SUMMARY OF SAFETY AND EFFECTIVENESS DATA (SSED)

I.   GENERAL INFORMATION

Device Generic Name: Temporary non-roller type right heart support blood pump

Device Trade Name: Impella RP® System

Device Procode: PYX

Applicant Name and Address: ABIOMED, Inc.
                                 22 Cherry Hill Drive
                                 Danvers, MA 01923

Date of Panel Recommendation: None

Premarket Approval Application   P170011
(PMA) Number:

Date of FDA Notice of Approval: September 20, 2017

The Impella RP® System was originally approved under Humanitarian Device Exemption (HDE), H140001, on January 23, 2015. The Summary of Safety and Probable Benefit (SSPB) to support the HDE approval is available on the CDRH website (http://www.accessdata.fda.gov/cdrh_docs/pdf14/H140001B.pdf) and is incorporated by reference herein. The current PMA application is a conversion from the original HDE based on additional clinical data collected since the HDE approval to support safety and effectiveness of the device.

II.   INDICATIONS FOR USE

The Impella RP® System is indicated for providing temporary right ventricular support for up to 14 days in patients with a body surface area ≥ 1.5 m^2, who develop acute right heart failure or decompensation following left ventricular assist device implantation, myocardial infarction, heart transplant, or open-heart surgery.

III.   CONTRAINDICATIONS

The Impella RP® System is contraindicated for patients with the following conditions:

- Disorders of the pulmonary artery wall that would preclude placement or correct positioning of the Impella RP device
- Mechanical valves, severe valvular stenosis or valvular regurgitation of the tricuspid or pulmonary valve
- Mural thrombus of the right atrium or vena cava

- Anatomic conditions precluding insertion of the pump
- Presence of a vena cava filter or caval interruption device, unless there is clear access from the femoral vein to the right atrium that is large enough to accommodate a 22 Fr catheter

IV.   WARNINGS AND PRECAUTIONS

The warnings and precautions can be found in the Impella RP System labeling.

V.   DEVICE DESCRIPTION

The Impella RP System is a minimally invasive, miniaturized percutaneous circulatory support system for the right ventricle. It is comprised of three components as shown in Figure 1:

- the Impella RP Catheter: a 22 Fr micro-axial flow pump catheter and its accessories
- the Automatic Impella Controller (AIC): a reusable external drive console
- the Impella Purge Cassette: an infusion pump used to flush the Impella RP Catheter

Figure 1: The Impella RP System
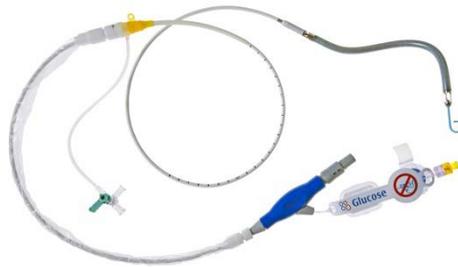
(a) The Impella RP Catheter

(b) Automatic Impella Controller (AIC)   (c) The Impella Purge Cassette

The AIC controls both the Impella RP Catheter and the Impella Purge Cassette. Both the AIC and the Impella Purge Cassette are also PMA approved (under P140003) for use with

the Impella family of left heart circulatory support catheters. The Impella RP Catheter and the Purge Cassette are sterile, single use products.

During use, the Impella RP Catheter is percutaneously placed across the tricuspid and pulmonic valves via single femoral venous access. It actively unloads the right ventricle by pumping blood from the inferior vena cava (IVC) into the pulmonary artery (PA), as shown in Figure 2. The catheter is connected to the AIC, as shown in Figure 3. The AIC generates the signals required to power the drive motor of the catheter and provides the user interface. The AIC also incorporates the Impella Purge Cassette purge system, which provides a pressure barrier to prevent blood from entering the catheter's drive motor. A dextrose (5-40% with 50 Units/ml of heparin added) solution is used as a purge fluid.

Two (2) additional sterile, disposable accessories are kitted with the Impella RP Catheter to assist in its percutaneous insertion. These components are original equipment manufacturer (OEM) products, namely, a 23 Fr Peel-away Introducer kit (Oscor Medical, cleared under K122084) and a 0.025″ placement guidewire (Boston Scientific, cleared under K935997). In addition, a reusable cart for the AIC is also provided to allow ease of patient transport.

