Impella® 2.5

with the Automated Impella® Controller

Circulatory Support System

INSTRUCTIONS FOR USE & CLINICAL REFERENCE MANUAL

(United States only)

ABIOMED®

Recovering hearts. Saving lives.

IMPORTANT NOTICE: Read this entire manual before using the Automated Impella® Controller and Impella® 2.5 Circulatory Support System (Impella® 2.5 System). The Impella® 2.5 System is to be used only in accordance with this manual. This manual is only applicable to Impella® systems using the Automated Impella® Controller.

Information contained in this document is subject to change without notice.

IMPELLA® 2.5 WITH THE AUTOMATED IMPELLA® CONTROLLER INSTRUCTIONS FOR USE & CLINICAL REFERENCE MANUAL

(UNITED STATES ONLY)

Rx Only

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INTRODUCTION

PURPOSE OF MANUAL

This Instructions for Use & Clinical Reference Manual is designed for healthcare professionals. It contains clinical and technical information to guide healthcare professionals in their use of the Impella® 2.5 Catheter with the Automated Impella® Controller. The Impella® System performs life-sustaining functions. To use the system you must understand and follow these instructions. The Impella® System may be used only for its intended purpose.

MANUAL OVERVIEW

This manual provides instructions for use of the Impella® 2.5 Catheter with the Automated Impella® Controller. The following summarizes the contents of each section of the manual.

- **Section 1: Indications, Contraindications, and Potential Adverse Events** discusses indications for use of the Impella® Catheter with the Automated Impella® Controller, contraindications, and potential adverse events that may be associated with the use of the system.
- **Section 2: Warnings and Cautions** discusses the warnings and cautions pertaining to the use of the Impella® Catheter with the Automated Impella® Controller.
- **Section 3: The Impella® Catheter and Automated Impella® Controller** provides an overview of the system and describes its major components and features.
- **Section 4: Using the Automated Impella® Controller** describes the controls and various screen types on the Automated Impella® Controller.
- **Section 5: Using the Automated Impella® Controller with the Impella® Catheter** provides the procedures for using the Impella® System.
- **Section 6: Clinical Experience** provides an overview of clinical studies of the Impella® System.
- **Section 7: Patient Management Topics** provides key information on various topics related to management of patients with the Impella®Catheter and Automated Impella® Controller.
- **Section 8: Automated Impella® Controller Alarms** provides a listing of Automated Impella® Controller alarms as well as information on what to do to resolve them.
- **Section 9: General System Information** contains information including definitions for key terms that appear in the manual, descriptions of the abbreviations and symbols that appear on Impella® Catheter and Automated Impella® Controller components and packaging, technical information pertaining to the Impella® Catheter and Automated Impella® Controller, and instructions on cleaning and storing system components as well as returning components to Abiomed.
- **Appendices** at the end of the manual provide supplemental information about topics including the Impella® Limited Service Warranty; Abiomed-approved guidewires and introducers; the Automated Impella® Controller menu structure; and axillary insertion technique.

1 INDICATIONS, CONTRAINDICATIONS, AND POTENTIAL ADVERSE EVENTS

INDICATIONS (UNITED STATES)

The Impella 2.5 System (Impella 2.5) is a temporary (< 6 hours) ventricular assist device indicated for use during high risk percutaneous coronary interventions (PCI) performed in elective or urgent, hemodynamically stable patients with severe coronary artery disease and depressed left ventricular ejection fraction, when a heart team, including a cardiac surgeon, has determined that high risk PCI is the appropriate therapeutic option. Use of the Impella 2.5 in these patients may prevent hemodynamic instability which can result from repeat episodes of reversible myocardial ischemia that occur during planned, temporary coronary occlusions and may reduce peri- and post-procedural adverse events.

CONTRAINDICATIONS (UNITED STATES)

Patients with aortic stenosis or other abnormal aortic valve performance may be compromised by the use of the Impella® Catheter. Patients with aortic valve disease should be observed for aortic insufficiency.

- Mural thrombus in the left ventricle
- Mechanical aortic valve or heart constrictive device
- Aortic valve stenosis/calcification (equivalent to an orifice of 0.6 cm^2 or less)
- Moderate to severe aortic insufficiency (echocardiographic assessment of aortic insufficiency graded as ≥ +2)
- Severe peripheral arterial disease that precludes the placement of the Impella® 2.5

POTENTIAL ADVERSE EVENTS (UNITED STATES)

- Acute renal dysfunction
- Aortic insufficiency
- Aortic valve injury
- Atrial fibrillation
- Bleeding
- Cardiogenic shock
- Cardiac tamponade
- Cardiopulmonary resuscitation
- Cerebral vascular accident / Stroke
- Death
- Device malfunction
- Failure to achieve angiographic success
- Hemolysis
- Hepatic failure
- Insertion site infection
- Limb ischemia
- Myocardial infarction
- Need for cardiac, thoracic or abdominal operation
- Perforation
- Renal failure
- Repeat revascularization
- Respiratory dysfunction
- Sepsis
- Severe hypotension
- Thrombocytopenia
- Thrombotic vascular (non-CNS) complication
- Transient ischemic attack
- Vascular injury
- Ventricular arrhythmia, fibrillation or tachycardia

2 WARNINGS AND CAUTIONS

WARNINGS

Use of the Impella® System by trained and experienced practitioners has been associated with improved outcomes. Consequently, the first use of Impella® should be preceded by the completion of a contemporary Abiomed Impella® training program and include on-site proctoring during the first use by Abiomed clinical support personnel certified in the use of Impella®.

Fluoroscopy is required to guide placement of the Impella® Catheter. The small placement guidewire must be reliably observed at all times.

Be sure that the stopcock on the peel-away introducer or repositioning sheath is always kept in the closed position. Significant bleed back can result if the stopcock is open.

Avoid manual compression of the inlet and outlet areas of the cannula assembly.

The sterile components of the Impella® System can be used only if the sterilization indicators show that the contents have been sterilized, the packaging is not damaged, and the expiration date has not elapsed.

Do ***NOT*** resterilize or reuse the Impella® Catheter. It is a disposable device and is intended for single use only. Reuse, reprocessing, or resterilization may compromise the structural integrity of the catheter and/or lead to catheter failure which, in turn, may result in patient injury, illness, or death.

Retrograde low will occur across the aortic valve if the flow rate of the Impella® Catheter is less than 0.5 L/min.

To prevent malfunction of the locking mechanism of the peel-away introducer, do ***NOT*** hold the hemostatic valve while inserting into the artery.

To prevent failure of the peel-away introducer, remove the peel-away introducer prior to transport when activated clotting time (ACT) is less than 150 seconds.

Do ***NOT*** use saline in the purge system.

Do ***NOT*** use an Impella® System if any part of the system is damaged.

To prevent the risk of explosion, do ***NOT*** operate the Impella® System near flammable anesthetics.

If at any time during the course of support with the Impella® Catheter, the Automated Impella® Controller alarms “Purge Pressure Low” or “Purge System Open,” follow the instructions presented in section 5 of this manual.

MR Unsafe - Do ***NOT*** subject a patient who has been implanted with an Impella® 2.5 to magnetic resonance imaging (MRI). The strong magnetic energy produced by an MRI machine may cause the Impella® 2.5 components to stop working, and result in injuries to the patient. An MRI may also damage the Impella® 2.5 electronics.

Cardiopulmonary support (CPR) should be initiated immediately per hospital protocol if indicated for any patient supported by the Impella® Catheter. When initiating CPR, reduce the Impella® Catheter flow rate. When cardiac function has been restored, return flow rate to the previous level and assess placement signals on the controller.

Warnings

Warnings alert you to situations that can cause death or serious injury. The red symbol ⚠ appears before warning messages.

	During defibrillation, do ***NOT*** touch the Impella® Catheter, cables, or Automated Impella® Controller.
	Power the Automated Impella® Controller using its internal battery if the integrity of the protective earth conductor is questionable.
	Lithium-ion battery replacement by inadequately trained personnel could result in excessive temperatures, fire, or explosion. Only technicians authorized by Abiomed should remove or change the battery.
	To avoid risk of electric shock, this equipment must only be connected to a supply mains with protective earth.
	No modification of this equipment is allowed.
	Medical electrical equipment needs special precautions regarding EMC and needs to be installed and put into service according to the electromagnetic compatibility (EMC) information provided in Section 9 of this manual.
	During transport, the Automated Impella® Controller may be exposed to stronger electromagnetic disturbance than during in-hospital use. Strong electromagnetic disturbance may cause the Automated Impella® Controller to display soft button menu selections that were not selected by the user. Operators should be aware that, under these conditions, the operating parameters are not affected. No user intervention is required. Monitor Impella® Catheter flow and patient hemodynamics to confirm normal operation. The condition will resolve itself once the Automated Impella® Controller is no longer exposed to the disturbance.
	Portable and mobile RF communications equipment can affect medical electrical equipment.
	The equipment or system should not be used adjacent to or stacked with other equipment. If adjacent or stacked use is necessary, the equipment or system should be observed to verify normal operation in the configuration in which it will be used.
	Use of cables, other than those sold by Abiomed, may result in increased emissions or decreased immunity of the Automated Impella® Controller.
	The Automated Impella® Controller uses RFID (radio frequency identification) to identify and communicate with the purge cassette. Other equipment may interfere with the Automated Impella® Controller even if that other equipment complies with CISPR emission requirements.
	Infusion through the sideport of the introducer can be done only after all air is removed from the introducer. If performed, the infusion should be done for flushing purposes only and ***NOT*** for delivering therapy or monitoring blood pressure.

CAUTIONS

	Handle with care. The Impella® Catheter can be damaged during removal from packaging, preparation, insertion, and removal. Do ***NOT*** bend, pull, or place excess pressure on the catheter or mechanical components at any time.
	Patients with aortic stenosis or other abnormal aortic valve performance may be compromised by the use of the Impella® Catheter. Patients with aortic valve disease should be observed for aortic insufficiency.
	Partial circulatory support with Impella® has been associated with more extensive use of rotational atherectomy. Extensive use of rotational atherectomy has been associated with a periprocedural increase in cardiac biomarkers indicative of myocardial injury. Rotational atherectomy, with or without the use of hemodynamic support, should be used in accordance with the manufacturer's instructions for use.
	Physicians should exercise special care when inserting the Impella® Catheter in patients with known or suspected unrepaired abdominal aortic aneurysm or significant descending thoracic aortic aneurysm or dissection of the ascending, transverse, or descending aorta.
	Use only original accessories and replacement parts supplied by Abiomed.
	Do ***NOT*** use damaged or contaminated connector cables.
	To prevent device failure, do ***NOT*** start the Impella® Catheter until the guidewire has been removed.
	Do ***NOT*** remove the Impella® Catheter over the length of the guidewire.
	When replacing the purge cassette, the replacement process must be completed within 2 minutes. The Impella® Catheter may be damaged if replacement takes longer than 2 minutes.
	To prevent malfunction of the Automated Impella® Controller, avoid long-term exposure to direct sunlight and excessive heat (40°C).
	To prevent overheating and improper operation, do ***NOT*** block the cooling vents of the Automated Impella® Controller while it is operating.
	Do ***NOT*** kink or clamp the Impella® Catheter or the peel-away introducer.
	During case start, make sure the yellow luer connection between the purge tubing and Y connector is tightened and not leaking.
	The Li-Ion batteries must be charged for 5 hours prior to system operation in order to meet the runtime requirement of 1 hour. Failure to do so will yield a shorter runtime. After being unplugged, the Automated Impella® Controller will operate for at least 60 minutes after the batteries have been fully charged.
	Minimize exposure of Impella® System components to sources of electromagnetic interference (EMI). Exposure to sources of EMI, such as cell phones and two-way radios, may cause operational interference. To clear interference, either increase the distance between system components and the EMI source or turn off the EMI source.

Cautions

Cautions indicate situations in which equipment may malfunction, be damaged, or cease to operate. The yellow symbol ⚠ appears before caution messages.

- Operation of Impella® System components may interfere with the operation of other devices. If interference occurs, increase the distance between the device and system components.
- Have a backup Automated Impella® Controller, purge cassette, connector cable, and Impella® Catheter available in the unlikely event of a device failure.
- Do ***NOT*** use the bed mount as a handle.
- Do ***NOT*** alter the Impella® Introducer kit in any way.
- Aspiration and saline flushing of the Impella® Introducer kit sheath, dilator, and valve should be performed to help minimize the potential for air embolism and clot formation.
- Indwelling introducer sheaths should be internally supported by a catheter or dilator.
- Dilators and catheters should be removed slowly from the sheath. Rapid removal may damage the valve, resulting in blood flow through the valve.
- Never advance the guidewire or sheath when resistance is met. Determine the cause of resistance using fluoroscopy and take remedial action.
- When injecting or aspirating through the sheath, use the sideport only.
- Operation of the system without heparin in the purge solution has not been tested. In the event that a patient is intolerant to heparin, due to heparin-induced thrombocytopenia or bleeding, physicians should use their clinical judgment to assess the risks versus benefits of operating the Impella® System without heparin. If it is in the best interest of the patient to operate the system without heparin, the dextrose solution is still required, and physicians should consider systemic delivery of an alternative anticoagulant. Do ***NOT*** add any alternative anticoagulant (such as a direct thrombin inhibitor) to the purge fluid. The Impella® Catheter has not been tested with any alternative anticoagulants in the purge solution.

3 THE IMPELLA® CATHETER AND AUTOMATED IMPELLA® CONTROLLER

OVERVIEW

The Impella® Catheter is an intravascular microaxial blood pump that supports a patient's circulatory system during PCI procedures in patients at high risk for hemodynamic instability. The Impella® Catheter is inserted percutaneously through the femoral artery and into the left ventricle (see Figure 3.1).

