Use of microaxial flow pumps in adolescents

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PII: S2666-2507(23)00269-9
DOI: https://doi.org/10.1016/j.xjtc.2023.07.021
Reference: XJTC 1458

To appear in: JTCVS Techniques

Received Date: 23 June 2023
Revised Date: 18 July 2023
Accepted Date: 26 July 2023


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Can the Impella 5.5 be safely used in adolescents?

August 2020 – March 2023
- 6 patients <18-years-old underwent attempted Impella 5.5 placement
- Patient characteristics and outcomes recorded

<table>
<thead>
<tr>
<th>Patient</th>
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<th>Age (yrs)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>M</td>
<td>13.2</td>
<td>Bridge to transplant</td>
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<tr>
<td>Case 2</td>
<td>M</td>
<td>13.4</td>
<td>Bridge to transplant</td>
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<tr>
<td>Case 3</td>
<td>M</td>
<td>13.7</td>
<td>Bridge to HM3 LVAD, high plasma reactive antibodies</td>
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<td>13.8</td>
<td>Failed insertion, VA-ECMO via R axillary artery</td>
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<td>Case 5</td>
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<td>Device failure via thrombosis, urgent HM3 placement</td>
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<td>Case 6</td>
<td>F</td>
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<td>Bridge to transplant</td>
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</table>

Device thrombosis associated with cardiac arrest and urgent HeartMate 3 placement

The Impella 5.5 can be placed in adolescent patients, but vessel size and angulation can be prohibitive. Post-operative monitoring of hemolysis risk and device positioning is critical.
Use of microaxial flow pumps in adolescents

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Disclosure Statement: JNS is a consultant for AbioMed.

Funding Statement: This work is not funded.

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Word count: 3269/3500
Glossary of Abbreviations: body mass index, BMI; body surface area, BSA; central venous pressure, CVP; ejection fraction, EF; fractional shortening, FS; intra-aortic balloon pump, IABP; intensive care unit, ICU; interquartile range, IQR; left ventricle, LV; left ventricular assist device, LVAD; left ventricular end-diastolic internal dimension, LVIDd; left ventricular end-systolic internal dimension, LVIDs; interventricular septal end-diastolic thickness, IVSd; interventricular septal end-systolic thickness, IVSs; left ventricular end diastolic posterior wall thickness, LVPWd; left ventricular end-systolic posterior wall thickness, LVPWs; left ventricle, LV; mechanical circulatory support, MCS; pulmonary capillary wedge pressure, PCWP; pulmonary vascular resistance, PVR; transesophageal echocardiography, TEE; veno-arterial extracorporeal membrane oxygenation, VA-ECMO.

Central Figure Legend: Impella 5.5 device with clot obstructing outflow.

Central Message: The Impella 5.5 can used as minimally invasive mechanical circulatory support in selected adolescent patients.

Perspective Statement: The prospect of using the Impella 5.5 in adolescent patients as total circulatory support for bridge to transplant is attractive. However, important considerations, including axillary artery dimensions, bony chest wall diameter, and risk of thrombosis must be carefully considered. Failed Impella 5.5 placement can be rescued by initiating VA-ECMO at the axillary artery graft.
Abstract

Objectives: The Impella 5.5 has been successfully utilized in the adult population, however safety and efficacy data in patients <18-years-old is limited.

Methods: Six pediatric patients, aged 13-16 years and weighing from 45-113 kg underwent axillary artery graft placement and attempted placement of the Impella 5.5 device at our institution between August 2020-March 2023.

Results: Indications for implantation were heart failure secondary to myocarditis (2), rejection of prior orthotopic heart transplant, idiopathic dilated cardiomyopathy (2), and heart failure after transposition of the great arteries repair. Placement was unsuccessful in a 13.8-year-old female patient due to prohibitively acute angulation of the right subclavian artery, and VA-ECMO cannulation was performed via the axillary graft. In five patients with successful Impella 5.5 placement, median duration of support was 13.5 days (range 7-42 days). One experienced cardiac arrest secondary to coagulation-associated device failure, requiring temporary HeartMate3 implantation. Four patients were bridged to transplant; three received transplant directly from Impella 5.5, while one received transplant after HeartMate3. The final patient received HeartMate3 on Impella day 42 and is awaiting transplant.