Figure 2: Impella RP Catheter Placement during Use
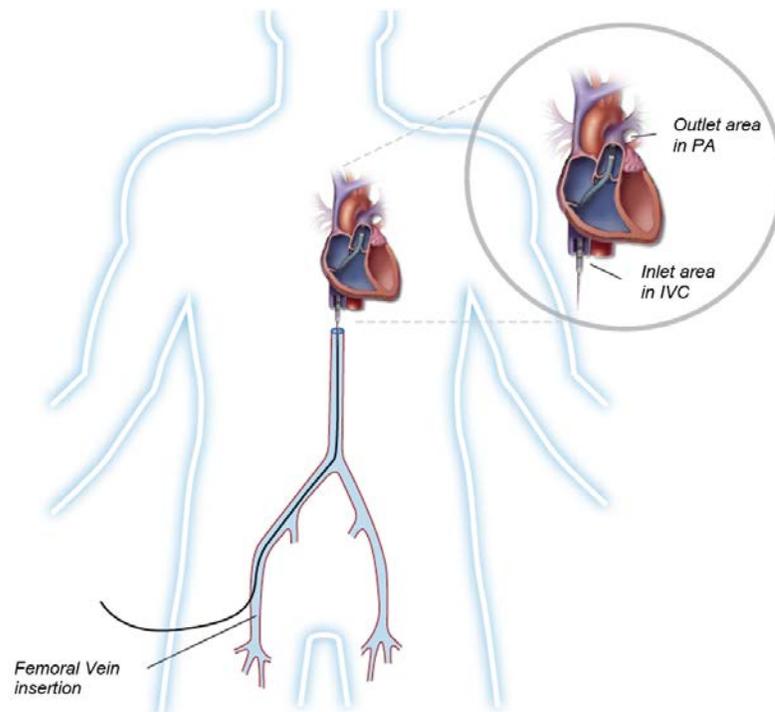
Figure 3: Clinical Use Set-up for the Impella RP System
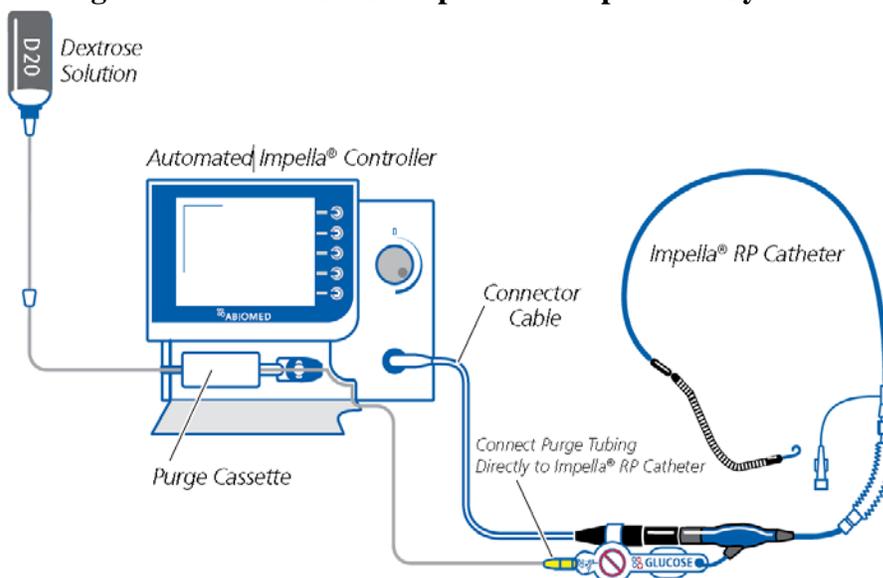
VI. ALTERNATIVE PRACTICES AND PROCEDURES

There are several other alternatives for the treatment of acute right heart failure, including the use of intravenous inotropic drugs and implantation of a surgical right ventricular assist device (RVAD). Three (3) RVADs are currently approved for commercialization in the United States: the BVS5000/AB5000 VAD systems (ABIOMED, Inc.), the pVAD/IVAD systems (Thoratec Corporation), and the CentriMag RVAD (Thoratec Corporation). Each alternative has its own advantages and disadvantages. A patient should fully discuss these alternatives with his/her physician to select the method that best meets expectations and lifestyle.

VII. MARKETING HISTORY

The Impella RP System received a CE Mark for marketing in the Europe Union (EU) on April 4, 2014; it is currently be used in the United Kingdom, Germany, Switzerland, Denmark, and Belgium. It was HDE approved (under H140001) in the U.S. in 2015. It also received a marketing license from Health Canada on March 8, 2017. The device has not been withdrawn from marketing for any reason related to its safety or effectiveness.

VIII. POTENTIAL ADVERSE EFFECTS OF THE DEVICE ON HEALTH

Below is a list of the potential adverse effects (e.g., complications) associated with the use of the device:

- Death
- Arrhythmia
- Atrial fibrillation
- Bleeding
- Cardiac tamponade

- Pulmonary valve insufficiency
- Respiratory dysfunction
- Sepsis
- Thrombocytopenia
- Thrombotic vascular (non-

- Cardiogenic shock
- Device malfunction
- Hemolysis
- Hepatic failure
- Insertion site infection
- Perforation
- Phlegmasia cerulea dolens (a severe form of deep venous thrombosis)
- central nervous system) complication
- Tricuspid valve injury
- Vascular injury
- Venous thrombosis
- Ventricular fibrillation and/or tachycardia

For the specific adverse events that occurred in the clinical study, please see Section X below.

IX. SUMMARY OF NONCLINICAL STUDIES

A summary of previously reported preclinical studies can be found in the SSPB for the original HDE (http://www.accessdata.fda.gov/cdrh_docs/pdf14/H140001B.pdf).

X. SUMMARY OF PRIMARY CLINICAL STUDY

The applicant collected clinical data to establish a reasonable assurance of safety and effectiveness of the Impella RP System in patients who developed acute right heart failure or decompensation and required temporary ($\leq$ 14 days) right heart support. The clinical data supporting the PMA approval were pooled from the following three (3) datasets:

- Impella RP System pivotal study: 30 patients
- Impella RP System continued access protocol (CAP) study: 4 patients
- Impella RP System post-approval study (PAS): 26 patients

A summary of these clinical studies is presented below.

A. Study Designs

Impella RP System Pivotal Study and CAP Study

The Impella RP System pivotal study (also known as the "RECOVER RIGHT" study) and the Impella RP System CAP study had the same study design and were prospective, multi-center, non-randomized studies conducted under investigational device exemption (IDE) G120159. Patients in these two (2) studies were treated between March 22, 2013 and January 19, 2015 at nine (9) investigational sites in the U.S.