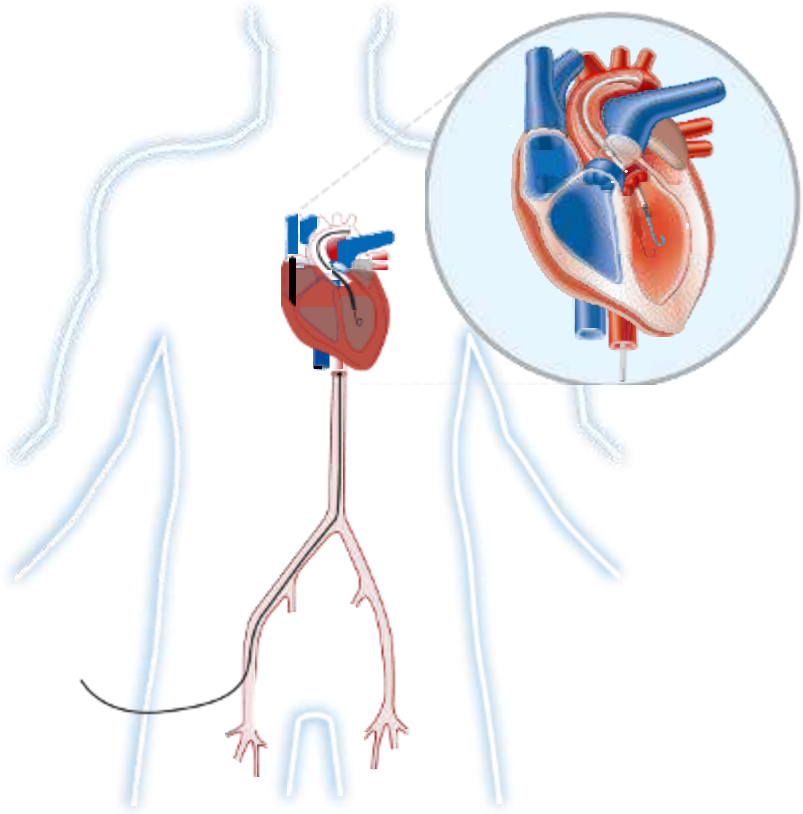


Figure 3.1 Impella® Catheter in the Heart

When properly positioned, the Impella® Catheter delivers blood from the inlet area, which sits inside the left ventricle, through the cannula, to the outlet opening in the ascending aorta. Physicians and device operators monitor the correct positioning and functioning of the Impella® Catheter on the display screen of the Automated Impella® Controller.

This section describes the components of the Impella® Catheter and the Automated Impella® Controller, as well as the accessory components.

REUSABLE SYSTEM COMPONENTS

The Impella® System consists of the following reusable components:

- Automated Impella® Controller—provides the user interface, alarm indications, and portable battery
- Automated Impella® Controller cart—for easy transport of the Automated Impella® Controller

SINGLE-USE SYSTEM COMPONENTS

The Impella® System also includes the following single-use components:

- Impella® Catheter
- Purge cassette
- Introducer kit
- 0.018 inch, 260 cm placement guidewire
- Connector cable

IMPELLA® SET-UP AND INSERTION KIT

The components of the Impella® System are packaged into a single box called the Impella® Set-up and Insertion kit. Table 3.1 describes the contents of this kit.

Table 3.1 Impella® Set-up and Insertion Kit Components

The Impella® Set-up and Insertion kit contains the following:

- Impella® Catheter
- 0.018 inch, 260 cm placement guidewire
- Connector cable
- Purge cassette
- Introducer kit
  - » Peel-away introducer (13 Fr for Impella® 2.5)
  - » Dilator (13 Fr for Impella® 2.5)
  - » 18 G Seldinger needle
  - » 12 cc syringe
  - » 0.035 inch stiff access guidewire

SYSTEM CONFIGURATIONS

Figure 3.2 illustrates how the Automated Impella® Controller connects to the Impella® Catheter and accessory components in the initial set-up configuration.

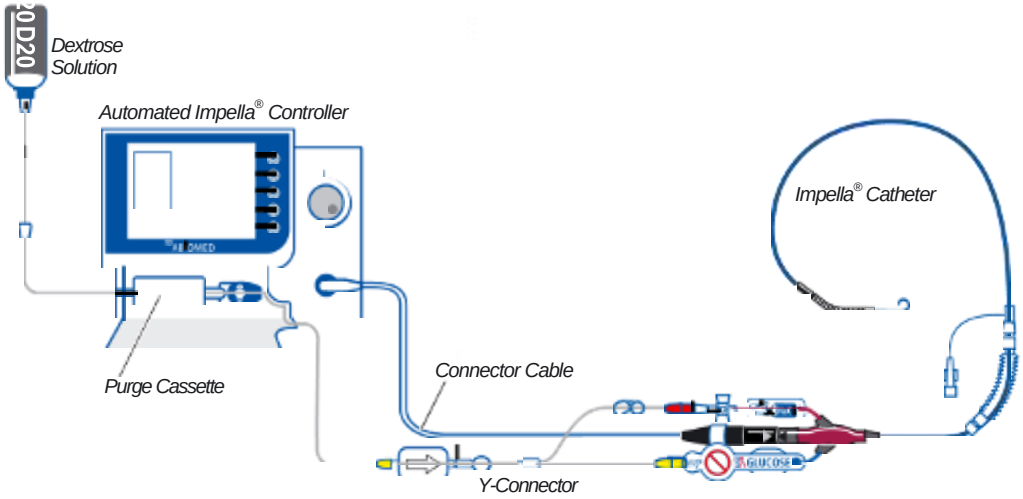


Figure 3.2 Set-up Configuration of the Automated Impella® Controller, Impella® Catheter, and Accessories

Figure 3.3 illustrates the standard configuration of the Impella® Catheter, Automated Impella® Controller, and accessory components.

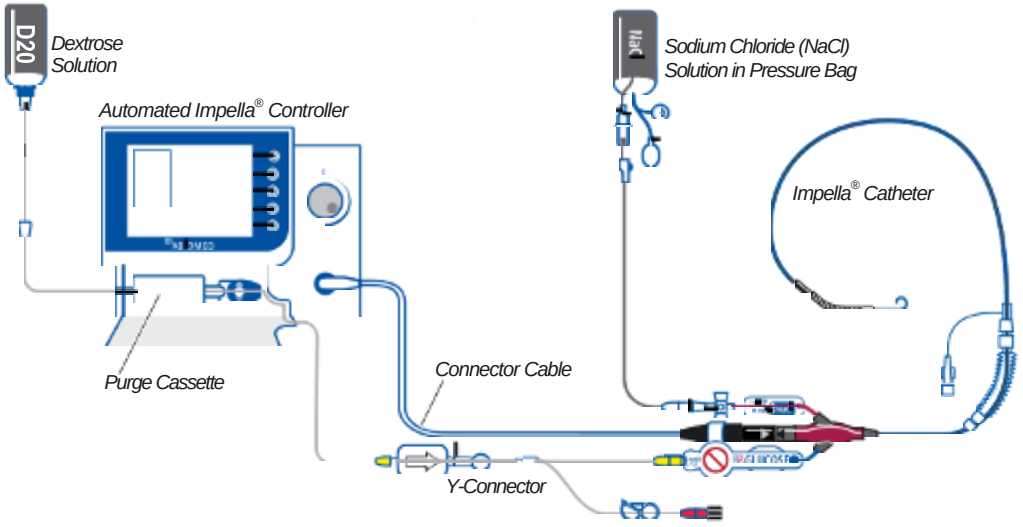


Figure 3.3 Standard Configuration of the Automated Impella® Controller, Impella® Catheter, and Accessories

IMPELLA® CATHETER

The Impella® Catheter is an intravascular microaxial blood pump that delivers up to 2.5 liters of bloodper minute from the left ventricle into the aorta during PCI procedures in patients at high risk for hemodynamic instability. Figure 3.4 illustrates the Impella® Catheter. Table 3.2 describes eachcomponent from the pigtail at one end to the check valve on the other end.

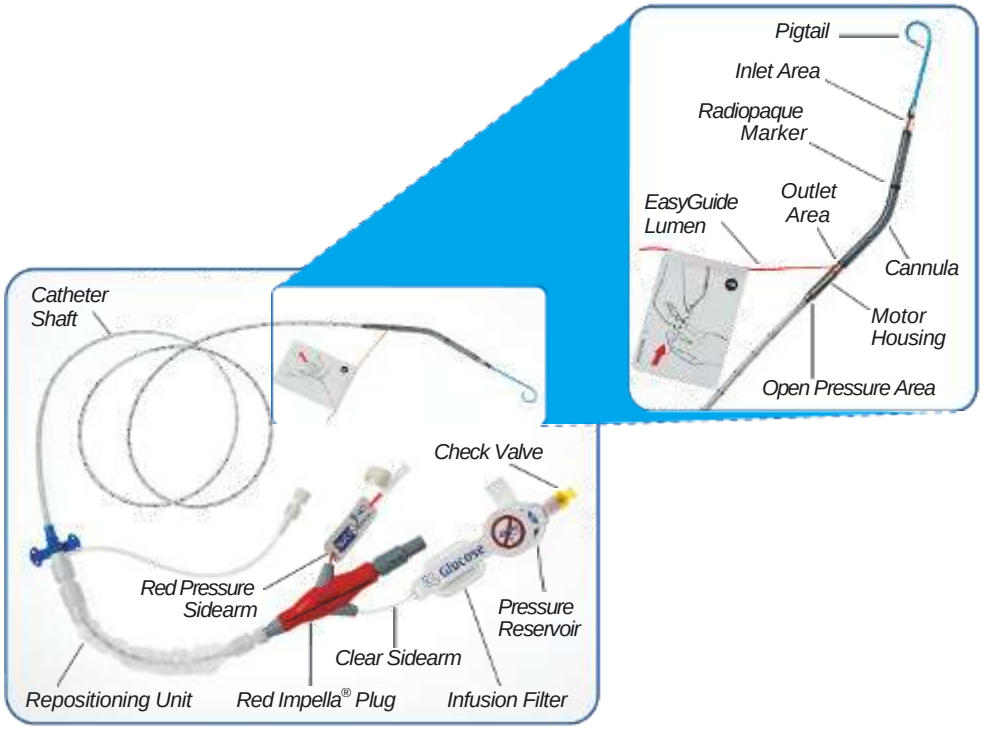


Figure 3.4 Impella® Catheter

Table 3.2 Impella® Catheter Components

Component	Description
Pigtail	The 6 Fr pigtail is attached to the cannula at the distal end of the inlet area. It assists with stabilizing the catheter in the correct position in the left ventricle.
Inlet area	The inlet area, located at the distal tip of the cannula, has four openings (windows) that allow blood to be drawn into the inlet and channeled through the cannula.
Radiopaque marker	The radiopaque marker on the catheter shaft is visible with fluoroscopy and, when properly positioned, appears at the level of the aortic valve annulus.
Cannula	The cannula (12 Fr for the Impella® 2.5) has a spiral-shaped reinforced body that is shaped in a 145-degree angle. The cannula is made of nitinol and covered in polyurethane.
Outlet area	The proximal end of the cannula is attached to the outlet area where the blood exits the cannula.
EasyGuide lumen	The red loading lumen, which runs from the tip of the pigtail through the outlet area of the cannula, facilitates loading the catheter onto the guidewire.

Table 3.2 Impella® Catheter Components (continued)

Component	Description
Motor housing	The motor housing (12 Fr for the Impella® 2.5) consists of an encapsulated motor.
Open pressure area	The open pressure area is an opening located between the motor housing and the distal end of the catheter shaft.
Catheter shaft	A 9 Fr catheter shaft is located between the motor housing and the red Impella® plug. The lumen of the catheter shaft contains a purge lumen, a pressure measurement lumen, a nitinol wire, and an electrical cable. The catheter shaft has longitudinal and transversal marks: • The longitudinal mark along the inner radius shows correct position of the 0.018 inch, 260 cm placement guidewire once backloaded on the Impella® Catheter. • The transversal marks at 1 cm intervals with numbers every 5 cm aid in proper positioning.
Repositioning unit	The repositioning unit consists of a sheath, an anticontamination sleeve with an anchoring ring, and suture pads. • The sheath (with hemostatic valve) is graduated from 9 Fr to 15 Fr. It is located on the catheter shaft and allows repositioning of the catheter. • The anchoring ring of the anticontamination sleeve secures the sheath to the catheter. • The StatLock® compatible suture pads help secure the repositioning sheath to the patient's skin.
Red Impella® plug	The red Impella® plug at the proximal end of the catheter connects the catheter to the Automated Impella® Controller through a connector cable. It contains: • A pressure transducer that translates pressure for the pressure lumen proximal to the motor • Memory that retains operating parameters in case the patient needs to be transferred to another controller • The placement signal lumen that allows for pressure and waveform displays It has two sidearms: a red pressure sidearm and a clear sidearm.
Red pressure sidearm	The red pressure sidearm is attached to a standard pressure bag and is used to prime the line of the pressure measurement system.
Clear sidearm	The clear sidearm is attached to the purge cassette tubing. It leads to the infusion filter, the pressure reservoir, and the check valve.
Infusion filter	The infusion filter prevents bacterial contamination and air from entering the purge lumen.
Pressure reservoir	The pressure reservoir includes a flexible rubber diaphragm that provides additional filling volume by means of an expansion chamber during purge solution change.
Check valve	The yellow check valve ensures that purge fluid does not flow in the reverse direction when the purge solution is exchanged.

Repositioning Sheath: Outer Diameter

The repositioning sheath for the Impella® 2.5 has a graduated outer diameter of 9 Fr to 15 Fr.

AUTOMATED IMPELLA® CONTROLLER

Automated Impella® Controller Battery Power

The controller can operate on its internal lithium-ion (Li-Ion) battery for at least 60 minutes when fully charged.

The Automated Impella® Controller (see Figure 3.5) provides three vital functions to the operation of the Impella® Catheter:

- The controller provides an interface for monitoring and controlling the function of the Impella® Catheter
- The controller provides a fluid purge to the Impella® Catheter
- The controller provides backup power when the Impella® System is operated away from AC power

The controller weighs 26 lbs (11.8 kg) and can operate on its internal battery for at least 60 minutes when fully charged.