Conclusions: Although exact size cutoffs and anatomy are still being determined, our experience provides a framework for use of the Impella 5.5 in adolescents.

Key words: Impella 5.5, cardiomyopathy, pediatric heart failure, LVAD
**Introduction**

The Impella 5.5 is a minimally invasive option for mechanical circulatory support (MCS) in patients with advanced heart failure, with the ability to provide up to 5.5L/min of flow. This offers a minimally invasive option for left ventricular support, enabling recovery, or serving as a bridge to transplantation or durable left ventricular assist device (LVAD) placement. The advantages of a high-flow, minimally invasive MCS are numerous. These devices may avoid multiple sternotomies in patients likely to receive transplant, while still offering functional benefits of more durable devices. In addition, axillary insertion of the Impella 5.5 may enable patients to participate in physical therapy earlier and more rigorously in the post-operative period and avoid deconditioning prior to heart transplantation or durable LVAD placement.

These advances in minimally invasive MCS have transformed adult heart failure therapy, however widespread use in young patients is inherently limited by the discrepancy between device and patient size. Although options for MCS in children have expanded with FDA approval of the RotaFlow, CentriMag, and PediMag centrifugal flow pumps, there are fewer options for minimally invasive circulatory support in the adolescent population. Previous versions of the Impella devices, including the Impella CP, Impella 2.5, and Impella 5.0, have been implemented in patients as young as nine-years-old, with promising results [1-12]. However, use of the Impella 5.5 in the adolescent population is limited to a single case report describing a 14-year-old patient who received Impella 5.5 as a bridge to heart transplant [8]. The Impella 5.5 not only provides greater circulatory support than past iterations of the device but has different mechanical properties including a stiffer body and lack of pigtail to better facilitate axillary insertion. Further, the Impella 5.5 is the only iteration of Impella devices approved for
total circulatory support in children. In this case series, we describe our institutional experience
with Impella 5.5 in six adolescent patients.

Methods

Ethical statement

This study was approved by the institutional review board of Duke University Medical Center
(PRO00101472), approved 1/2/2019. Individual patient consent was waived.

Patient Population and Data Collection

This retrospective observational study identified all patients under 18-years-old who underwent
Impella 5.5 placement from August 2020 to March 2023. Data were obtained from a
prospectively maintained institutional database and manual chart review. Demographic data,
including age, sex, height, weight, body mass index (BMI), body surface area (BSA), and family
history of cardiomyopathy or congenital heart disease were recorded. Bony chest wall width was
measured at the level of the diaphragm on chest x-ray. Information regarding clinical course and
outcomes was recorded. All data were maintained in protected servers.

Statistical Analysis and Visualization

Data were analyzed and visualized in GraphPad Prism (Dotmatics, San Diego, California, USA).
Data are expressed as median (Interquartile range [IQR]) or mean +/- standard deviation as
indicated.