The studies consisted of the following two (2) cohorts:

- Cohort A: Patients who develop right heart failure within 48 hours post-implantation of an FDA approved implantable surgical left ventricular assist device (LVAD).
- Cohort B: Patients who developed cardiogenic shock involving right heart failure or

dysfunction post cardiotomy within 48 hours post surgery or post myocardial infarction.

The primary endpoint was the survival rate at 30 days post device explant or hospital discharge (whichever is longer), or at induction of anesthesia for a longer term therapy, including heart transplant or implantation of a surgical RVAD (as a bridge-to-recovery or bridge-to-transplant).

The secondary safety endpoints were determined by the rates of the following adverse events at 30 days or discharge (whichever is longer), or at induction of anesthesia for a longer term therapy:

– Major bleeding
– Hemolysis
– Pulmonary embolism
– Tricuspid/pulmonary valve dysfunction (defined as tricuspid/pulmonic valve injury resulting in increased valve regurgitation versus baseline)

The secondary effectiveness endpoints included the following:

– Central venous pressure (CVP) and cardiac index (CI) improvement post initiation of Impella RP support
– Decreased use of inotropes during support
– Improvement in LVAD flow or left ventricle pumping function secondary to the increased venous return by the Impella RP within 48 hours post implant

Further information on the pivotal study design can be found in the SSPB for the original HDE.

Impella RP System PAS

The Impella RP System PAS was a prospective, multi-center, non-randomized study conducted as a condition of approval for the original HDE. Patients in the study were treated in the commercial setting between May 27, 2015 and September 24, 2016 at 8 investigational sites in the U.S.

1. Clinical Inclusion and Exclusion Criteria

Enrollment in the Impella RP System PAS was limited to patients who met the approved indication of the device under the HDE and who were not contraindicated.

2. Follow-up Schedule

All patients were scheduled to return for follow-up examinations at 30 and 180 days post device explant.
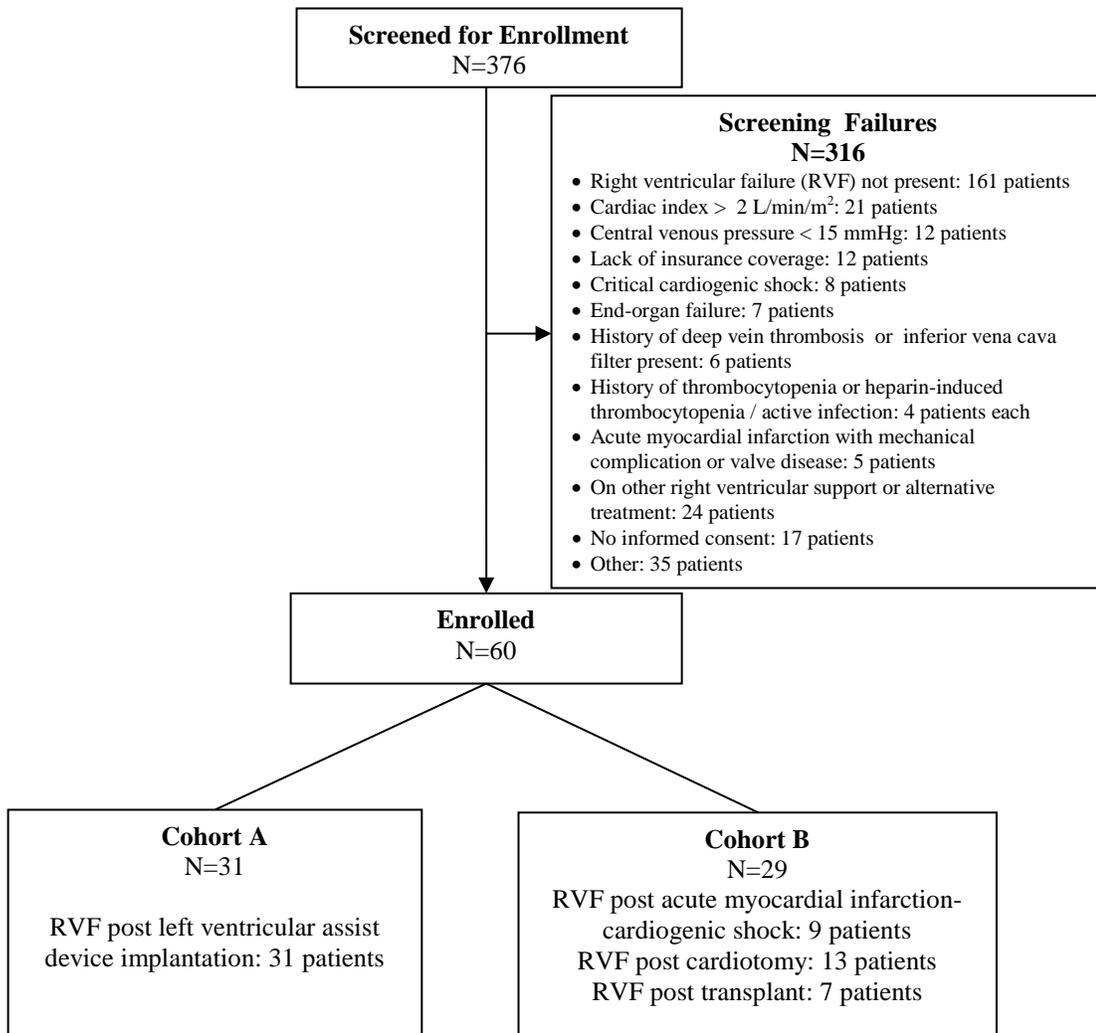
3. Clinical Endpoints

The clinical endpoints of the study were the same as the pivotal study.