Automated Impella® Controller Power Cord

Use caution when moving equipment to prevent damaging the controller's power cord.

Automated Impella® Controller operation is described in detail in section 4 of this manual.

Figure 3.5 Automated Impella® Controller – Front View

PURGE CASSETTE

Do not use saline in the purge system.

The purge cassette delivers rinsing fluid to the Impella® Catheter. The purge fluid (typically 20% dextrose solution) flows from the purge cassette through the catheter to the microaxial blood pump to prevent blood from entering the motor. When the purge cassette is properly installed in the Automated Impella® Controller, the Abiomed logo is upright and facing you. Figure 3.6 illustrates the purge cassette and related components. Table 3.3 describes each component.

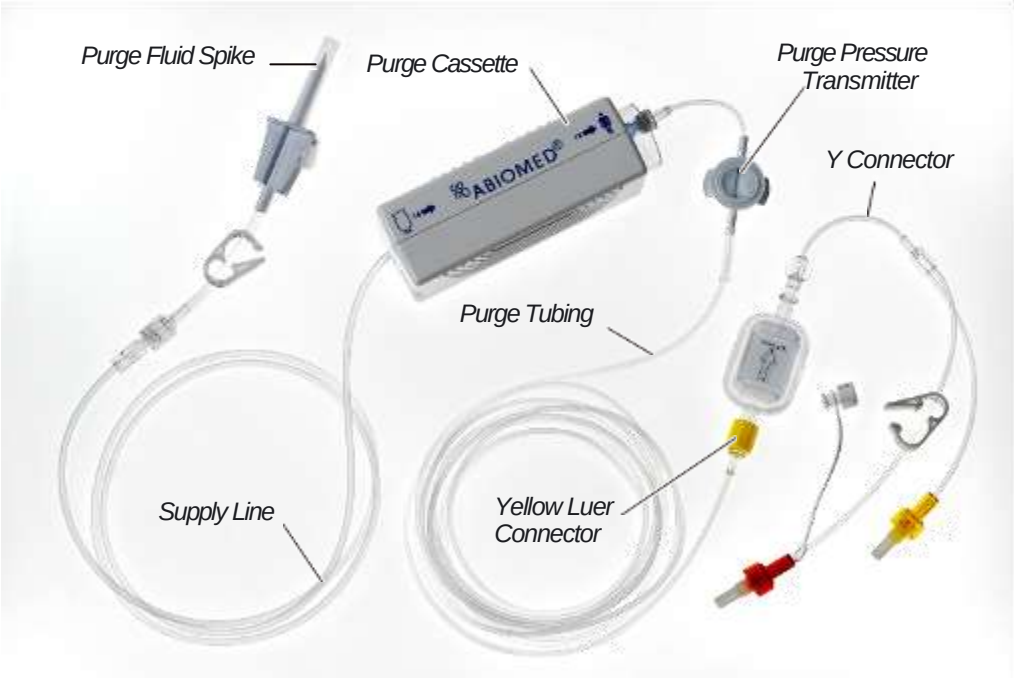


Figure 3.6 Purge Cassette

Y connector for Set-up Configuration

The Y connector attached to the purge tubing is used for the initial set-up configuration of the Impella® 2.5 System. Switch to the standard configuration as soon as practical.

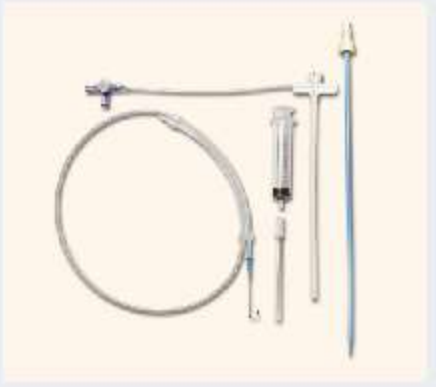
Table 3.3 Purge Cassette Components

Component	Description
Purge fluid spike	One end spikes the purge fluid bag and the other end connects the bag to the purge cassette supply line
Supply line	Carries fluid from the purge fluid bag to the purge cassette
Purge cassette	Contains the components for delivering the purge fluid; maintains the pressure barrier between the blood and the motor to prevent blood from entering the motor
Purge pressure transmitter	Transmits pressure to the controller based on the purge pressure in the purge tubing; a sensor in the controller measures the pressure so that it can be displayed on the screen and used by the purge pressure algorithm to maintain the purge pressure
Purge tubing	Carries purge fluid from the purge cassette to the Impella® Catheter
Yellow luer connector	Connects the purge tubing to the Y connector at case start and to the check valve (yellow luer lock) on the Impella® Catheter during system change
Y connector	Adapter that connects the purge tubing to the sidearms of the Impella® Catheter during case start. The Y connector consist of: • Yellow luer that connects to the clear sidearm • Red luer that connects to the red sidearm • Cap for the red luer when it is disconnected from the sidearm for transfer to the standard configuration • Clamp for the purge tubing leading to the red sidearm • Rectangular antibacterial air filter

ACCESSORIES

Table 3.4 illustrates and describes the accessories used with the Impella® Catheter and Automated Impella® Controller.

Table 3.4 Impella® Catheter and Automated Impella® Controller Accessories

Component	Description
	The white connector cable connects the Impella® Catheter to the Automated Impella® Controller. Clips on the cable are used to secure the purge tubing to the cable. • The socket at the black end of the cable connects to the Impella® Catheter plug. • The white plug at the opposite end of the cable is inserted into the blue catheter plug on the front of the Automated Impella® Controller.
Figure 3.7 White Connector Cable	
	The introducer kit is used to gain arterial access for the Impella® Catheter. It contains: • Peel-away introducer—with hemostatic valve for tight it around components and single-step "break-away" configuration • Dilator—easy to insert and remove with soft design for atraumatic approach into femoral artery • 18 G Seldinger needle • 12 cc syringe • 0.035 inch stiff access guidewire
Figure 3.8 Introducer Kit	
	The 0.018 inch, 260 cm placement guidewire is used for the placement of the catheter. The guidewire has a radiopaque, shapable tip.
Figure 3.9 0.018 inch, 260 cm Placement Guidewire	

Guidewire Use

It is important to use only the guidewire supplied with the system or an Abiomed-approved alternative. Refer to Appendix B for more information about Abiomed-approved guidewires.

Component	Description
	Hospital Provided: Dextrose solution (typically 20% dextrose in water with 50 IU/mL of heparin) is used as the purge fluid through the Impella® Catheter.
	The Automated Impella® Controller cart holds the Automated Impella® Controller. The cart has wheels for easy transport of the controller and a storage basket.

Figure 3.10 Dextrose Solution

Figure 3.11 Automated Impella® Controller Cart

4 USING THE AUTOMATED IMPELLA® CONTROLLER

OVERVIEW

The Automated Impella® Controller is the primary user control interface for the Impella® Catheter. It controls the Impella® Catheter performance, monitors the catheter for alarms, and provides real-time catheter position information regarding the location of the catheter across the aortic valve. The controller can be powered by AC power or can operate on internal battery power for at least 60 minutes when fully charged.

This section of the manual discusses Automated Impella® Controller features and displays.

AUTOMATED IMPELLA® CONTROLLER FEATURES

IMPORTANT NOTE: The underside of the Automated Impella® Controller has a battery switch to turn on the batteries. This switch is turned off for shipping purposes. Before operating the Automated Impella® Controller for the first time, make sure you turn this switch on. If the battery switch is not turned on, the Automated Impella® Controller will not be able to operate on battery power.

Figure 4.1 illustrates the features on the front of the Automated Impella® Controller. These features are described in Table 4.1.

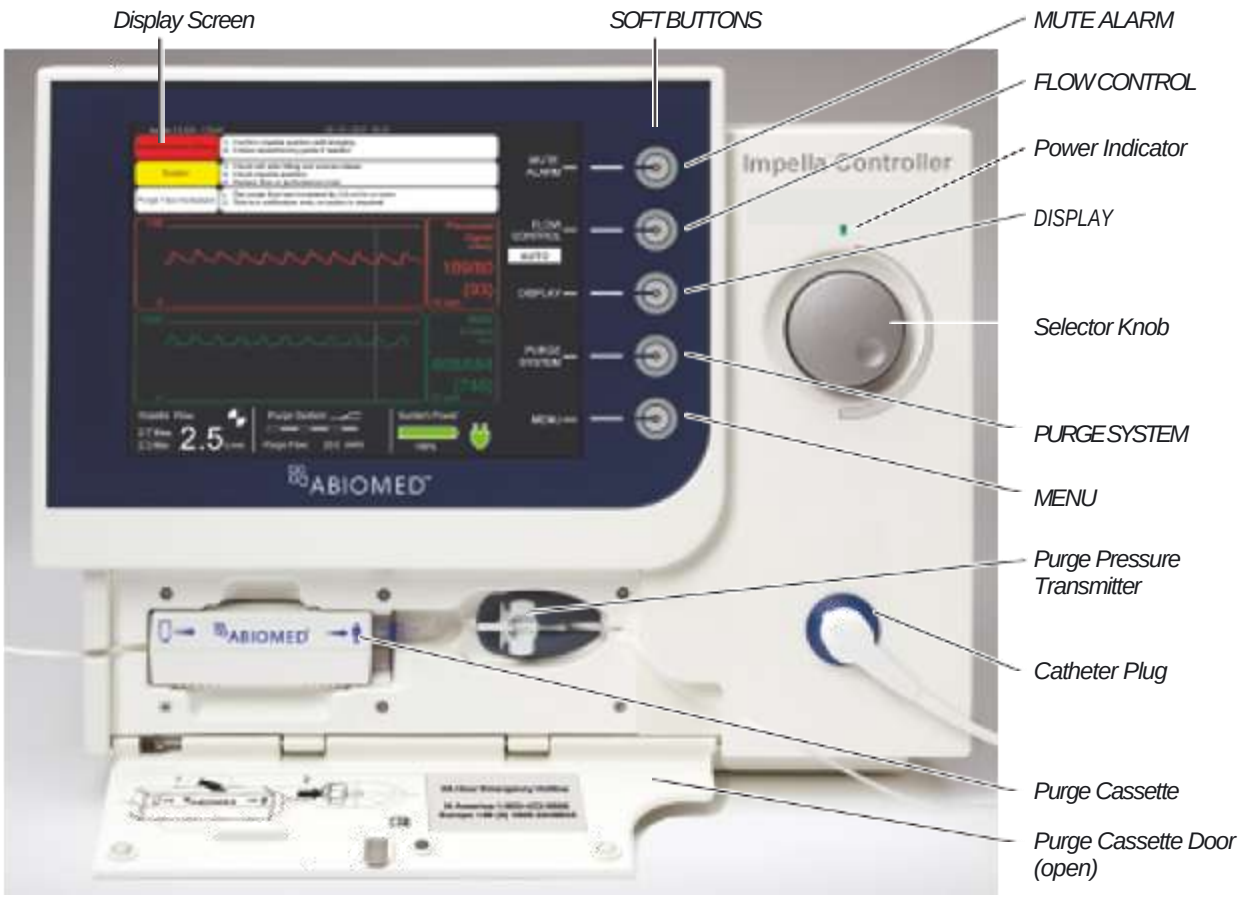


Figure 4.1 Automated Impella® Controller Features – Front View

Table 4.1 Automated Impella® Controller Front View Features

Feature	Description
Display screen	Displays user information, including the labels for the soft buttons. (Display screen elements described in detail later in this section.)
Soft buttons	Display, open, and close menus. The function for each soft button is defined by labels adjacent to the button on the display screen; function changes depending on the screen. (Soft button functions are described in Table 4.3.) When the Impella® Catheter is running, the default soft button labels are as follows: • **MUTE ALARM** • **FLOW CONTROL** • **DISPLAY** • **PURGE SYSTEM** • **MENU**
Power indicator	LED light above the selector knob; indicates the power status of the Automated Impella® Controller. • Green light—controller is on and plugged into AC power or running on battery power • Amber light—controller is off but plugged into AC power • No light—controller is off and not plugged into AC power
Selector knob	Rotating push button; turn clockwise and counterclockwise to navigate through menu items; push to make a selection.
Purge pressure transmitter	A flexible diaphragm on the purge cassette tubing used to monitor purge pressure and regulate purge flow
Catheter plug	Connection point on the controller for the connector cable that connects to the Impella® Catheter.
Purge cassette	Contains the components for delivering the purge fluid; maintains the pressure barrier between the blood and the motor to prevent blood from entering the motor. (The purge cassette and its components are described in Section 3 of this manual.)
Purge cassette door	Spring-loaded door that opens to provide access to the purge cassette.

Display Options

If equipped with a VGA connector, the controller can be connected to a monitor to display information on another screen as described under "Slave Monitor Connection" in Section 9 of this manual.

Selector Knob Function

***Rotate** the selector knob on the controller to navigate through menu items.*
***Push** the selector knob to confirm your selection.*

Figure 4.2 illustrates the features on the left and right sides of the Automated Impella® Controller. These features are described in Table 4.2.

Figure 4.2 Automated Impella® Controller Features – Side Views

Table 4.2 Automated Impella® Controller Side View Features

Feature	Description
Bed mount	Metal bracket on the back of the controller; attaches controller to the cart or bed
Purge cassette door release	Button located on the left side of the controller; press to open the purge cassette door
VGA OUT	Connection for connecting the controller to another monitor to slave the display
USB connector	Connection used by Abiomed maintenance or service personnel
Service	Interface for data transfer by Abiomed maintenance or service personnel
AC fuses	Electrical safety device in the event of current overload
AC plug	Connection point on the controller for the AC power cord
Power switch	Button that turns the controller on or off • ON: Press and hold the power switch for 3 seconds • OFF: (1) Disconnect the Impella® Catheter from the Automated Impella® Controller (2) Press and hold the power switch for 3 seconds (3) A pop-up confirmation box will appear (4) Press OK using the selector knob to confirm that the controller should be turned off NOTE: Holding down the power switch for longer than 30 seconds during operation will cause the controller to initiate an emergency shutdown
Equipotential ground stud	Used to ground the Automated Impella® Controller according to hospital procedures
Ethernet jack	Connection for downloading data

HOME SCREEN

The home screen displays operating parameters and information for the entire Impella® System. Figure 4.3 illustrates the home screen. Each element of the display is described in Table 4.3.