Operative Technique
Impella 5.5 insertion in the adolescent population presents unique operative considerations. Prior to incision, we inspect with echocardiogram for five key characteristics: (1) left ventricular thrombus, (2) right heart function, (3) significant septal defects, (4) aortic valve competency, and (5) device fit. For device fit the cage must be inside the ventricle and the outflow must be above the aortic valve, and the device must fit through the aortic valve without occluding coronary or other arterial flow. Manufacturer contraindications include aortic valve diameter <1.5cm and ventricular long axis length <7cm. A 4-6 cm right subclavian incision facilitates exposure of the right axillary artery. After administration of 5000 units of heparin, the right axillary artery is then clamped. A longitudinal arteriotomy is made, and we anastomose an 8mm or 10mm beveled (approximately 45-60 degree) Dacron chimney graft to the axillary artery, regardless of patient’s axillary artery diameter. The graft is tunneled superficial to the chest wall muscles and out through a separate incision inferior on the axilla. After clamp removal and assurance of hemostasis at the anastomosis, additional heparin is administered to achieve a goal activated clotting time of >250s. With assistance of transesophageal echocardiography (TEE) and fluoroscopy, a 0.035-inch diagnostic J-wire is manually placed through the graft and advanced to the ascending aorta. An AL-1 catheter advances the j-wire through the aortic valve and into the left ventricle. After exchanging the j-wire for a 0.018-inch placement guidewire, the Impella 5.5 is advanced over the wire into the left ventricle pointing toward the apex, with the bend below the aortic valve. This often requires graft palpation under fluoroscopy to guide the rigid motor housing through the vascular graft anastomosis, along the curvature of the subclavian and innominate, and into the ascending aorta then ventricular apex. Additional maneuvers that can be helpful include (1) papaverine solution topically on the axillary artery, (2) exchange for a stiffer
wire such as a 0.027-inch size, (3) dilator passage along the subclavian artery with fluoroscopic
guidance, or (4) moving the arm up above the head.

After removal of the wire, positioning of the device in the left ventricle is assessed with
fluoroscopy and TEE. Generally, the distance from the center of the inlet cage to the aortic valve
annulus is approximately 5cm. After ensuring appropriate positioning, the device is started, and
further adjustments to device position are made as needed. The Dacron graft is then cut to the
appropriate size, and the insertion sheath is advanced, and the device secured in place. The right
subclavian incision is then closed, and sterile dressings are applied. In cases where the device
cannot be placed due to small artery size or acute angulation of the great vessels, options include
aborting to left sided axillary placement, direct aortic placement via partial or full sternotomy, or
conversion to VA-ECMO with a cannula placed within the Dacron graft as described in case #3
of this report.

**Perioperative Considerations**

Given that use of Impella 5.5 is not widespread in the adolescent population, there are several
perioperative considerations when caring for these patients. All adolescent patients undergoing
nonemergent evaluation for Impella 5.5 therapy received preoperative computed tomography
(CT) or ultrasound imaging to exclude aberrant right subclavian artery, which is not uncommon
in patients with congenital heart disease (**Table 1**). Further, caring for these patients requires
nursing staff to be familiar with Impella 5.5 management. Initially, all patients <18 years with
Impella 5.5 were cared for in the adult cardiothoracic surgical intensive care unit (ICU), however
with implementation of programmatic training of congenital nursing staff, these patients now
remain in the pediatric cardiac ICU. After device placement, our patients are carefully monitored for hemolysis, and initially receive twice-daily hemolysis labs, which include plasma-free hemoglobin, lactate dehydrogenase, and haptoglobin (Table 2). Anticoagulation is also carefully monitored. Ensuring proper placement of the device is critical to optimize function and avoid arrhythmia, and daily echocardiograms are performed to confirm device placement and facilitate any necessary repositioning. Generally, PA catheters are used to monitor device assisted output and volume status, but in smaller patients this is not always possible, and we have been satisfied with the flow estimations of the device in combination with routine clinical noninvasive parameters.