The three (3) datasets listed above were pooled and analyzed descriptively. The success criterion was based on clinical judgement.

B. Accountability of PMA Cohort

A total of 60 subjects were treated in the three (3) prospective studies, including 31 subjects (52%) enrolled in Cohort A and 29 subjects (48%) enrolled in Cohort B, as shown in Figure 4.

Figure 4: Patient Accountability

Screened for Enrollment
N=376

Screening Failures
N=316
- Right ventricular failure (RVF) not present: 161 patients
- Cardiac index > 2 L/min/m^2: 21 patients
- Central venous pressure < 15 mmHg: 12 patients
- Lack of insurance coverage: 12 patients
- Critical cardiogenic shock: 8 patients
- End-organ failure: 7 patients
- History of deep vein thrombosis or inferior vena cava filter present: 6 patients
- History of thrombocytopenia or heparin-induced thrombocytopenia / active infection: 4 patients each
- Acute myocardial infarction with mechanical complication or valve disease: 5 patients
- On other right ventricular support or alternative treatment: 24 patients
- No informed consent: 17 patients
- Other: 35 patients

Enrolled
N=60

Cohort A
N=31

RVF post left ventricular assist device implantation: 31 patients

Cohort B
N=29
RVF post acute myocardial infarction-cardiogenic shock: 9 patients
RVF post cardiotomy: 13 patients
RVF post transplant: 7 patients

C. Study Population Demographics and Baseline Parameters

The demographics and baseline characteristics of the study population, as summarized in

Table 1, are typical for a temporary right ventricular support study performed in the U.S. The majority of the patients had hypertension (81.7%), coronary artery disease (CAD; 58.6%), congestive heart failure (CHF; 83.6%), or arrhythmia (76.4%), and were in New York Heart Association (NYHA) class III/IV (93.8%).

Table 1: Patient Demographics and Baseline Characteristics

Demographics and Baseline Characteristics	Summary Statistics[*]		
	Cohort A (N=31)	Cohort B (N=29)	All Patients (N=60)
Age	54.5±14.9 (31)	62.9±14.3 (29)	58.6±15.1 (60)
Gender			
Male	80.6% (25/31)	55.2% (16/29)	68.3% (41/60)
Female	19.4 (6/31)	44.9% (13/29)	31.7% (19/60)
Race			
White	54.8% (17/31)	44.8% (13/29)	50.0% (30/60)
Black or African American	41.9% (13/31)	44.8% (13/29)	43.3% (26/60)
Asian	3.2% (1/31)	6.9% (2/29)	5.0% (3/60)
Body surface area (m^2)	2.0±0.2 (31)	1.9±0.2 (29)	1.9±0.2 (60)
Hypertension	77.4% (24/31)	86.2% (25/29)	81.7% (49/60)
Coronary artery disease	60.0% (18/30)	57.1% (16/28)	58.6% (34/58)
Congenital heart disease	7.7% (2/26)	8.0% (2/25)	7.8% (4/51)
Congestive heart failure	96.8% (30/31)	66.7% (16/24)	83.6% (46/55)
New York Heart Association (NYHA) Classification			
I	0.0% (0/29)	5.0% (1/20)	2.0% (1/49)
II	3.4% (1/29)	5.0% (1/20)	4.1% (2/49)
III	10.3% (3/29)	15.0% (3/20)	12.2% (6/49)
IV	86.2% (25/29)	75.0% (15/20)	81.6% (40/49)
Myocardial infarction	46.4% (13/28)	52.0% (13/25)	49.1% (26/53)
Percutaneous coronary intervention	41.9% (13/31)	32.1% (9/28)	37.3% (22/59)
Coronary artery bypass grafting	9.7% (3/31)	17.2% (5/29)	13.3% (8/60)
Arrhythmia	79.3% (23/29)	73.1% (19/26)	76.4% (42/55)
Cerebrovascular accident	10.7% (3/28)	28.0% (7/25)	18.9% (10/53)
Stroke	7.1% (2/28)	4.0% (1/25)	5.7% (3/53)
Transient ischemic attack	0.0% (0/28)	24.0% (6/25)	11.3% (6/53)
Other	3.6% (1/28)	0.0% (0/25)	1.9% (1/53)
Smoking	46.7% (14/30)	51.7% (15/29)	49.2% (29/59)
Chronic obstructive pulmonary disease	20.7% (6/29)	7.7% (2/26)	14.5% (8/55)
Diabetes	51.6% (16/31)	41.4% (12/29)	46.7% (28/60)
Chronic kidney disease	37.9% (11/29)	32.0% (8/25)	35.2% (19/54)
Valve replacement/repair	12.9% (4/31)	17.2% (5/29)	15.0% (9/60)
Implantable cardioverter defibrillator /Pacemaker implanted	64.5% (20/31)	24.1% (7/29)	45.0% (27/60)
Left ventricular ejection fraction (LVEF; %)	13.8±6.0 (28)	46.5±15.9 (25)	29.2±20.2 (53)

Demographics and Baseline Characteristics	Summary Statistics[*]		
	Cohort A (N=31)	Cohort B (N=29)	All Patients (N=60)
Tricuspid annular plane systolic excursion (TAPSE; mm)	13.9±6.5 (14)	11.7±4.8 (14)	12.8±5.7 (28)

[*]Categorical data: % (n/total no.); variable data: mean±SD (n)

The baseline laboratory parameters are provided in Table 2. Both kidney and liver functions were reflective of poor end-organ perfusion prior to device insertion.