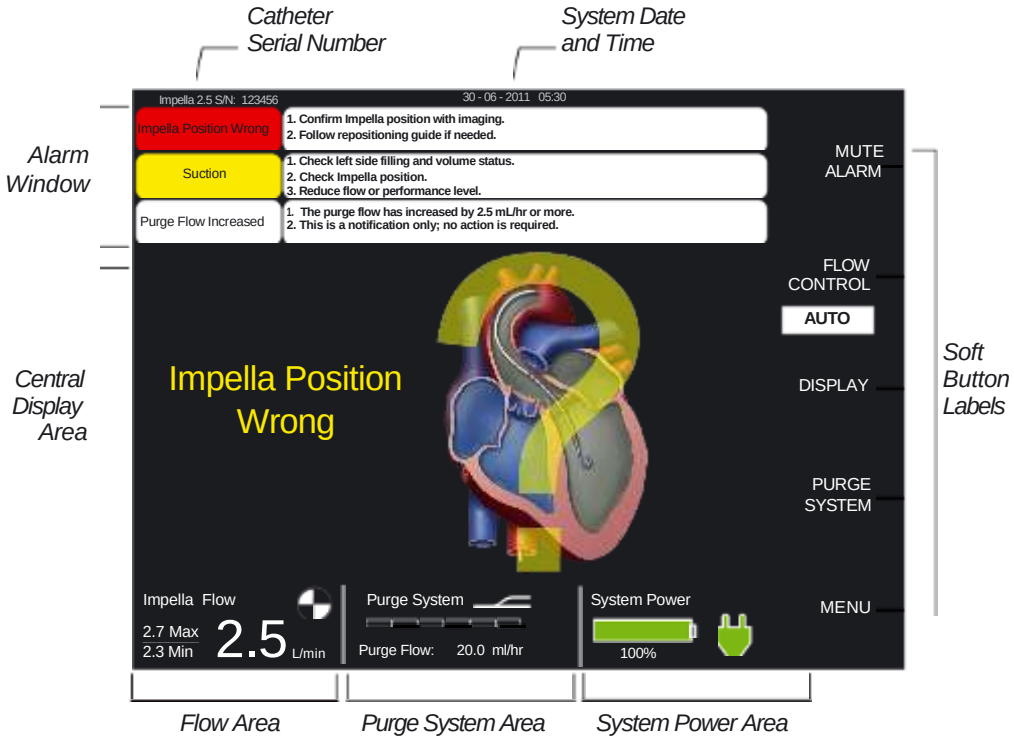


Figure 4.3 Home Screen

Table 4.3 Automated Impella® Controller Display Elements

Display Element	Description
Alarm window	The alarm window displays up to 3 alarms simultaneously, in order of priority from top to bottom. For each alarm, the alarm window displays: • Alarm header – displayed in the left column; window is color-coded red for critical alarms, yellow for serious alarms, white for advisory notifications, gray for resolved alarms • Detailed text – up to 3 lines of instructions for resolving the alarm condition are displayed in the right column of the alarm window next to the alarm header and subhead information (See Section 8 of this manual for further discussion of alarms.)
Catheter serial number	Displayed in the upper left of the display screen if a catheter is connected to the controller.
System date and time	The current date (DD-MM-YYYY) and time (24-hour format; HH:MM) are displayed in the upper center of the screen display. (In this example it is June 30, 2011 at 5:30am.)

Table 4.3 Automated Impella® Controller Display Elements (continued)

Display Element	Description
Mute alarm indicator	Displayed in place of the words "MUTE ALARM" when an alarm is silenced. (See Section 8 of this manual for more information about the mute alarm function; Figure 8.1 illustrates the mute alarm indicator.) • Yellow bell with red X displayed when an alarm is muted • Not displayed when an alarm is active (but not muted) or when there are no active alarms
Soft button labels	The soft buttons on the Automated Impella® Controller have corresponding labels adjacent to them on the display screen. These labels change depending on the type of screen displayed. (Refer to Appendix C in this manual for more details about the menu structure.) **MUTE ALARM** • Mutes (silences) active alarms **FLOW CONTROL** (or **NEXT**) • **FLOW CONTROL** – Allows you to control the flow of the Impella® Catheter • **NEXT** – Advances to the next screen **DISPLAY** (or **BACK**) • **DISPLAY** – Brings up the Display menu for viewing waveforms and navigating to other screen displays • **BACK** – Returns to the previous screen **PURGE SYSTEM** (or **EXIT**) • **PURGE SYSTEM** – Brings up the Purge System menu for changing the purge fluid, purge cassette, or purge system; de-airing the purge system; or transferring to the standard configuration • **EXIT** – Exits the current procedure **MENU** (or **Exit Repositioning Guide**) • **MENU** – Brings up a menu of options related to controller settings, alarm history, repositioning, and starting a case • **Exit Repositioning Guide** – Exits the repositioning guide
System power area	System power information is displayed to the right of the purge system information on the bottom of the display screen. Battery status – Bar within battery symbol indicates the overall remaining capacity of the batteries • Full green bar for fully charged battery • Partial green bar for battery that is at least 50% charged • Partial yellow bar for battery that is between 16% and 50% charged • Partial red bar for battery that is less than or equal to 15% charged • Moving gray bar for battery that is in charging mode • Percentage of battery power remaining displayed below the battery icon AC plug indicator • Green plug indicates that the controller is running on AC power • Gray plug with a red X indicates no AC power detected and the controller is running on battery power

Purge System Stabilization

The purge system must stabilize after case start, a purge procedure, or resolution of a purge alarm. During this time, it may take up to 3 minutes for purge system information to display on the screen.

Table 4.3 Automated Impella® Controller Display Elements (continued)

Display Element	Description
Purge system area	Information about the purge system is displayed to the right of the flow area at the bottom of the display screen. Purge system marquee—scrolls from left to right when purge system is operating • Slow scrolling represents normal purge flow rate • Fast scrolling represents bolus flow rate and priming flow rate Y connector icon • Appears above the purge system marquee when the Impella® System is configured using the Y connector in the set-up configuration Purge flow • Current purge flow displayed in mL/hr below the purge system marquee if the purge flow is known • Not displayed when the purge system is stabilizing, when there is no purge cassette, or when the procedure has not yet started
Flow area	Information about Impella® Catheter flow is displayed in the lower left corner of the display screen. Max/Min • Max/Min displays the range for the flow rate Current flow rate • Mean catheter flow displayed in liters per minute (L/min)—the numbers appear in white if the catheter position is correct; yellow if the catheter position is incorrect or unknown • If the system is unable to calculate flow, a yellow triangular caution icon is displayed with the message “Flow Calculation Disabled” Catheter operation icon • The circular catheter operation icon rotates when the Impella® Catheter is running
Central display area	On the home screen, the central display area displays a heart pictogram and Impella® Catheter position indicator message. Heart pictogram appears in the center of the home screen display. • Provides a visual representation of the current Impella® Catheter position • Overlaid with a translucent yellow “?” when the controller cannot determine catheter position, position is wrong, and placement monitoring is suspended or disabled Impella® Catheter position indicator message displayed to the left of the heart icon. • Displays “Impella Position OK” in green when catheter position is correct • Displays “Impella Position Unknown” in yellow when catheter position is unknown • Displays “Impella Position in Ventricle” in yellow when catheter is in the ventricle • Displays “Impella Position Wrong” in yellow when catheter position is incorrect • Displays “Placement Monitoring Suspended” in yellow when there is a fault in the sensor • Displays “Placement Monitoring Disabled” in yellow when you turn off placement monitoring through the menu

PLACEMENT SCREEN

The placement screen (see Figure 4.4) displays real-time operating data for the system. The screen displays the placement signal and motor current waveforms as well as the maximum/ minimum and average values for each waveform in the central display area of the screen.

Use the **DISPLAY** soft button to navigate to the placement screen.

Figure 4.4 Placement Screen

Figure 4.4 shows two time-based waveform signals from different sources.

- Placement signal waveform
- Motor current waveform

PLACEMENT SIGNAL WAVEFORM

The placement signal waveform displays a pressure measurement that is useful for determining the location of the open pressure area of the catheter with respect to the aortic valve. The placement signal is used to verify whether the Impella® Catheter is in the aorta or in the ventricle by evaluating the current pressure waveform as an aortic or ventricular waveform. The scale for the placement signal waveform is displayed to the left of the waveform. The default scaling is 0–160 mmHg. It can be adjusted in 20 mmHg increments, with a minimum upper limit of 100 mmHg and a maximum upper limit of 240 mmHg for the Impella® Catheter.

To the right of the waveform is a display that labels the waveform, provides the units of measurement, and shows the maximum and minimum values and the average value from the samples received. At the bottom of that window is the time scale, which you can set by pressing the **DISPLAY** soft button.

Retrograde Flow

A setting of P-0 will result in retrograde flow when the Impella® Catheter is placed across the aortic valve. Retrograde flow may also occur at P-1.

MOTOR CURRENT WAVEFORM

Motor current is a measure of the energy intake of the Impella® Catheter motor. The energy intake varies with motor speed and the pressure difference between the inlet and outlet areas of the cannula. Motor current (see Figure 4.4) provides information about the catheter position relative to the aortic valve. When the Impella® Catheter is positioned correctly, with the inlet area in the ventricle and the outlet area in the aorta, the motor current is pulsatile because the pressure difference between the inlet and outlet areas changes with the cardiac cycle. When the inlet and outlet areas are on the same side of the aortic valve, the motor current will be dampened or flat because there is little or no pressure difference between the inlet and outlet areas.

The scale for the motor current waveform is displayed to the left of the waveform. The default scaling is 0–1000 mA. It is adjustable in 100 mA increments for the Impella® Catheter, with a minimum difference between upper and lower limits of 200 mA and a maximum difference of 1000 mA.

To the right of the waveform is a display that labels the waveform, provides the units of measurement, and shows the maximum and minimum values and the average value from the samples received. You can set the time scale at the bottom of that window by pressing the **DISPLAY** soft button.

PURGE SCREEN

The purge screen (see Figure 4.5) displays purge system data. In the central display area of the screen, the purge flow rate and purge pressure are plotted as a function of time. To the right of the plots, the current purge flow rate and purge pressure are displayed.

Use the **DISPLAY** soft button to navigate to the purge screen.

Figure 4.5 Purge Screen

PURGE FLOW

The purge flow rate delivered by the purge cassette is displayed in mL/hr. The standard scale for the purge flow (0–30 mL/hr) is displayed to the left of the purge flow plot. The maximum value on this scale can be adjusted from 20 mL/hr to 200 mL/hr in increments of 10 mL/hr.

To the right of the plot is a display that labels the plot and shows the most recent value update. You can set the time scale at the bottom of the window by pressing the **DISPLAY** soft button.

An advisory alarm will be displayed in the alarm window when the purge flow rate increases or decreases by 2.5 mL/h. The message is intended to aid patient management by alerting the clinician to changes in the rates of dextrose and heparin infusion through the purge fluid. The alarm clears when you press the **MUTE ALARM** button.

PURGE PRESSURE

The Automated Impella® Controller regulates purge pressure, the pressure of the purge fluid delivered through the catheter to the motor. The purge pressure generated by the purge cassette is displayed in mmHg. The standard scale for the purge pressure (0–1500 mmHg) is displayed to the left of the purge pressure plot. The maximum value on this scale can be adjusted from 100 mmHg to 2000 mmHg in increments of 100 mmHg. An alarm appears if purge pressure falls below 300 mmHg or exceeds 1100 mmHg.

To the right of the plot is a display that labels the plot and shows the most recent value update. You can set the time scale at the bottom of the window by pressing the **DISPLAY** soft button.

Purge Flow

In the initial set-up configuration of the Impella® System, purge flow is regulated to keep the purge pressure at 600 mmHg, although it may not reach 600 mmHg in flow resistance catheters in this configuration.

In the standard configuration, purge flow can range from 2 to 30 mL/hr and purge pressure can range from 300 to 1100 mmHg.

Purge Pressure Depends on System Configuration

When in the initial set-up configuration, the purge pressure is set to 600 mmHg with flows between 2 and 30 mL/hr. After switching to the standard configuration, the purge pressure is set to an ideal pressure between 300 and 1100 mmHg and flows between 2 and 30 mL/hr.

INFUSION HISTORY SCREEN

The infusion history screen displays the infusion volume as well as the amount of heparin and dextrose infused each hour. The current time period is displayed at the top of the list.

Use the **DISPLAY** soft button to navigate to the infusion history screen.

Figure 4.6 shows a sample infusion history screen.

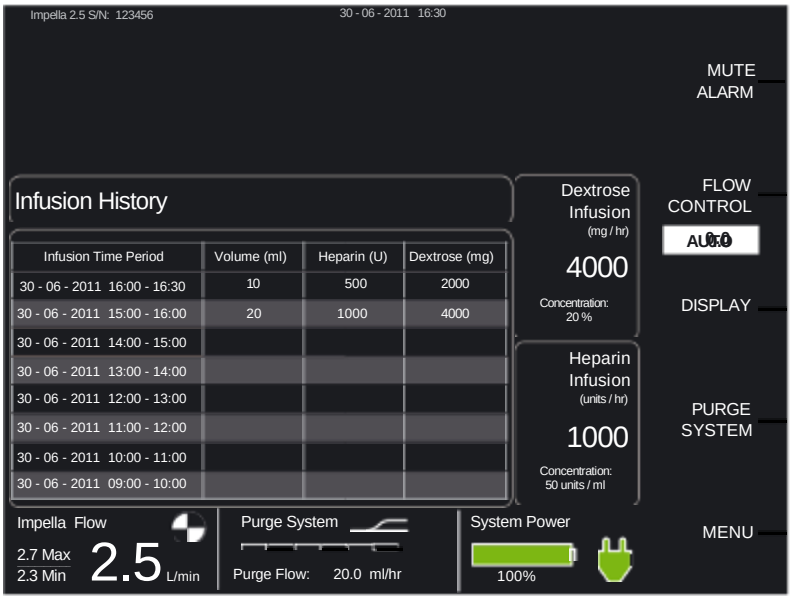


Figure 4.6 Infusion History Screen

MOBILE OPERATION

The Li-Ion batteries must be charged for 5 hours prior to system operation in order to meet the runtime requirement of 1 hour. Failure to do so will yield a shorter runtime. After being unplugged, the Automated Impella® Controller will operate for at least 60 minutes after the batteries have been fully charged.