Results

Case 1

A 13-year-old male (59.6kg, BSA 1.58 m²) with a history of Coxsackie myocarditis complicated by dilated cardiomyopathy, severe pulmonary hypertension, and severe mitral regurgitation presented with acute on chronic systolic dysfunction. An intra-aortic balloon pump (IABP) was placed, however ongoing cardiogenic shock led to placement of femoral venous-arterial extracorporeal membrane oxygenation (VA-ECMO) on post-IABP day 4. The patient was transferred to our institution and the IABP was removed. Given worsening pulmonary hypertension and concern for left atrial hypertension, right heart catheterization was performed which revealed elevated pulmonary pressures (pulmonary capillary wedge pressure (PCWP) 38 mmHg, pulmonary vascular resistance (PVR) 108 dynes/m/sec, central venous pressure (CVP) 10 mmHg). Balloon atrial septostomy was performed to alleviate left atrial hypertension and left atrial pressure at time of septostomy was 43 mmHg, with a left-to-right gradient of 14 mmHg.
after septostomy creation. On ECMO day 11, an acute upper gastrointestinal bleed was
identified, and the patient was taken to the operating room for ECMO decannulation and
placement of right axillary Impella 5.5. Pre-operative imaging identified axillary artery diameter
of 4.1 mm, an aortic annulus diameter of 1.5 cm, aortic annulus to LV apex distance of 10.0 cm,
and bony chest width of 32 cm. There were no operative complications, and post-operative care
was completed in the adult cardiothoracic surgical ICU. The patient was extubated on post-
operative day 1, and the upper gastrointestinal bleed resolved after decreasing anticoagulation
while on the Impella 5.5. On post-operative day 17, a suitable donor was identified, and the
patient underwent orthotopic heart transplantation and removal of the Impella 5.5. The patient’s
pulmonary hypertension resolved with continued inotropic support and diuresis, and
catheterization on post-transplant day 7 demonstrated favorable hemodynamics (PCWP 10, CVP
5), and all inotropic support was weaned. Post-transplant course was complicated by positive
crossmatch requiring five plasmapheresis sessions and intravenous immunoglobulins given signs
of antibody-mediated rejection on initial cardiac biopsy. He was discharged on post-Impella 5.5
day 30. Eight days after discharge, he was briefly readmitted after routine cardiac catheterization
demonstrated decreased cardiac function, raising concern for continued antibody-mediated
rejection. However, endomyocardial biopsy did not demonstrate signs of cell- or antibody-
mediated rejection, and cardiac function improved with diuresis. He continues to do well with
routine outpatient management.

**Case 2**

A 13-year-old male (52.5 kg, BSA 1.59 m^2) with history of dilated cardiomyopathy diagnosed at
birth presented with emesis, poor oral intake, and radiating chest pain after 1 week of viral
symptoms. On arrival to the ED, ECG demonstrated no ST changes, and infectious workup was positive for parainfluenza virus. His echocardiogram demonstrated acutely decompensated heart failure, with EF of 18% from a baseline of 28%, and was transferred to our institution for further evaluation. The patient demonstrated some improvement in hypotension and cardiac output with milrinone and epinephrine but experienced refractory atrial fibrillation/flutter requiring rate control with diltiazem. Given persistently inadequate cardiac output and refractory arrhythmia, the team decided to pursue Impella 5.5 therapy to support electrical cardioversion and assist in possible functional recovery or as bridge to durable VAD or transplant. Pre-operative imaging revealed an aortic annulus of 2.0 cm, right axillary artery diameter of 7.5 mm, aortic annulus to LV apex distance of 9.9 cm, and bony chest wall width of 28 cm. The Impella 5.5 was placed successfully and permitted electrical cardioversion. He was extubated on post-Impella day 1, and subsequently listed status 1A for heart transplantation. On post-Impella day 7, the patient experienced ventricular tachycardia that resolved after Impella repositioning. The patient was transplanted on Impella day 21 and continues to do well.

Case 3

A 13-year-old male (72.5kg, BSA 1.82 m²) with history of D-transposition of the great arteries, status post aortic translocation and right ventricle to pulmonary conduit in infancy, and pulmonary valve replacement with a 23mm Sapien valve at 10-years-old. He developed progressive systolic and diastolic dysfunction with ventricular tachycardia. After the patient experienced pulseless cardiac arrest with return of spontaneous circulation achieved after defibrillation, the decision was made to proceed with advanced MCS while the patient was evaluated for cardiac transplantation. Pre-operative imaging revealed an aortic annulus of 1.5
cm, right axillary artery diameter of 5.3 mm, aortic annulus to LV apex distance of 12.3 cm, and bony chest wall width of 30 cm. The patient was listed status 1A for cardiac transplantation, however, was shaded due to prohibitively high panel reactive antibodies requiring desensitization. The patient was extubated on Impella day 15 and underwent Impella 5.5 removal and durable LVAD placement on Impella 5.5 day 42. He is undergoing desensitization for plasma reactive antibodies prior to transplant.