Table 2: Baseline Laboratory Parameters

Laboratory Parameters	Summary Statistics[*]		
	Cohort A (N=31)	Cohort B (N=29)	All Patients (N=60)
White blood cell (WBC) count (10^3)	12.1±6.8 (31)	14.4±9.5 (29)	13.2±8.2 (60)
Platelets count (10^3)	208.1±92.3 (31)	230.4±133.4 (29)	218.9±113.6 (60)
Hemoglobin (g/dL)	10.1±2.0 (31)	10.9±2.0 (29)	10.5±2.0 (60)
Hematocrit (%)(N)	30.9±6.2 (31)	33.3±5.9 (29)	32.1±6.1 (60)
Plasma free hemoglobin (mg/dL)	13.6±11.8 (16)	39.0±59.1 (12)	24.5±40.8 (28)
Blood urea nitrogen (BUN; mg/dL)	27.3±17.2 (31)	31.5±16.6 (29)	29.4±16.9 (60)
Serum creatinine (mg/dL)	1.5±0.6 (31)	1.5±0.7 (29)	1.5±0.6 (60)
Creatinine clearance (mL/min)	76.8±55.1 (23)	68.9±55.2 (22)	73.0±54.7 (45)
Total bilirubin (mg/dL)	1.6±1.1 (29)	1.1±0.6 (29)	1.4±0.9 (58)
Lactate dehydrogenase (LDH; U/L)	539.5±345.9 (24)	715.0±553.6 (14)	604.1±435.2 (38)

[*]Mean±SD (n)

The baseline support and hemodynamic characteristics are summarized in Table 3. All patients enrolled presented with right ventricular failure and poor hemodynamics at the time of implant, despite high dose of inotropes/pressors.

Table 3: Baseline Support and Hemodynamic Characteristics

Support and Hemodynamic Characteristics	Summary Statistics[*]		
	Cohort A (N=31)	Cohort B (N=29)	All Patients (N=60)
Number of inotropes/pressors (prior to device insertion)	3.6±1.2 (31)	3.1±1.3 (28)	3.4±1.2 (59)
Hemodynamics (prior to device insertion)			
Cardiac index (L/min/m^2)	1.8±0.5 (31)	1.9±0.6 (28)	1.9±0.5 (59)
Cardiac output (L/min)	3.9±1.4 (31)	3.8±1.3 (28)	3.9±1.3 (59)
Pulmonary capillary wedge pressure/left arterial pressure (mmHg)	14.5±4.6 (8)	20.4±8.5 (8)	17.4±7.3 (16)
Right arterial pressure/central venous pressure (mmHg)	18.4±4.8 (31)	19.8±5.8 (29)	19.1±5.3 (60)

Support and Hemodynamic Characteristics	Summary Statistics[*]		
	Cohort A (N=31)	Cohort B (N=29)	All Patients (N=60)
Pulmonary artery pressure: Systolic (mmHg)	39.4±12.1 (29)	39.8±10.3 (26)	39.6±11.1 (55)
Pulmonary artery pressure: Diastolic (mmHg)	23.9±11.6 (31)	21.2±7.8 (27)	22.5±9.9 (58)
Mean arterial Pressure (mmHg)	75.6±12.4 (24)	65.9±16.3 (24)	70.7±15.1 (48)
Heart rate (BPM)	91.9±19.7 (28)	86.1±18.0 (28)	89.0±18.9 (56)
LVAD flow (L/min; Cohort A only)	4.0±0.7 (19)	N/A	4.0±0.7 (19)

[*]Mean±SD (n)

D. Safety and Effectiveness Results

1. Primary Endpoint

The primary endpoint of survival at 30 days or discharge post device removal (whichever is longer), or at induction of anesthesia for the next longer-term therapy (i.e., heart transplant or implantation of a surgical RVAD) was achieved in 73.3% of the patients, with 77.4% in cohort A and 69.0% in cohort B, as shown in Table 4. All patients discharged from the hospital (70% of all patients) recovered their right heart function and were discharged without any right ventricular mechanical support.

Table 4: Patient Survival Outcomes

Event	Summary Statistics[*]		
	Cohort A (N=31)	Cohort B (N=29)	All Patients (N=60)
Alive at 30 days/discharge/next therapy	77.4% (24/31)	69.0% (20/29)	73.3% (44/60)
Alive at next longer term therapy	16.1% (5/31)	6.9% (2/29)	11.7% (7/60)
Alive at 30 days	77.4% (24/31)	65.5% (19/29)	71.7% (43/60)
Alive at discharge	71.0% (22/31)	69.0% (20/29)	70.0% (42/60)
Right ventricle recovered (discharged without RVAD)	100% (22/22)	100% (20/20)	100% (42/42)

[*]% (n/total no.)

2. Secondary Endpoints

Safety Endpoints

The secondary safety endpoint results are summarized in Table 5, which were measured at hospital discharge or to induction of anesthesia to a longer term therapy.

Table 5: Secondary Safety Endpoint Results

| Endpoints	Summary Statistics[*]		
	Cohort A (N=31)	Cohort B (N=29)	All Patients (N=60)
Major bleeding	54.8% (17/31)	41.4% (12/29)	48.3% (29/60)
Hemolysis	29.0% (9/31)	24.1% (7/29)	26.7% (16/60)
Pulmonary embolism	0.0% (0/31)	0.0% (0/29)	0.0% (0/60)

[*]% (n/total no.)