The Automated Impella® Controller can be operated on internal battery power when it is not connected to AC power.

1. Disconnect the Automated Impella® Controller from AC power.
2. The Automated Impella® Controller beeps once every 5 minutes to alert you that it is running on battery power and a white advisory notification appears in the alarms area on the screen. The AC power icon turns gray with an X through it.
3. When the Automated Impella® Controller is connected back to AC power, the white advisory notification turns gray and the AC power icon turns green.

5 USING THE AUTOMATED IMPELLA® CONTROLLER WITH THE IMPELLA® CATHETER

PRE-SUPPORT EVALUATION

Before initiating the procedure, evaluate the patient for factors that may prevent successful placement of the Impella® Catheter. Use imaging technology to examine the patient's vasculature and femoral access site. An echo assessment of the left ventricle is also recommended to rule out left ventricular thrombus, mechanical aortic valves, or severe aortic insufficiency.

Table 5.1 Evaluation Prior to Inserting the Impella® Catheter

Technology	Observations
• Standard traditional angiography • Magnetic resonance angiography (MRA) • Coronary computed tomography angiography (CTA) • Ultrasound • Echocardiography	• LV thrombus • Mechanical aortic valve • Aortic valve stenosis / calcification • Moderate to severe aortic insufficiency • Tortuous iliac artery (see below)• Severe peripheral arterial obstructive disease

ALTERNATIVE SHEATHS AND SURGICAL TECHNIQUES

If the patient has a tortuous iliac artery, an alternative 30 cm sheath can be used for insertion of the Impella® Catheter. The Impella® Catheter can also be inserted surgically. A surgical technique is described in Appendix D.

STARTUP

Do NOT use an Impella® System if any part of the system is damaged.

The sterile components of the Impella® System can be used only if the sterilization indicators show that the contents have been sterilized, the packaging is not damaged, and the expiration date has not elapsed.

Do ***NOT*** resterilize or reuse the Impella® Catheter. It is a disposable device and is intended for single use only.

To prevent malfunction of the Automated Impella® Controller, avoid long-term exposure to direct sunlight and excessive heat (40°C).

To prevent overheating and improper operation, do ***NOT*** block the cooling vents of the Automated Impella® Controller while it is operating.

The Li-Ion batteries must be charged for 5 hours prior to system operation in order to meet the runtime requirement of 1 hour. Failure to do so will yield a shorter runtime. After being unplugged, the Automated Impella® Controller will operate for at least 60 minutes after the batteries have been fully charged.

Have a backup Automated Impella® Controller, purge cassette, connector cable, and Impella® Catheter available in the unlikely event of a device failure.

SUPPLIES NEEDED

- Automated Impella® Controller
- Impella® Catheter Set-up and Insertion kit
- Diagnostic catheter (AL1 or MP without side holes or pigtail with or without side holes)
- 5–8 Fr introducer and 10 Fr dilator
- Standard 0.035" x 175 cm J-tip guidewire
- Standard IV infusion set
- Normal saline flush solution with pressure bag
- 500 cc bag of dextrose solution for purge solution (20% recommended; 5% to 40% acceptable) with 50 IU heparin/mL

TURNING ON THE AUTOMATED IMPELLA® CONTROLLER

To turn the controller on:

1. Press and hold the power switch on the right side of the Automated Impella® Controller for 3 seconds (see Figure 5.1).

Figure 5.1 Automated Impella® Controller Power Switch

The Automated Impella® Controller automatically performs a system test when turned on.

A display bar shows the progress of the system test. If the system test passes, the system displays the startup screen (see Figure 5.2).

If the system test fails, the controller displays a system self check failure message:

SYSTEM SELF CHECK FAILED.
CHANGE CONSOLE IMMEDIATELY.

The controller displays the reason for the system test failure at the bottom of the screen.

Battery Switch

Before operating the Automated Impella® Controller for the first time, turn on the switch on the underside of the controller to turn on the batteries.

THE STARTUP SCREEN

Check Date and Time

The current date and time appear at the top of the startup screen. Confirm that these are correct. For more information, refer to Appendix C.

The startup screen (see Figure 5.2) appears when you successfully turn on the Automated Impella® Controller.

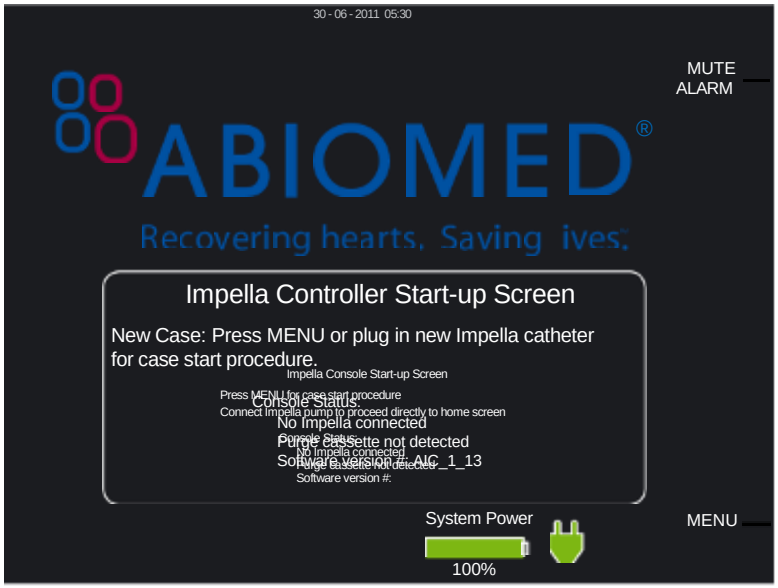


Figure 5.2 Automated Impella® Controller Startup Screen

The startup screen displays:

- The current status of the Impella® Catheter (currently not connected to the Automated Impella® Controller in Figure 5.2).
- The current status of the purge cassette (no purge cassette detected in Figure 5.2).
- The current version of the software that the Automated Impella® Controller is running.

The startup screen also displays system power information along the bottom of the screen and two active soft buttons—**MUTE ALARM** and **MENU**—along the right side of the screen.

CASE START

Fluoroscopy is required to guide placement of the Impella® Catheter. The small placement guidewire must be reliably observed at all times.

The sterile components of the Impella® System can be used only if the sterilization indicators show that the contents have been sterilized, the packaging is not damaged, and the expiration date has not elapsed.

Avoid manual compression of the inlet and outlet areas of the cannula assembly.

Do ***NOT*** remove the Impella® Catheter over the length of the guidewire.

Handle with care. The Impella® Catheter can be damaged during removal from packaging, preparation, insertion, and removal. Do ***NOT*** bend, pull, or place excess pressure on the catheter or mechanical components at any time.

During case start, make sure the yellow luer connection between the purge tubing and Y connector is tightened and not leaking.

Do ***NOT*** kink or clamp the Impella® Catheter or the peel-away introducer.

Sensitive Medical Device

The Impella® Catheter is a sensitive medical device with extremely fine tolerances. In particular, the inlet and outlet areas of the catheter assembly may be damaged if subjected to strong external forces.

CASE START

1. Press the **MENU** soft button from the startup screen. “Case Start” is the default selection on the pop-up menu that appears on the screen.
2. Press the selector knob to select “Case Start.” The controller displays the screen shown in Figure 5.3.

Two Ways to Start the Setup Procedure

*You can start the setup procedure from the **MENU** on the startup screen (as described on this page) or when a new Impella® Catheter is plugged into the controller.*

Figure 5.3 Initial Case Start Screen

INSERT PURGE CASSETTE

Shaded Steps

All shaded steps require sterile technique.

Purge Solution Bottles

If the purge solution is supplied in bottles, open the vent on the purge fluid spike and follow the same procedure as if supplied in bags.

Connect Purge Pressure Transmitter Within 10 Seconds

An alarm will appear if the purge pressure transmitter is not snapped into place within 10 seconds of inserting the purge cassette.

Close Purge Cassette Door

Once the purge cassette is installed, be sure to close the purge cassette door to prevent the purge cassette from being dislodged accidentally.

1. Open the purge cassette package.
2. Secure the red and yellow luers to the sterile field.
3. Pass the purge cassette and spike off the sterile field.
4. Spike the fluid bag/bottle.
5. Open the purge cassette door by pressing the release on the left side of the controller. Insert the purge cassette into the Automated Impella® Controller (as shown in Figure 5.4 and described in the steps that follow).

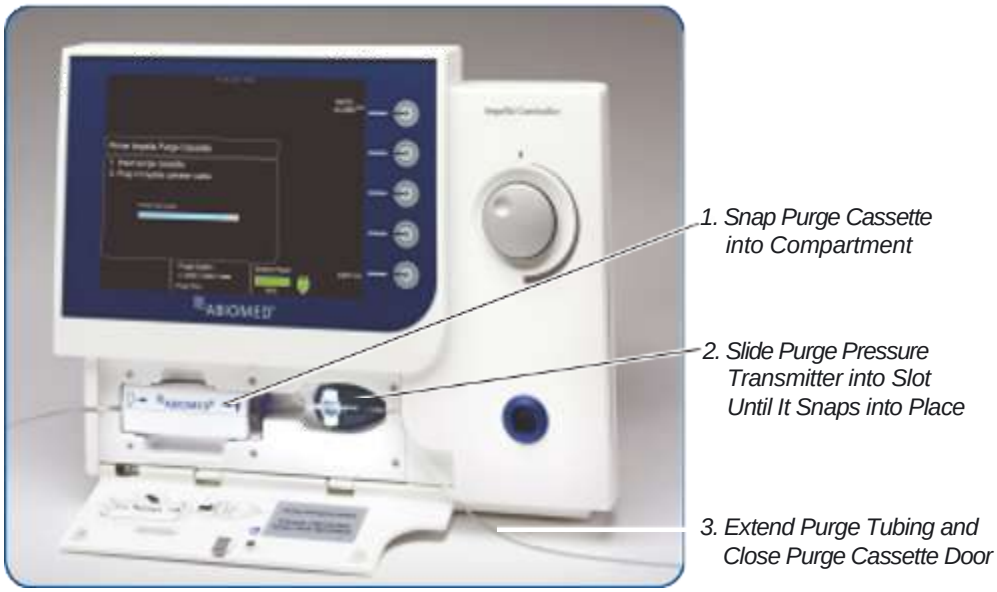


Figure 5.4 Inserting Purge Cassette into Automated Impella® Controller

6. Insert the purge cassette into the molded compartment on the front of the controller. Follow the diagram on the inside of the purge cassette door for proper placement.
7. Slide the purge pressure transmitter into the slot to the right of the purge cassette until it snaps into place. The controller will automatically begin priming the purge cassette.
8. Extend the purge tubing and close the purge cassette door. There is sufficient room around the edges of the purge cassette door so that it will not pinch the purge tubing as it exits.
9. The controller automatically begins priming the purge cassette after it is inserted. The progress bar shown in Figure 5.3 marks the progress of the purge cassette priming.

CONNECT THE IMPELLA® CATHETER

1. Remove the Impella® Catheter from its package using sterile technique and inspect the catheter, including its connector, for damage.
2. Remove the white connector cable from its package using sterile technique.
3. Inspect the cable for damage, including damage to the connector pins at the controller end.
4. Secure the black end of the cable to the sterile field.
5. Insert the catheter plug into the connector cable socket (black end). The tab and the slot must be aligned during connection (see Figure 5.5).

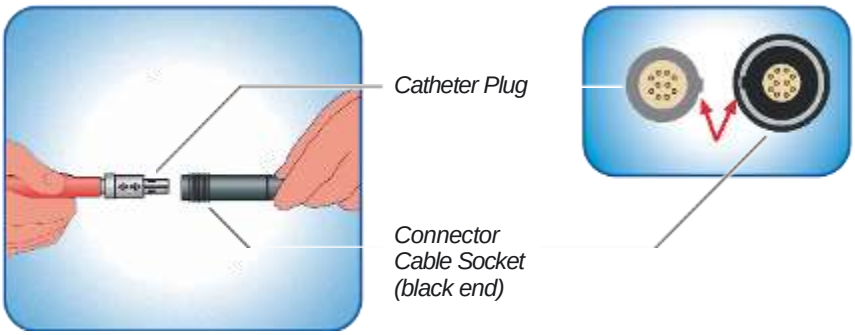


Figure 5.5 Inserting the Catheter Plug into the Connector Cable

6. Pull back on the connection to make sure that the plug has snapped into place.
7. Snap the plastic clip (located on the pressure reservoir of the clear sidearm) to the connector cable as shown in Figure 5.6.

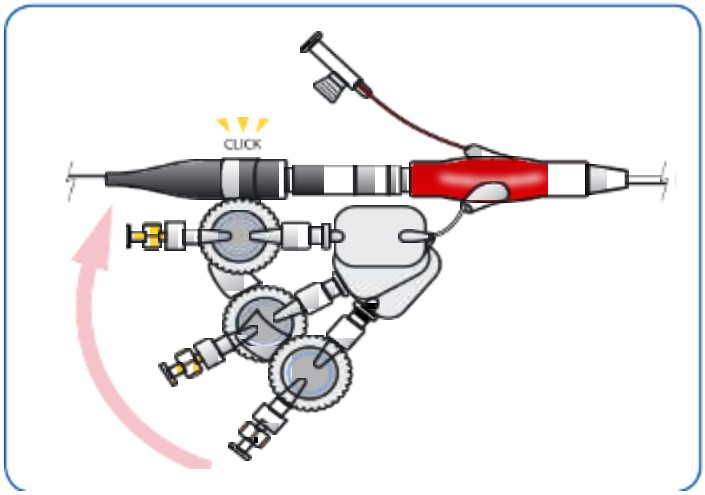


Figure 5.6 Snapping Plastic Clip to Connector Cable

8. Pass the sterile connector cable from the Impella® Catheter off the sterile field.

Important Step

Snapping the plastic clip on the pressure reservoir to the connector cable is important to prevent the tube from kinking.