Case 4

A 13-year-old female (45.0 kg, BSA 1.37 m²) presented with 5-days of upper respiratory symptoms and one day of altered mental status. Labs indicated multi-organ failure and echocardiogram revealed severely decreased biventricular function, with thrombus in the left ventricle. The patient was intubated and placed on high-intensity inotropes and transferred to our institution for transplant evaluation. Pre-operative CT imaging could not be completed due to urgent need for surgical intervention. Intraoperatively the right axillary artery diameter was approximately 4mm. The aortic annulus measured 1.59 cm, and bony chest wall width was 23 cm. She was taken to the operating room immediately upon arrival to our institution for Impella 5.5 placement. In the operating room, an axillary cutdown was performed and a 10mm Dacron graft was anastomosed to the axillary artery. The Impella 5.5 was inserted into the Dacron graft and through the axillary artery, however subclavian artery angulation was too acute to facilitate Impella 5.5 passage. We elected to place the patient on VA-ECMO via the axillary artery graft, followed by atrial septostomy for left atrial decompression. Post-septoplasty right heart catheterization demonstrated persistently elevated left atrial pressure, and a percutaneous left atrial vent was placed. Continuous renal replacement therapy was initiated on VA-ECMO day 8.
for anuric renal failure. VA-ECMO and left atrial vent were discontinued after 11 days, and echocardiogram demonstrated mild to moderate LV dysfunction. Unfortunately, 53 days after ECMO decannulation, the patient had acutely decompensated cardiac function, resulting in hypotensive arrest. Given persistent renal failure and worsening cardiac function, this patient transitioned to comfort care and died 54 days after ECMO decannulation.

Case 5

A 16-year-old male (113.2 kg, BSA 2.41 m²) with a history of mild COVID-19 infection 1-month prior to symptom onset, presented with vomiting, syncope, and ventricular ectopy. He was diagnosed with dilated cardiomyopathy and transferred to our institution for transplant evaluation. His heart failure was refractory to medical therapy, including carvedilol, lisinopril, milrinone, and sotalol, and progressed to the development of persistent non-sustained ventricular tachycardia. Cardiac MRI demonstrated diffuse epicardial scarring consistent with a chronic, progressive cardiomyopathy rather than an acute COVID-19 associated myocarditis. Cardiac catheterization showed significantly elevated right-sided pressures (PCWP 34 mmHg, PVR 560 dynes/m/s, CVP 6 mmHg). Pre-operative imaging revealed an aortic annulus of 1.36 cm, right axillary artery diameter of 13.6 mm, aortic annulus to LV apex distance of 11.4 cm, and bony chest wall width of 37 cm. After multidisciplinary discussion, the team elected to proceed with MCS and Impella 5.5 implantation as a bridge to transplantation. Unfortunately, on postoperative day 5, the patient had ventricular fibrillation cardiac arrest requiring defibrillation due to device failure secondary to coagulopathy. The ICU and cardiac surgery teams proceeded with intracorporeal left ventricular assist device (LVAD) implantation as a bridge to transplantation. After Impella 5.5 explant, the team observed a complete occlusion of the outflow tract by clot
Repeat catheterization 26 days after durable LVAD insertion showed significant improvement in right sided heart pressures and permissive of transplant. The patient received cardiac transplantation on post-Impella 5.5 day 36. Post-transplant course was initially complicated by low cardiac output, which improved with diuresis and inotropic support. A filling defect in the transverse aorta was observed on left heart catheterization, which prompted CT angiography and identification of a small, contained transverse aortic arch dissection which is being managed with labetalol to a blood pressure goal of less than 135/85 mmHg, and regular CT angiograms to evaluate dissection progression. He was discharged on post-Impella day 50 and continues to do well with outpatient management.