Effectiveness Endpoints

Central venous pressure and cardiac index:

The overall central venous pressure and cardiac index changes over time are shown in Figures 5 and 6, respectively. The central venous pressure decreased from 19.0 ± 0.7 to 13.7 ± 0.6 mmHg during support; the cardiac index increased from 1.9 ± 0.1 to 3.1 ± 0.2 L/min/m^2 during support. In addition, both the central venous pressure and the cardiac index remained stable post removal of the Impella RP.

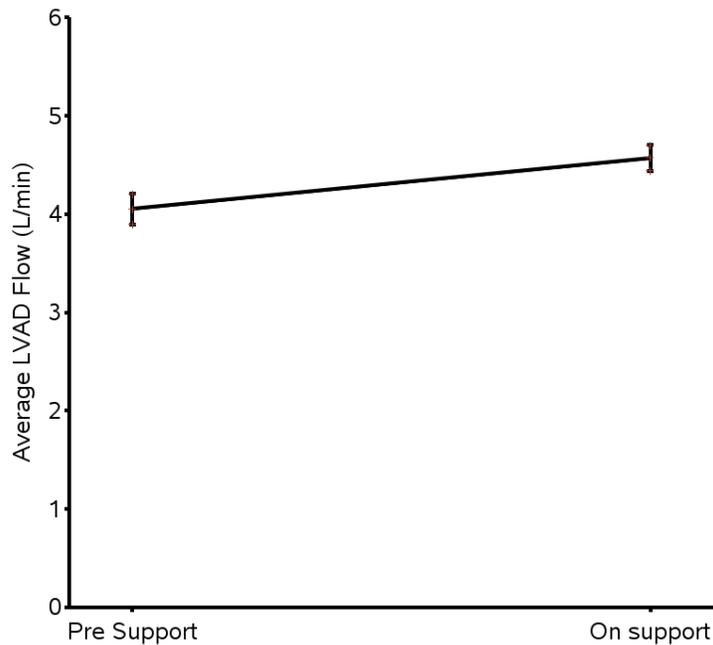**Figure 5: Central Venous Pressure Change Over Time**
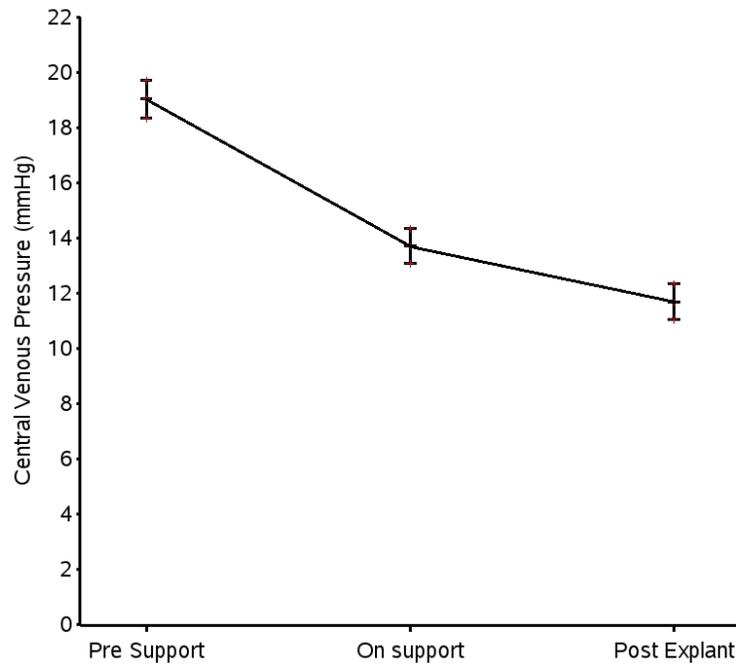
Figure 6: Cardiac Index Change Over Time
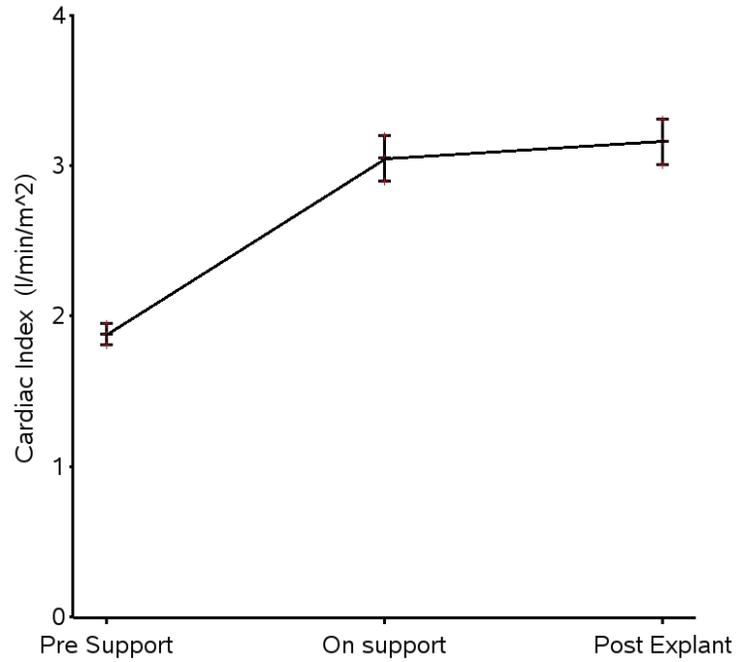
LVAD flow:

The LVAD flow in Cohort A patients is shown in Figure 7. The flow increased from 4.0 ± 0.2 L/min to 4.6 ± 0.1 L/min post support.
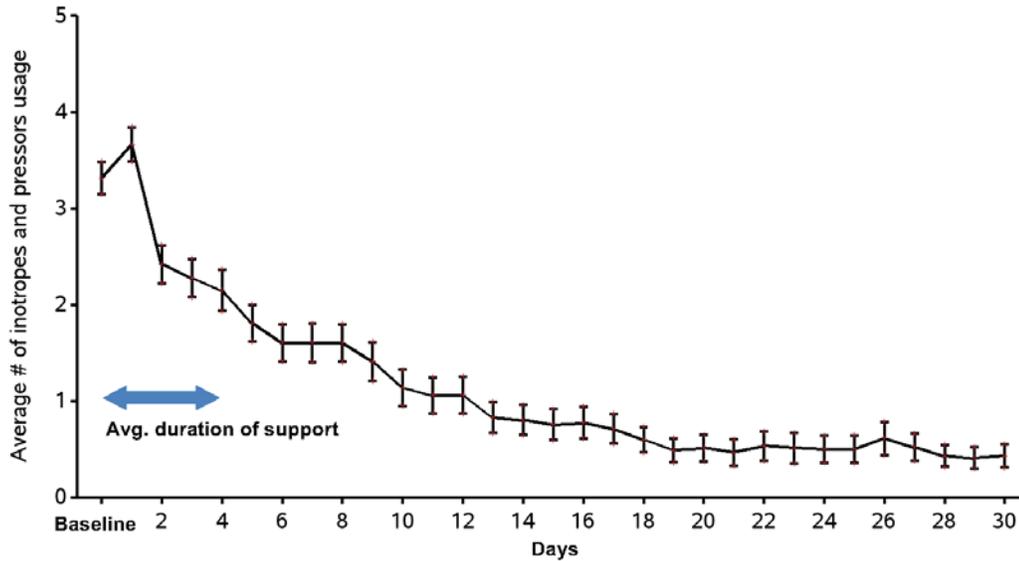
Figure 7: LVAD Flow Change from Baseline to On-support

Inotrope and pressor uses during support:

The inotrope and pressor uses during support are shown in Figure 8. A rapid decrease of such uses was seen post initiation of Impella RP support.

Figure 8: Inotrope and Pressor Uses during Support

3. Other Results:

Procedural Parameters

The procedural parameters are summarized in Table 6.

Table 6: Procedural Parameters

Procedural Parameters	Summary Statistics*		
	Cohort A (N=31)	Cohort B (N=29)	All Patients (N=60)
Side of implantation			
Left femoral vein	0.0% (0/31)	6.9% (2/29)	3.3% (2/60)
Right femoral vein	100.0% (31/31)	93.1% (27/29)	96.7% (58/60)
Estimated blood loss during introducer insertion			
<25 mL	86.4% (19/22)	88.5% (23/26)	87.5% (42/48)
25-50 mL	9.1% (2/22)	7.7% (2/26)	8.3% (4/48)
>100 mL	4.5% (1/22)	3.8% (1/26)	4.2% (2/48)
Estimated blood loss during catheter placement			
<25mL	66.7% (14/21)	46.2% (12/26)	55.3% (26/47)
25-50 mL	28.6% (6/21)	38.5% (10/26)	34.0% (16/47)
>100 mL	4.8% (1/21)	7.7% (2/26)	6.4% (3/47)
Duration of support (hours)	101.2±66.0 (21)	81.9±49.1 (29)	90.0±57.0 (50)

Procedural Parameters	Summary Statistics*		
	Cohort A (N=31)	Cohort B (N=29)	All Patients (N=60)
Average device flow (L/min)	3.2±0.4 (23)	3.2±0.4 (27)	3.2±0.4 (50)

*Categorical data: % (n/total no.); variable data: mean±SD (n)

4. Subgroup Analyses

Gender Analysis

The outcomes by gender were also examined. A trend towards higher mortality was observed in female patients; the rate of the other adverse events appeared comparable between genders. However, the small sample size and the multiple cohorts studied prevent any conclusions based on gender.

5. Pediatric Extrapolation

In this premarket application, existing clinical data were leveraged to support the reasonable assurance of safety and effectiveness of the Impella RP System in pediatric patients who have a body surface area ≥1.5 m^2. The leveraging was based on the consideration that these pediatric patients have a suitable anatomy for the pump. In the pooled dataset, there was a single pediatric aged patient (21 year old male) who was successfully bridged by an Impella RP pump to a longer-term therapy.

E. **Financial Disclosure**

The Financial Disclosure by Clinical Investigators regulation (21 CFR 54) requires applicants who submit a marketing application to include certain information concerning the compensation to, and financial interests and arrangement of, any clinical investigator conducting clinical studies covered by the regulation. The clinical studies reported herein included 20 principal investigators of which none was a full-time or part-time employee of the sponsor and two (2) had disclosable financial interests/arrangements as defined in 21 CFR 54.2(a), (b), (c) and (f) and described below:

- Compensation to the investigator for conducting the study where the value could be influenced by the outcome of the study: None
- Significant payment of other sorts: 2
- Proprietary interest in the product tested held by the investigator: None
- Significant equity interest held by investigator in sponsor of covered study: None

The applicant has adequately disclosed the financial interest/arrangements with clinical investigators. Statistical analyses were conducted by FDA to determine whether the financial interests/arrangements had any impact on the clinical study outcome. The information provided does not raise any questions about the reliability of the data.