9. Line up the notch on the connector cable with the notch in the blue catheter plug on the front of the Automated Impella® Controller and plug the cable into the controller.

10. Once the purge cassette is primed and the controller detects that the connector cable is plugged in, it prompts you to connect the luer(s) to the Impella® Catheter. (See Figure 5.7)

Error Screens

If you miss a step in the process of setting up the Impella® Catheter, or if you exceed the amount of time allowed to complete a step, the Automated Impella® Controller will display an error screen with instructions for continuing the setup process.

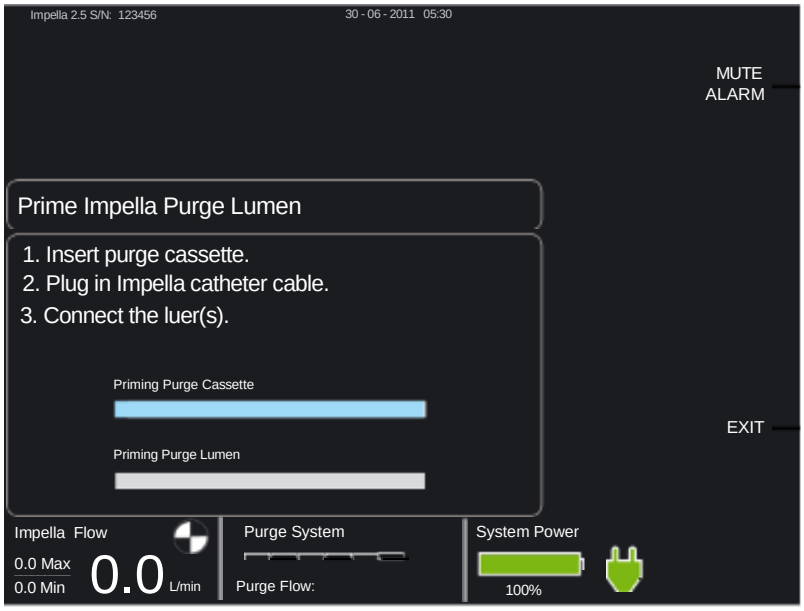


Figure 5.7 Priming the Impella Purge Lumen

11. Connect and tighten the luer(s) on the purge tubing to the Impella® Catheter sidearms as shown in Figure 5.8

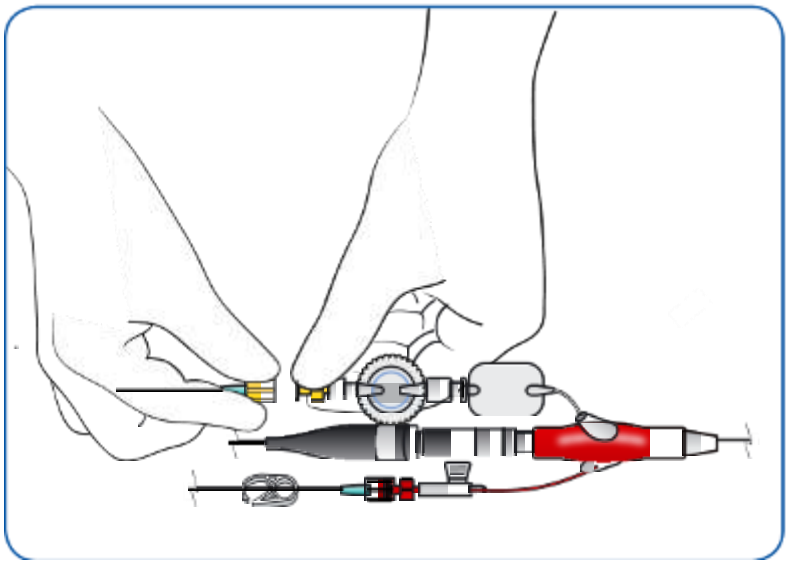


Figure 5.8 Connecting the Luer(s) to the Impella® Catheter

12. When the controller detects that the luer(s) are connected, it automatically begins priming the purge lumen at a bolus rate of greater than 250 mL/h and tracking the progress on the second progress bar.

13. Once the purge lumen is primed, the controller automatically advances to the next screen (Figure 5.9).

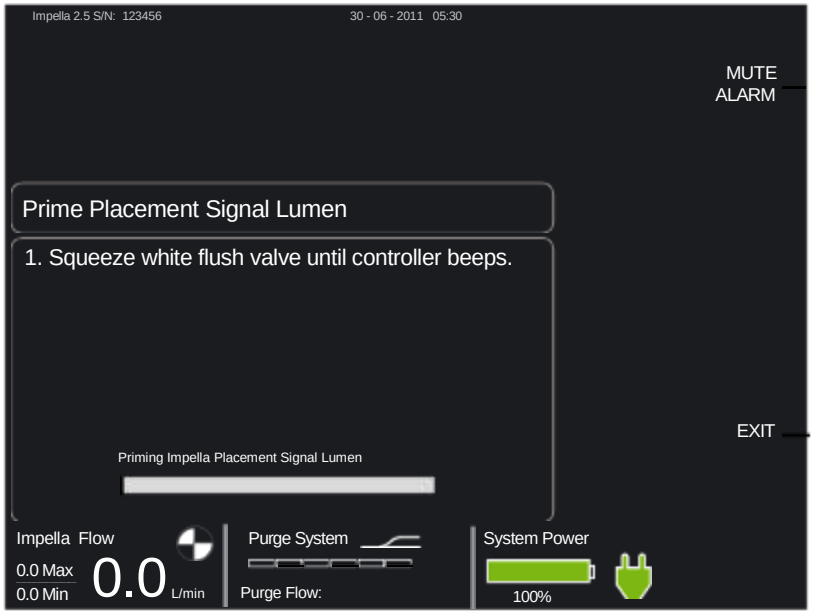


Figure 5.9 Priming the Placement Signal Lumen

14. Prime the Impella® Catheter placement signal lumen by squeezing the white flush valve for 10 seconds (see Figure 5.10) until the Automated Impella® Controller beeps. The progress bar shows the progress of the priming.

Figure 5.10 Squeezing the White Flush Valve to Prime the Placement Signal Lumen

15. When the system detects that the flush solution has reached the target pressure within the required amount of time, the system will advance to the next screen automatically.

16. The first step on the next screen prompts you to confirm that fluid is exiting the Impella® Catheter (see Figure 5.11).

ENTER PURGE FLUID DATA

1. After confirming that fluid is exiting the Impella® Catheter, enter the purge fluid information. The screen in Figure 5.11 shows a table of recommended default values for the purge fluid.

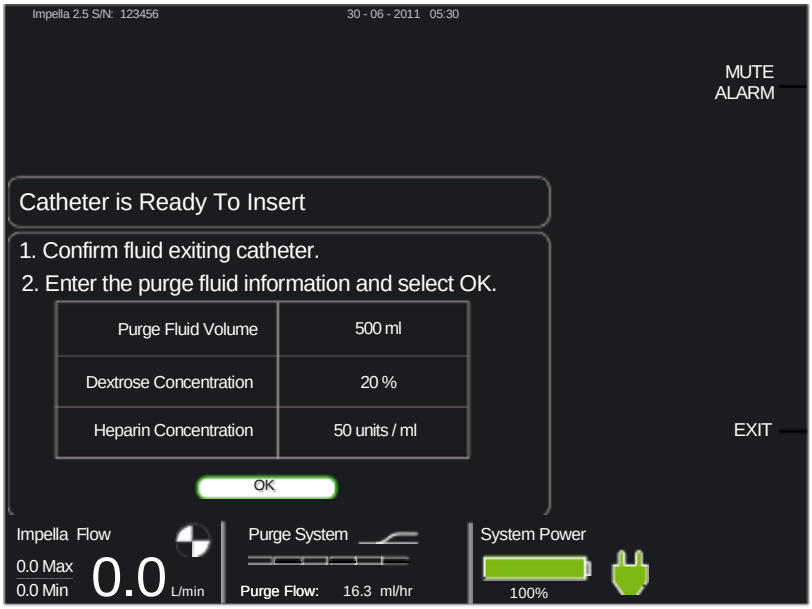


Figure 5.11 Entering Purge Fluid Information

2. To select the default values displayed on the screen, scroll to OK below the table and press the selector knob. This will select those values and automatically advance to the next screen.
3. To change the purge fluid information, scroll to the appropriate item and push the selector knob to select it. Then scroll through the values and push the selector knob to make a new selection. The controller will use the default values if no other selections are made.
   - Purge fluid can be set to 50 mL, 100 mL, 250 mL, 500 mL (default), or 1000 mL.
   - Dextrose concentration can be set to 5%, 10%, 20% (default), 30%, or 40%.
   - Heparin concentration can be set to 0, 5, 10, 12.5, 15, 20, 25, or 50 units/mL (default).

SECURE THE PURGE TUBING

1. To complete the setup, connect the purge tubing to the white connector cable by pushing the purge tubing into the clips attached to the white connector cable as shown in Figure 5.12.

Figure 5.12 Connecting the Purge Tubing to the Connector Cable

IMPELLA® SYSTEM SET-UP CONFIGURATION

Figure 5.13 illustrates the correct set-up configuration of the Impella® System.

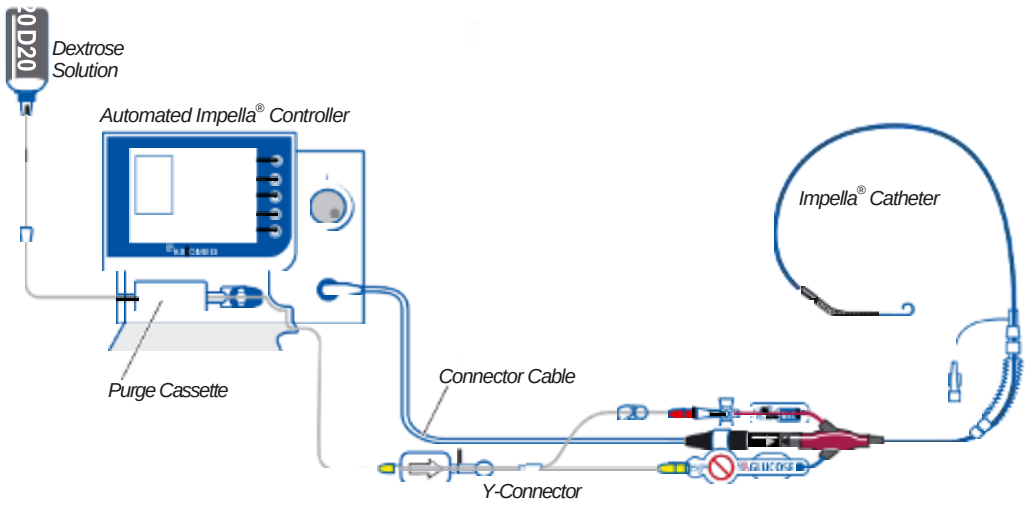


Figure 5.13 Set-up Configuration of the Impella® System

INSERTING THE IMPELLA® CATHETER (WIRED INSERTION)

NOTE – Proper insertion procedures and techniques are the responsibility of the medical professional. The described procedure is furnished for information purposes only. Each physician must evaluate the appropriateness of the procedure based on his or her medical training and experience, the type of procedure, and the type of systems used.

Fluoroscopy is required to guide placement of the Impella® Catheter. The small placement guidewire must be reliably observed at all times

Avoid manual compression of the inlet and outlet areas of the cannula assembly.

To prevent malfunction of the locking mechanism of the peel-away introducer, do ***NOT*** hold the hemostatic valve while inserting into the artery.

Do ***NOT*** kink or clamp the Impella® Catheter or the peel-away introducer.

Handle with care. The Impella® Catheter can be damaged during removal from packaging, preparation, insertion, and removal. Do ***NOT*** bend, pull, or place excess pressure on the catheter or mechanical components at any time.

Patients with aortic stenosis or other abnormal aortic valve performance may be compromised by the use of the Impella® Catheter. Patients with aortic valve disease should be observed for aortic insufficiency.

1. Obtain access to the femoral artery.
2. Insert a 5–8 Fr introducer over the 0.035 guidewire (provided) to pre-dilate the vessel.
3. Remove the 5–8 Fr introducer over the 0.035 guidewire. Predilate the artery with a 10 Fr dilator prior to inserting the 13 Fr peel-away introducer with dilator (see Figure 5.14). While inserting the introducer, hold the shaft of the introducer to slide it into the artery.

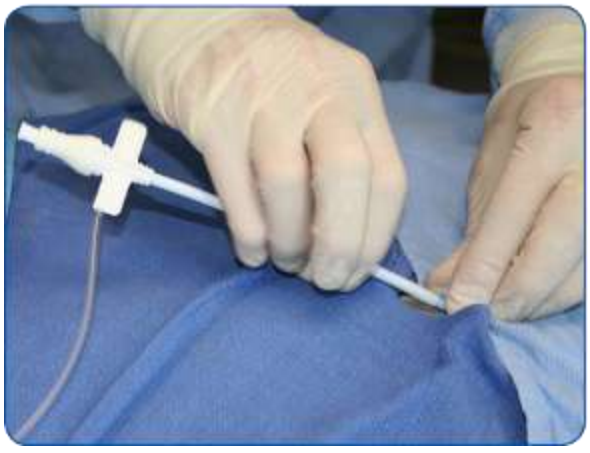


Figure 5.14 Inserting the Peel-Away Introducer

4. Administer heparin. When the ACT is greater than or equal to 250 seconds, remove the dilator.

Use Fluoroscopy for Placement

Impella® Catheter performance will be compromised if correct placement cannot be confirmed. While other imaging techniques, such as transesophageal echocardiography (TEE), portable C-Arm fluoroscopy, or chest x-ray can help confirm the position of the Impella® Catheter after placement, these methods do not allow visualization of the entire catheter assembly and are inadequate for reliably placing the Impella® Catheter across the aortic valve.