Case 6

A 16-year-old female (81.4 kg, BSA 1.95 m²) with a history of TNNT2-positive dilated cardiomyopathy status post orthotopic heart transplantation at age 14 presented with allograft rejection. Transthoracic echocardiography showed severely decreased LV ejection fraction (20%) and severe RV dysfunction. She was transferred to our institution for re-transplant evaluation. Following right heart catheterization showing reduced cardiac index and elevated filling pressures, the cardiothoracic surgery team elected to proceed with femoral VA-ECMO cannulation. Pre-operative imaging revealed an aortic annulus of 2.9 cm, right axillary artery diameter of 7.9 mm, aortic annulus to LV apex distance of 9.3 cm, and bony chest wall width of 28 cm. ECMO course was complicated by cannulation site bleeding and compartment syndrome on ECMO day 3 leading to Impella 5.5 implantation on ECMO decannulation. A suitable donor was identified, and she underwent a repeat heart transplantation 10 days following Impella 5.5 insertion. Cardiac catheterization on post-transplant day 7 showed improved hemodynamics and
no evidence of rejection. Her hospital course was complicated by a generalized seizure expected
to be posterior reversible encephalopathy syndrome related to post-transplant hypertension. She
was discharged on post-Impella day 24 and continues to do well with routine outpatient
management.

Discussion
In this manuscript, we describe our institutional experience with the Impella 5.5 in six adolescent
patients. Four patients were successfully bridged to transplant, with one requiring initial bridge
to LVAD due to Impella device failure. One patient remains on HeartMate3 support awaiting
cardiac transplantation. One patient had failed Impella 5.5 insertion due to acute subclavian
artery angulation, and instead was placed on VA-ECMO via the axillary artery graft. This patient
highlights challenges with Impella 5.5 use in small adolescent patients. Bony chest wall diameter
may provide a crude estimation of great vessel angulation and contour without axial imaging,
though we do not have enough patients to determine a threshold for insertion. Importantly, this
case illustrates the alternative approach of using the already-placed axillary artery Dacron graft
as a conduit for VA-ECMO.

The most notable adverse event in this patient cohort was in Case 3. This patient experienced
Impella 5.5 outflow thrombosis, resulting in complete outflow occlusion, ventricular tachycardia
cardiac arrest, and subsequent conversion to intracorporeal LVAD. This patient had a history of
presumed COVID-19 infection approximately 1 month prior to the onset of heart failure
symptoms, given several members of his household were symptomatic, though only one sibling
had COVID-19 testing at this time, which was positive. The patient’s COVID-19 symptoms
were reportedly mild, with only one day of fever and no respiratory symptoms. The patient did
test positive for COVID-19 at the time he presented with symptoms of heart failure. Thus, it is
possible that this patient’s coagulopathy was related to recent COVID-19 infection. We also
considered insufficient anticoagulation or heparin-induced thrombocytopenia, however HIT
panels were negative and activated prothrombin time ranged from 40.7 to 44.6 seconds 24 hours
prior to thrombosis. The most likely etiology is device malpositioning; this patient experienced
significant ectopy secondary to presumed arrhythmogenic cardiomyopathy, and the Impella 5.5
was repositioned multiple times to avoid triggering ventricular arrhythmia. It is possible that
repositioning to avoid ectopy inadvertently caused the Impella 5.5 outflow cannula to push
against the aortic wall, leading to stasis and serving as a nidus for clot formation or aspiration.
Notably, we have not observed this complication in the >100 Impella 5.5 devices we have placed
in adults at our institution. Though the etiology remains uncertain, this underscores the
importance of regular positioning verification with echocardiogram and routine lab monitoring in
the immediate post-operative period.

