td>26/15</td>
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<tr>
<td>PCWP (mmHg)</td>
<td>18</td>
<td>9</td>
<td>21</td>
<td>9</td>
<td>23</td>
<td>18</td>
<td>15</td>
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<tr>
<td>CO (L/min)</td>
<td>4.64</td>
<td>5.42</td>
<td>3.14</td>
<td>5.02</td>
<td>5.5</td>
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<td>CI (L/min/m²)</td>
<td>2.76</td>
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<td>2.5</td>
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<tr>
<td>SVR (dynes-sec-cm⁻⁵)</td>
<td>977</td>
<td>1053</td>
<td>1535</td>
<td>1130</td>
<td>1169</td>
<td>617</td>
<td>612</td>
</tr>
</tbody>
</table>

POD, postoperative day; GFR, glomerular filtration rate; AST, aspartate aminotransferase; ALT, alanine transaminase; MCS, mechanical circulatory support; IABP, intra-aortic balloon pump; SvO2, venous oxygen saturation; CVP, central venous pressure; PAP, pulmonary arterial pressure; PCWP, pulmonary capillary wedge pressure; CO, cardiac output; CI, cardiac index; SVR, systemic vascular resistance; PVR, pulmonary vascular resistance
Despite three inotropic agents (milrinone, dobutamine and epinephrine), iNO and CRRT, Impella RP Flex was placed via the right internal jugular vein on post-operative day (POD) 12 due to refractory right-heart failure. Impella RP Flex was chosen as a mechanical RV support device given its ease of insertion, ability to facilitate mobility and physical therapy in a recovering transplant patient. The patient was also on systemic anticoagulation with heparin with a goal activated clotting time (ACT) of 180–200 sec, and a higher-than-typical goal ACT (160–180) was chosen due to the patient’s history of hypercoagulable Leiden V mutation. The implantation procedure was well tolerated, with the patient ambulatory the following day and able to continue physical therapy with the device in place (Fig. 3). Epinephrine and dobutamine were slowly weaned, and on POD 25, the Impella RP flex was removed. iNO and milrinone were subsequently weaned and the patient achieved native renal recovery and no longer required CRRT. Intrinsic rhythm improved to sinus rhythm (Fig. 2), and the patient was ultimately discharged on POD 50 without inotropes and with normal kidney function. Pre-discharge TTE revealed a normal LVEF of 60–65% and low-normal RV function with normal cavity size and TAPSE 1.6 cm.

**Discussion**

RV dysfunction accounts for up to 50% of all cardiac complications and nearly 20% of all early deaths post heart transplantation. While RV dysfunction is multifactorial, it most frequently results from pairing a donor heart unaccustomed to the elevated PAP and resistance to the pulmonary hypertensive, increased afterload environment of the recipient. The ability of the donor heart to adjust may be further impaired by ischemia and reperfusion injury associated with organ preservation therapies. The key elements in the management of RV dysfunction include reducing RV preload with aggressive diuresis to maintain a CVP of < 10–12 mmHg, increasing RV contractility with isoproterenol and/or dobutamine, and reducing RV afterload with pulmonary vasodilators including inhaled NO, intravenous prostacyclin, prostaglandin E1, adenosine and milrinone. Clinicians can also employ devices to provide further support and time for the RV to recover.

There are a number of options available for RV support, including peripheral veno-arterial extracorporeal membrane oxygenation (VA-ECMO), Protek Duo temporary right ventricular assist device (RVAD), open central RVAD, and percutaneous two-cannula RVAD. Each of these approaches offer benefits to the failing RV, but also carry significant drawbacks. While VA-ECMO offers robust perfusion, it increases the RV afterload, further stressing the RV. Furthermore, both VA-ECMO and traditional open central RVAD are inserted through invasive surgical sternotomy and pulmonary artery cannulation. Percutaneous support options such as two-cannula and single dual-lumen RVAD instead approach through the internal jugular vein; however, these devices still require full anticoagulation therapy, which can be an absolute contraindication for use in some patients. Conversely, the Impella RP Flex is heparin-free, and the single-lumen 11 Fr flexible cannula is smaller than its counterparts; the smaller cannula occupies less space in the superior vena cava and avoids distortion of the RV. Collectively these features enable patients to be easily ambulatory with the device in place. Indeed, in this case the patient was ambulatory the day following insertion, and was able to participate in physical therapy with the device in place.

Experience with RVAD (ABIOMED 5000 BVS RVAD and Bio-Medicus Centrifugal Pump) in post-transplant and post-LVAD patients demonstrated improved hemodynamics, increased urine output, and improved serum transaminase level if implanted early; however mortality was still high (n = 5/11, 45%) due to sepsis, biventricular failure and coagulopathy. Early implantation to avoid potentially irreversible end-organ impairment is crucial to improving mortality and patient outcomes. The Impella RP Flex can be quickly inserted at the earliest indication of RV failure to prevent irreversible shock, and can provide continuous RV support for up to 14 days. Our case report supports the first successful use of the Impella RP Flex in a patient post OHT to facilitate RV recovery.
Conclusion

RV failure accounts for significant morbidity and mortality post heart transplantation, and prompt initiation of support is necessary to avoid end-organ injury. The Impella RP Flex, which occupies less space in the superior vena cava and avoids distortion of the RV, offers a new and safe avenue of treating the RV dysfunction, including after OHT. Although more real-world data is needed to assess the outcomes with this device, our experience is nevertheless a promising indication for its future role in single ventricle and biventricular support post transplantation.

Declarations

Ethics approval and consent to participate

An informed consent was obtained from the patient to publish the information / images for and open-access publication.

Consent for publication

An informed consent was obtained from the patient to publish the information / images for and open-access publication.

Availability of data and materials

There is no supplementary data with this case report that is required to be submitted. All pertinent data is already included in main manuscript file.

Competing interests

The authors declare no conflicts of interest or disclosures with regards to the generation of this manuscript.

Funding

There was no funding involved in writing of this manuscript.

Authors’ contributions

All authors confirm the responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

Acknowledgements

JetPub Scientific Communications LLC, supported by Abiomed, assisted in the preparation of this manuscript.

References


**Figures**

![Figure 1](image_url)

**Figure 1**

Risk assessment and management of right ventricular failure after heart transplantation
Figure 2

A- Electrocardiogram post-transplant depicting complete AV dissociation.

B- Electrocardiogram prior to discharge showing return to sinus rhythm
Figure 3

Chest X-ray of the patient with Impella RP Flex in place.