Introducer Setup

Refer to the instructions for use for each introducer for setup instructions.

Keep ACT ≥250 Seconds

Achieving an ACT ≥ 250 seconds prior to removing the dilator will help prevent a thrombus from entering the catheter and causing a sudden stop on startup.

GP IIb-IIIa Inhibitors

If the patient is receiving a GP IIb-IIIa inhibitor, the dilator can be removed and the Impella® Catheter inserted when ACT is 200 or above.

5. Insert a diagnostic catheter (Abiomed recommends a 6 Fr AL1 or Multipurpose without side holes or 4–5 Fr pigtail with or without side holes) over a 0.035 inch diagnostic guidewire into the introducer and advance it into the left ventricle.

Figure 5.15 Inserting the Diagnostic Catheter

6. Remove the 0.035 inch diagnostic guidewire, leaving the diagnostic catheter in the ventricle. Form a curve or bend on the end of the 0.018 inch, 260 cm placement guidewire, following the instructions and heeding the precautions described in the sidebar box.

7. Advance the placement guidewire into the apex of the left ventricle.

8. Remove the diagnostic catheter.

To backload the catheter using the EasyGuide lumen

9. Insert the placement guidewire into the red EasyGuide lumen at the tip of the pigtail as shown in Figure 5.16. (If the catheter does not have a red EasyGuide lumen, follow the procedure outlined in step 10.)

   a. Advance the guidewire until it exits the red lumen near the label.

   b. Remove the EasyGuide lumen by gently pulling the label in line with the catheter shaft while holding the Impella® Catheter as shown in Figure 5.16.

   c. If you suspect that a portion of the red lumen remains in the catheter, do NOT use the Impella® Catheter. Measure red lumen length using catheter markings (intact length is between 21.5 cm and 22.5 cm).

   d. Skip to step 11 if the catheter is successfully backloaded on the guidewire.

Figure 5.16 Loading the Catheter on the Guidewire using the EasyGuide Lumen

Using a Pigtail Diagnostic Catheter with Side Holes

When using a pigtail diagnostic catheter with side holes, ensure that the guidewire exits the end of the catheter and not the side hole. To do so, magnify the area one to two times as the guidewire begins to exit the pigtail.

Shaping the 0.018" Placement Guidewire

Place the shaping tool just distal to the weld separating the shaping ribbon from the body of the placement guidewire. Bend the shaping ribbon against the tool, using minimal force. Do NOT use a shaping tool with a sharp tip or edge. Do NOT pull the shaping tool along the length of the shaping ribbon as this could strip the coil off the guidewire and cause it to unfurl and separate. Inspect the coil and guidewire for damage after shaping and before using.

Do NOT reinsert the EasyGuide lumen

Once you remove the EasyGuide lumen from the Impella® Catheter, do not attempt to reinsert it. If necessary, follow instructions for backloading the catheter ***without*** *the EasyGuide lumen.*

To backload the catheter without the EasyGuide lumen

10. Wet the cannula with sterile water and backload the catheter onto the placement guidewire. One or two people can load the catheter on the guidewire.

One-person technique

a. Advance the guidewire into the Impella® Catheter and stabilize the cannula between the fingers as shown in Figure 5.17. This prevents pinching of the inlet area. The guidewire must exit the outlet area on the inner radius of the cannula and align with the straight black line on the catheter as shown in Figure 5.17. The cannula can be hyperextended as necessary to ensure the guidewire exits on the inner radius of the cannula.

Two-person technique

b. The scrub assistant can help stabilize the catheter by holding the catheter proximal to the motor. This will allow the implanting physician to visualize the inner radius. The guidewire must exit the outlet area on the inner radius of the cannula and align with the straight black line on the catheter, as shown in Figure 5.17. The physician can focus on advancing the guidewire and, if the cannula needs to be hyperextended, the scrub assistant is available to assist.

Avoid Damaging Inlet Area

During placement of the Impella® Catheter, take care to avoid damage to the inlet area while holding the catheter and loading the placement guidewire.

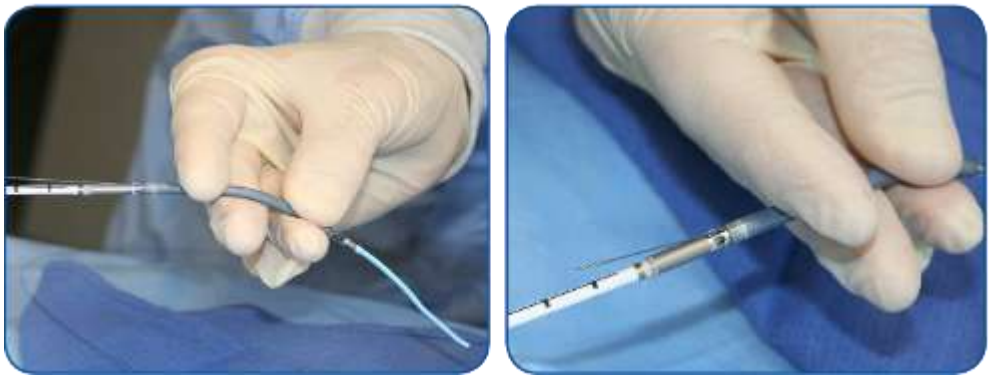


Figure 5.17 Loading the Catheter on the Guidewire without the EasyGuide Lumen and Aligning the Placement Guidewire

Positioning in Small Hearts

If a patient has a smaller than normal ventricular cavity, the proper placement of the inlet area of the catheter may be 3 cm (rather than 3.5 cm) from the aortic valve.

11. Advance the catheter through the hemostatic valve into the femoral artery (see Figure 5.18) and along the placement guidewire and across the aortic valve using a fixed-wire technique. Follow the catheter under fluoroscopy as it is advanced across the aortic valve, positioning the inlet area of the catheter 3.5 cm below the aortic valve annulus and in the middle of the ventricular chamber, free from the mitral valve chordae. Be careful not to coil the guidewire in the left ventricle.

Figure 5.18 Inserting the Impella® Catheter

> To prevent device failure, do ***NOT*** start the Impella® Catheter until the guidewire has been removed.
>
> Do ***NOT*** remove the Impella® Catheter over the length of the guidewire.

12. Remove the placement guidewire.
13. Confirm position with fluoroscopy and confirm that an aortic waveform (see Figure 5.19) is displayed on the Automated Impella® Controller.

Figure 5.19 Aortic Waveform on Placement Signal Screen

Take "Small Bites" During Insertion

While inserting the Impella® Catheter, push the catheter from only a few centimeters behind the hub of the peel-away introducer. This prevents the catheter from buckling during insertion.

Do NOT Touch Inlet or Outlet Areas

While feeding the Impella® Catheter through the introducer, hold the catheter at the cannula or motor housing. Do NOT touch the inlet or the outlet areas.

Maintaining ACT

After insertion of the catheter (and until explant), ACT should be maintained at 160 to 180 seconds.

WIRELESS INSERTION OF THE IMPELLA® 2.5 CATHETER

OVERVIEW

Physicians should exercise special care when inserting the Impella® Catheter in patients with known or suspected unrepaired abdominal aortic aneurysm or significant descending thoracic aortic aneurysm or dissection of the ascending, transverse, or descending aorta.

Physicians have developed a wireless technique as an alternative to the standard insertion method for the Impella® 2.5 Catheter. This technique eliminates several of the steps in the traditional insertion method.

Wireless Insertion

The Impella® 2.5 Catheter must be visualized at all times.

Do NOT apply excessive force on the catheter when advancing it across the aortic valve. The spring characteristics and robust catheter design should make it easy for the catheter to cross the aortic valve and move into position.

WIRELESS INSERTION TECHNIQUE

1. Place a 13 Fr introducer in the usual manner.
2. Administer heparin. When the ACT is above 250 seconds, remove the 13 Fr dilator.
3. Straighten the pigtail at the end of the Impella® 2.5 Catheter by hand and advance it through the hemostatic valve. Advance the catheter in small steps to avoid kinking.
4. Track the catheter through the descending aorta using fluoroscopy. Maintain the pigtail curve on the medial aspect of the aorta closer to the spine.
5. When the pigtail reaches the aortic valve, rest the pigtail against the medial cusp and continue to advance it until the catheter begins to prolapse.
6. Pull back while turning the catheter clockwise, allowing it to advance (“pop”) across the aortic valve.
7. If the catheter fails to advance across the valve, pull back, twist 45°, and repeat the process.

RECOMMENDATIONS FOR HANDLING THE IMPELLA® 2.5 CATHETER

Unsuccessful Wireless Insertion

Persistent unsuccessful attempts at wireless insertion of the Impella® 2.5 Catheter will require reverting to the standard wired procedure.

During wireless insertion of the Impella® 2.5 Catheter, avoid twisting the catheter more than 360°. Doing so will tangle the connector cable and purge tubing. To reduce the likelihood of twisting or stressing the clear sidearm, ensure that the clear sidearm is clipped to the connector cable and is rotating with the red Impella plug. When in the initial set-up configuration, carefully inspect the catheter for kinking. In this configuration, occlusion alarms will not sound.

If the Impella® 2.5 Catheter must be removed from the patient, carefully rinse the catheter with heparinized saline solution to prevent blood from clotting on it when it is exposed to air. Use a new, clean basin to ensure the catheter will not come in contact with any loose fibers that could interfere with the operation of the motor.

Retrograde flow will occur across the aortic valve if the flow rate of the Impella® Catheter is less than 0.5 L/min.

1. Place the catheter plug at the same level as the patient's heart.
2. Reconfirm that the placement guidewire has been removed. Also reconfirm that the controller displays an aortic waveform (refer back to Figure 5.19) and the radiopaque marker band is located at the aortic valve. (See step 7 if the controller displays a ventricular waveform.)
3. Press the **FLOW CONTROL** soft button to open the menu. (see Figure 5.20). **Start Pump** is highlighted in blue. Press the selector knob to select **Start Pump** and the controller starts in **AUTO**, which automatically increases the flow rate over 30 seconds.

Figure 5.20 Starting the Impella® 2.5 Catheter

4. Once the controller has begun to run in **AUTO**, pressing the **FLOW CONTROL** soft button again opens the **FLOW CONTROL** menu with options for **BOOST**, **AUTO**, and P-levels ranging from P-0 to P-8 as shown in Figure 5.21 and described in the "Modes of Operation" discussion that follows.

Figure 5.21 FLOW CONTROL Options for the Impella® 2.5 Catheter

BOOST

The "BOOST" FLOW CONTROL setting maximizes the Impella® Catheter flow for 5 minutes. At the end of 5 minutes, the controller returns to the AUTO setting (or P-8 if previously running in P-level mode).

Importance of Proper Impella® Catheter Placement

When the Impella® Catheter is not correctly placed, there is no effective unloading of the ventricle. The patient may not be benefiting from the flow rate shown on the controller.

5. Wait 30 seconds for flow to reach its maximum value, then confirm correct and stable placement. Evaluate the catheter position in the aortic arch and remove any excess slack. The catheter should align against the lesser curvature of the aorta rather than the greater curvature. Verify placement with fluoroscopy and with the placement signal screen.
6. Reposition the catheter as necessary.
7. If the Impella® Catheter advances too far into the left ventricle and the controller displays a ventricular waveform (see Figure 5.22) rather than an aortic waveform, follow these steps to reposition the catheter.

a. Pull the catheter back until an aortic waveform is present on the placement screen.
b. When the aortic waveform is present, pull the catheter back an additional 4 cm. (The distance between adjacent markings on the catheter is 1 cm.) The catheter should now be positioned correctly.

Placement Monitoring Suspended

When the Impella® Catheter is operating in a low flow range, placement monitoring may be suspended and the flow rate in the lower left corner of the controller display screen will turn yellow to indicate that Impella position is unknown.

Figure 5.22 Ventricular Waveform on Placement Signal Screen

Reverse Flow

If the Impella® Catheter flow is below 0.1 L/min for more than 30 seconds and the controller detects reverse flow, it will increase the motor speed.

MODES OF OPERATION

AUTO

In **AUTO**, the Automated Impella® Controller sets the motor speed of the Impella® Catheter to achieve the maximum possible flow without causing suction.

BOOST

If you select **BOOST**, the Automated Impella® Controller maximizes the Impella® 2.5 Catheter flow for 5 minutes. At the end of 5 minutes, the controller returns to the AUTO setting (or P-8 if previously running in P-level mode).

P-LEVEL

In **P-LEVEL** mode you can select one of nine P-levels (P-0 to P-8) for the Impella® Catheter (see Table 5.2). Select the lowest P-level (P-2 or higher) that will enable you to achieve the flow rate necessary for patient support.

Table 5.2 P-level Flow Rates

P-level		*Flow Rate (L/min)	Revolutions Per Minute (rpm)
P-0	Impella® Catheter motor is stopped	0.0	0
P-1	Flow rate increases as the P-level increases	0.0 – 1.1	25,000
P-2		0.8 – 1.5	35,000
P-3		1.1 – 1.7	38,000
P-4		1.3 – 1.8	40,000
P-5		1.5 – 1.9	43,000
P-6		1.7 – 2.1	45,000
P-7		1.8 – 2.2	47,000
P-8	Recommended maximum P-level for continuous use	2.1 – 2.4	50,000
BOOST	Used to confirm stable position after placement; can be used to provide maximum flow for up to 5 minutes. After 5 minutes, the Automated Impella® Controller will automatically default to AUTO or P-8.	2.1 – 2.5	51,000

*Flow rate can vary due to suction or incorrect positioning.

To operate the Impella® Catheter in P-level mode:

1. Press the **FLOW CONTROL** soft button to open the **FLOW CONTROL** menu.
2. Turn the selector knob to increase or decrease the flow rate.
3. Press the selector knob to select the new flow rate.