Currently, only one adolescent patient supported with the Impella 5.5 is described in the
literature - a 14-year-old with acute systolic dysfunction who was bridged to transplant after 21
days of Impella 5.5 support (Table 1) [8]. Our case series adds to a growing body of literature
describing minimally invasive MCS in adolescent patients. One limitation is that many of our
patients <18 years old could be considered adult sized, and our smallest successful insertion was
in a patient weighing 51 kg. However, age is positively correlated with vessel diameter
independent of weight, and body size may not always predict successful insertion[13, 14].
Further studies are needed to determine exact measurement thresholds and guidelines for use of Impella 5.5 in adolescent patients.

Conclusion

The Impella 5.5 can be used to bridge adolescent patients to cardiac transplantation (Figure 2).

Although exact size cutoff and anatomic guidelines are still being determined, this article gives a framework for the use of the device in adolescents.

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<th>Case 4</th>
<th>Case 5</th>
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</tbody>
</table>

Table 1: Body mass index, BMI; body surface area, BSA; left ventricular end-diastolic internal dimension, LVIDd; left ventricular end-systolic internal dimension, LVIDs; interventricular septal end-diastolic thickness, IVSd; interventricular septal end-systolic thickness, IVSs; left ventricular end diastolic posterior wall thickness, LVPWd; left ventricular end-systolic posterior wall thickness, LVPWs; fractional shortening, FS; ejection fraction, EF; left ventricle, LV.

Table 2. Operative Outcomes

<table>
<thead>
<tr>
<th>Case</th>
<th>Implant Duration (days)</th>
<th>Bridge to LVAD</th>
<th>Time to LVAD (days)</th>
<th>Bridge to transplant</th>
<th>Time to transplant (days)</th>
<th>ICU LOS (days)</th>
<th>Hospital LOS (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td>26</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td>36</td>
<td>43</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>Y</td>
<td>42</td>
<td></td>
<td></td>
<td>99</td>
<td>99</td>
</tr>
<tr>
<td>4</td>
<td>0 – Failed Impella placement, VA-ECMO placed as bridge to recovery</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Y</td>
<td></td>
<td></td>
<td></td>
<td>65, deceased</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: length of stay, LOS; left ventricular assist device, LVAD; intensive care unit, ICU; veno-arterial extracorporeal membrane oxygenation, VA-ECMO
References


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**Figures**

Figure 1: Operative image demonstrating occlusive clot at the Impella 5.5 outflow tract in Case 5.

Figure 2: Graphical abstract.
Can the Impella 5.5 be safely used in adolescents?

August 2020 – March 2023

- 6 patients <18-years-old underwent attempted Impella 5.5 placement
- Patient characteristics and outcomes recorded

<table>
<thead>
<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age (yrs)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>M</td>
<td>13.2</td>
<td>Bridge to transplant</td>
</tr>
<tr>
<td>Case 2</td>
<td>M</td>
<td>13.4</td>
<td>Bridge to transplant</td>
</tr>
<tr>
<td>Case 3</td>
<td>M</td>
<td>13.7</td>
<td>Bridge to HM3 LVAD, high plasma reactive antibodies</td>
</tr>
<tr>
<td>Case 4</td>
<td>F</td>
<td>13.8</td>
<td>Failed insertion, VA-ECMO via R axillary artery</td>
</tr>
<tr>
<td>Case 5</td>
<td>M</td>
<td>16.8</td>
<td>Device failure via thrombosis, urgent HM3 placement</td>
</tr>
<tr>
<td>Case 6</td>
<td>F</td>
<td>16.9</td>
<td>Bridge to transplant</td>
</tr>
</tbody>
</table>

Device thrombosis associated with cardiac arrest and urgent HeartMate 3 placement

The Impella 5.5 can be placed in adolescent patients, but vessel size and angulation can be prohibitive. Post-operative monitoring of hemolysis risk and device positioning is critical.