XI. PANEL MEETING RECOMMENDATION AND FDA'S POST-PANEL ACTION

In accordance with the provisions of section 515(c)(3) of the act as amended by the Safe Medical Devices Act of 1990, this PMA was not referred to the Circulatory Systems Device panel, an FDA advisory committee, for review and recommendation because the information in the PMA substantially duplicates information previously reviewed by this panel.

XII. CONCLUSIONS DRAWN FROM PRECLINICAL AND CLINICAL STUDIES

A. Effectiveness Conclusions

In the clinical studies completed, use of the Impella RP System to provide percutaneous hemodynamic support for right heart failure had a survival rate of 73.3% at 30 days or discharge (whichever is longer), or at induction of anesthesia for the next longer-term therapy. Additional benefits included reduction in central venous pressure (from 19.0 ± 0.8 to 13.0 ± 0.7 mmHg) and increase in cardiac index (from 1.9 ± 0.1 to 3.1 ± 0.2 L/min/m^2) during support. The inotrope and pressor uses also decreased rapidly during support. The LVAD patients experienced an increase in pump flow from 4.0 ± 0.2 L/min to 4.6 ± 0.1 L/min during support.

B. Safety Conclusions

The risks of the device are based on nonclinical laboratory and animal studies as well as data collected in clinical studies as described above. The main adverse events observed in the clinical studies included major bleeding and hemolysis, which occurred in 48.3% and 26.7% of patients, respectively. No pulmonary embolism was reported.

C. Benefit-Risk Conclusions

The probable benefits of the Impella RP System for patients who develop acute right heart failure or decompensation included a 73.3% chance of survival at 30 days or discharge (whichever is longer), or survival at induction of anesthesia for the next longer-term therapy. This represents a substantial improvement over expected survival for medically treated patients. The improvement in survival was attributable to the improvements in hemodynamics which allowed for the right ventricle to recover.

The probable risks of the Impella RP System included death, major bleeding, and hemolysis. The nature and types of these risks were consistent with those commonly seen in mechanical circulatory support.

An additional factor considered in determining probable risks and benefits for the Impella RP System was the ability of the device to be inserted and removed percutaneously. The implantation procedure of the Impella RP System is much less invasive than a surgical RVAD.

1. Patient Perspectives

    This submission did not include specific information on patient perspectives for this device.

In conclusion, given the available information above, the data support that for patients with acute right heart failure or decompensation, the probable benefits of implanting the Impella RP device outweigh the probable risks.

D. Overall Conclusions

The data in this application support the reasonable assurance of safety and effectiveness of the Impella RP System in providing temporary ($\leq$ 14 days) right heart support in patients with a body surface area $\geq$1.5 m^2 who develop acute right heart failure or decompensation following LVAD implantation, myocardial infarction, heart transplant, or open-heart surgery.

XIII. CDRH DECISION

CDRH issued an approval order on September 20, 2017. The final conditions of approval cited in the approval order are described below.

The applicant must conduct the following two (2) post-approval studies:

1. ***Impella RP – Real-World Evidence Evaluation and Periodic Reporting***: The applicant is required to provide post-approval safety and effectiveness data to FDA on the Impella RP System per the agreed-upon protocol. Data will be captured in the cVAD Registry.

    The applicant must provide analysis results on 60 consecutively treated patients (age $\geq$ 18 years old). The patients will be treated and followed according to standard of care and institution guidelines. Post-discharge data will be collected prospectively through telephone contact and review of existing medical records at 30 days, 90 days, and 1 year.

    The applicant will perform analyses and provide results on the following outcomes: (a) survival rate at 30 days post device explant or hospital discharge (whichever is longer), or at induction of anesthesia to a longer term therapy, which includes heart transplant or implantation of a surgical RVAD; (b) bleeding, hemolysis and pulmonary embolism at 30 days or discharge (whichever is longer); and (c) device malfunction, central venous pressure, cardiac index, and LVAD flow.

    The study results will be presented descriptively as means and standard deviations and compared against those reported in the PMA application where applicable.

2. ***Impella RP Pediatric – Real-World Evidence Evaluation and Periodic Reporting***: The applicant is required to provide post-approval safety and effectiveness data to FDA on the Impella RP System for the pediatric patients per the agreed-upon analysis plan. This study is a continuation of the "Impella RP Pediatric Study" ordered as a condition of

approval for the Impella RP HDE H140001. Data from the pediatric patients will continue to be captured in the cVAD Registry at a minimum of 5 sites.

The applicant must provide analysis results on 15 consecutively treated pediatric patients under 18 years of age or all pediatric patients under 18 years of age treated over a 5-year period (whichever comes first). The patients will be treated and followed according to standard of care and institution guidelines. Post-discharge data will be collected retrospectively at 30 days and 180 days.

The applicant will perform analyses and provide results on the following outcomes: (a) survival rate at 30 days post device explant or hospital discharge (whichever is longer), or at induction of anesthesia to a longer term therapy, which includes heart transplant or implantation of a surgical right ventricular assist device (RVAD); (b) bleeding, hemolysis and pulmonary embolism at 30 days or discharge (whichever is longer); (c) device malfunction, central venous pressure, cardiac index, and LVAD flow; and (d) survival rate at 180 days.

The study results will be presented descriptively as means and standard deviations and compared against those reported in the PMA application where applicable.

The applicant's manufacturing facilities have been inspected and found to be in compliance with the device Quality System (QS) regulation (21 CFR 820).

XIV. APPROVAL SPECIFICATIONS

Directions for use: See device labeling.

Hazards to health from use of the device: See indications, contraindications, warnings, precautions, and adverse events in the device labeling.

Post-approval requirements and restrictions: See approval order.