Figure 5.23 Adjusting P-level

USE OF THE REPOSITIONING SHEATH AND THE PEEL-AWAY INTRODUCER

To prevent failure of the peel-away introducer, remove the peel-away introducer prior to transport when activated clotting time (ACT) is less than 150 seconds.

Be sure that the stopcock on the peel-away introducer or repositioning sheath is always kept in the closed position. Significant bleed back can result if the stopcock is open.

Maintaining ACT

After insertion of the catheter (and until explant), ACT should be maintained at 160 to 180 seconds.

1. Flush the sidearm of the repositioning sheath located on the catheter shaft.
2. **Remove the peel-away introducer completely from the artery** over the catheter shaft to prevent trauma and significant bleeding and apply manual pressure above the puncture site.

3. Grasp the two "wings" and bend back until the valve assembly comes apart. Continue to peel the two wings until the introducer is completely separated from the catheter shaft (see Figure 5.24).
4. Flush the sidearm of the repositioning sheath prior to advancing the sheath.

Figure 5.24 Removing the Peel-Away Introducer

Addition of Heparin to the Purge Solution

As soon as practical after catheter placement, change the purge fluid to include heparin. The recommended heparin concentration is 50 IU/mL in 20% dextrose solution. (Follow the Change Purge Fluid procedure described later in this section to change the purge fluid.)

5. Place a deadend cap on the sidearm of the repositioning sheath to prevent further usage. The sideport should not be used to give medication or draw blood because the blood could potentially clot. Pressure bags should not be connected to the sideport of the repositioning sheath. If a pressure bag is connected, the sideport must have an infusion pump or flow limiting valve in place to control the amount of fluid administered to the patient.
6. Slide the repositioning sheath over the catheter shaft and advance it into the artery to the blue suture pads.
7. Secure the repositioning unit to the patient with the blue suture pads or a StatLock® stabilization device.
8. Evaluate the catheter position in the aortic arch and remove any excess slack. The catheter should align against the lesser curvature of the aorta rather than the greater curvature. Verify placement with fluoroscopy and with the placement signal.
9. Attach the anticontamination sleeve to the blue section of the repositioning sheath. Lock the anchoring ring in place by turning it clockwise. Secure the catheter shaft in place by tightening the connected anchoring ring.
10. Carefully extend the anticontamination sleeve to maximum length and secure the end closest to the red Impella® plug by tightening the anchoring ring.

TRANSFER TO STANDARD CONFIGURATION

Abiomed recommends transitioning from the initial set-up configuration to the standard configuration as soon as practical. The standard configuration ensures that purge solution is delivered through the catheter to prevent blood from entering the motor. After 2 hours of operation, if the system is still in the set-up configuration, a white, advisory alarm notifies the operator to transfer to the standard configuration. Press **MUTE ALARM** to silence the alarm for 30 minutes.

To transfer to the standard configuration, follow these steps.

1. Press **PURGE SYSTEM** and select "Transfer to Standard Configuration" from the menu.
2. Set-up a standard sodium chloride solution with pressure bag (pressurized to 300–350 mmHg) using straight tubing without injection ports.
3. Clamp the red luer on the Y connector from the red pressure sidearm. Disconnect and end cap the red luer.
4. Create a slow drip from the NaCl pressure bag to flood the luer connector of the red pressure sidearm and make a wet-to-wet connection. Fully open the roller clamp. The controller may alarm during this step.
5. Select **OK** to confirm the transfer. You will no longer see the set-up icon on the bottom of the screen. The advisory alarm message will be gray.

Figure 5.25 illustrates the correct configuration of the Impella® System components after transitioning to the standard configuration from the set-up configuration.

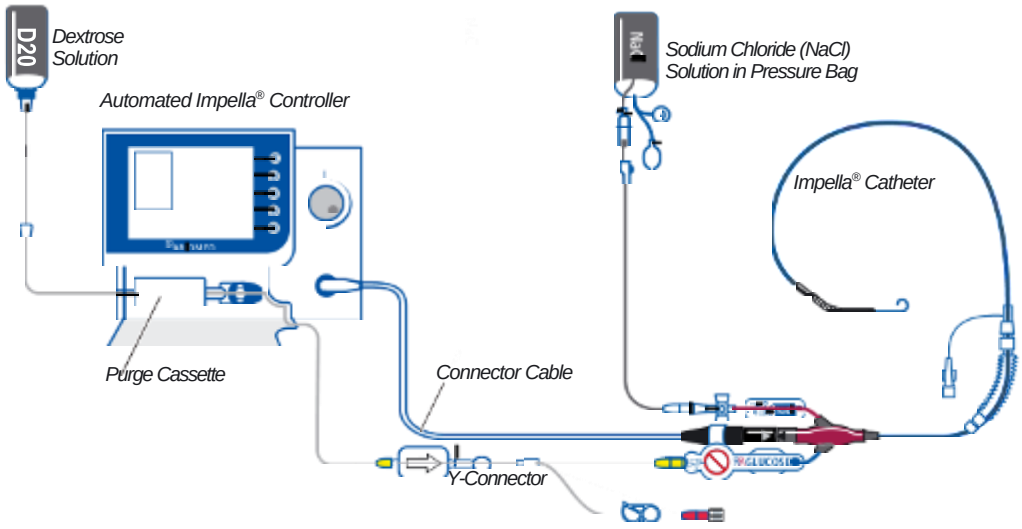


Figure 5.25 Standard Configuration for Impella® System after Transfer from the Set-up Configuration

Purge Pressure

When you transfer to the standard configuration, the purge pressure is no longer regulated at 600 mmHg. In the standard configuration, purge flow can range from 2 to 30 mL/hr and purge pressure can range from 300 to 1100 mmHg.

Handling Precaution

When connecting or disconnecting the red luer on the Y connector, do NOT grasp the white flush valve or apply force. Grasp the luer on both sides beneath the white flush valve while connecting or disconnecting lines from the red pressure sidearm.

Disconnecting the Y Connector

When you switch to the standard configuration, you can simply clamp, disconnect, and cap the red luer on the Y connector (as shown in Figure 5.26) or you can disconnect the Y connector entirely and connect the yellow luer on the purge tubing directly to the yellow check valve on the Impella® Catheter.

PURGE CASSETTE PROCEDURES

Replacement Time

If the purge flow is more than 7 mL/hr or the dextrose concentration is less than 20%, replacement time will be less than 2 minutes. Replacement should always be performed as quickly as possible.

When replacing the purge cassette, the replacement process must be completed within 2 minutes. The Impella® Catheter may be damaged if replacement takes longer than 2 minutes.

There are five procedures for maintaining the Impella® Catheter purge system:

- Change purge system (changing cassette and purge fluid)
- Change purge fluid
- Change purge cassette
- De-air purge system
- Transfer to standard configuration

Each procedure can be accessed using the PURGE SYSTEM soft button. Transferring to the standard configuration was discussed above. The other four purge cassette procedures are discussed below.

CHANGE PURGE SYSTEM

Change of the Purge Cassette should not be required during normal use for temporary support (<6 hours). However, Purge Cassette change out may be required if extended use of the Impella 2.5 and Purge Cassette is required as an unintended consequence of the inability to wean the patient. Follow these steps to change both the purge cassette and purge fluid:

1. Press **PURGE SYSTEM** and select “Change Purge System” from the menu.
2. Open the purge cassette package. If the system is in the standard configuration, disconnect the Y connector from the purge cassette tubing as shown in Figure 5.26.

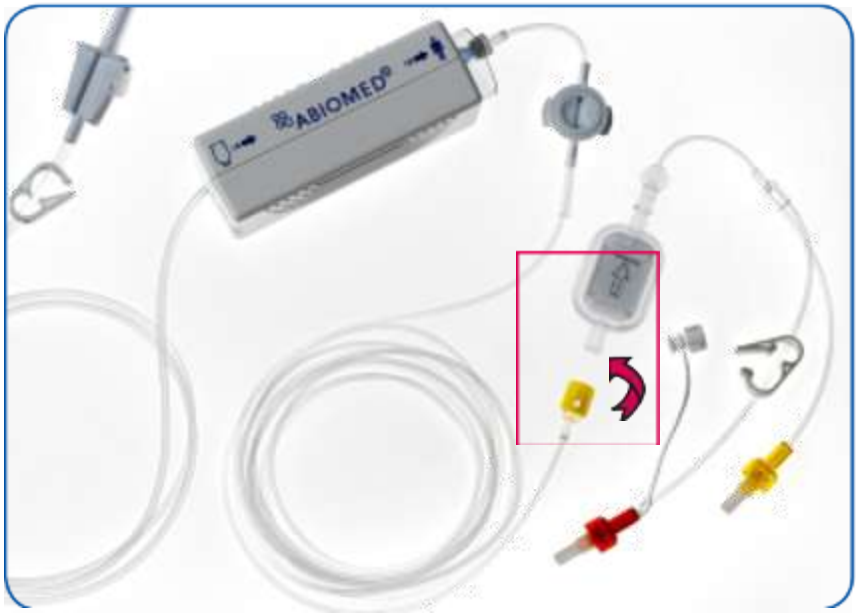


Figure 5.26 Disconnecting the Y Connector from the Purge Cassette Tubing

3. Spike the fluid bag/bottle.
4. Select **OK** to deliver a bolus to the pressure reservoir so that the reservoir can maintain purge pressure during the change. A progress bar shows the progress of the bolus. After the bolus is delivered, the controller automatically proceeds to the next screen.
5. Disconnect the luer(s) from the Impella® Catheter and remove the used purge cassette.
6. Insert the new purge cassette into the controller. Be sure to slide the purge pressure transmitter into place and extend the purge tubing through the gap in the purge cassette door when you close the door.
7. The system automatically primes the purge cassette. A progress bar shows the progress of the priming. Once the priming is complete, you are prompted to connect the purge tubing to the Impella® Catheter.
8. Connect the luer(s) on the end of the purge tubing to the luer(s) on the Impella® Catheter.
9. Purge system change is complete. Enter the purge fluid information and select **OK**.

a. To select the default purge fluid values displayed on the screen, scroll to and select **OK**. This will select those values and automatically advance to the next screen.

b. To change the purge fluid information, scroll to the appropriate item and push the selector knob to select it. Then scroll through the values and push the selector knob to make a new selection. (Refer to "Entering Purge Fluid Data" in the Case Start discussion at the beginning of this section for a listing of purge fluid, dextrose concentration, and heparin concentration options.) The controller will use the default values if no other selections are made.

Connecting the Purge Tubing to the Catheter

If you have NOT switched to the standard configuration, be sure to connect both the red and yellow luers on the Y connector to the Impella® Catheter.

If you have switched to the standard configuration, connect the yellow luer on the purge tubing directly to the yellow check valve on the Impella® Catheter.

CHANGE PURGE FLUID

These are the steps you will follow to change only the purge fluid.

1. Press **PURGE SYSTEM** and select "Change Purge Fluid."
2. Select **OK** to deliver a bolus to the pressure reservoir so that the reservoir can maintain purge pressure during the change. A progress bar shows the progress of the bolus. After the bolus is delivered, the controller automatically proceeds to the next screen.
3. Clamp the supply line before removing the purge fluid bag.
4. Replace the purge fluid bag and unclamp the supply line.
5. Select **OK** to complete bag change and start purge system again.
6. Enter the purge fluid information and select **OK**.

a. To select the default purge fluid values displayed on the screen, scroll to and select **OK**. This will select those values and automatically advance to the next screen.

b. To change the purge fluid information, scroll to the appropriate item and push the selector knob to select it. Then scroll through the values and push the selector knob to make a new selection. (Refer to "Entering Purge Fluid Data" in the Case Start discussion at the beginning of this section for a listing of purge fluid, dextrose concentration, and heparin concentration options.) The controller will use the default values if no other selections are made.

Purge Solution Bottles

If the purge solution is supplied in bottles, open the vent on the purge fluid spike and follow the same procedure as if supplied in bags.

Flushing Purge Cassette Fluid

It may be helpful to flush the fluid from the purge cassette when you are changing dextrose concentration.

7. The next screen asks whether you want to flush the fluid from the purge cassette.
   a. To proceed with the flush, scroll to and select **OK**.
   b. To skip the flush, press **EXIT** to complete the Change Purge Fluid procedure.
8. If you are proceeding to flush the purge fluid from the cassette, select OK to deliver a bolus to the system. A progress bar shows the progress of the bolus. After the bolus is delivered, the controller automatically proceeds to the next screen.
9. Disconnect the luer(s) from the Impella® Catheter and select OK to flush the purge cassette. A progress bar shows the progress of the flush. When complete, the controller proceeds to the next screen.
10. When the purge cassette flush is complete you can connect the luer(s) to the Impella Catheter to complete the procedure or press **BACK** to repeat the flush.

Changing the Purge Cassette

The Change Purge Cassette procedure will only be available if the Automated Impella® Controller detects that the cassette is defective, purge pressure is low, or the purge system is open.

CHANGE PURGE CASSETTE

These are the steps you will follow to replace only the purge cassette.

1. Press **PURGE SYSTEM** and select "Change Purge Cassette."
2. Open the purge cassette package.
3. Disconnect the luer(s) from the Impella® Catheter and remove the used purge cassette.
4. Spike the fluid bag.
5. Insert a new purge cassette into the controller. Be sure to slide the purge pressure transmitter into place and extend the purge tubing through the gap in the purge cassette door when you close the door.
6. The system automatically primes the purge cassette. A progress bar shows the progress of the priming. Once the priming is complete, you are prompted to connect the purge cassette to the Impella® Catheter.
7. Connect the luer(s) on the end of the purge tubing to the luer(s) on the Impella® Catheter.
8. When the purge cassette change is complete, press **OK** to exit.

DE-AIR PURGE SYSTEM

These are the steps you will follow to de-air the purge system.

1. Press **PURGE SYSTEM** and select "De-air Purge System."
2. Make sure that the purge fluid bag is ***NOT*** empty or inverted and that the tubing is ***NOT*** clamped.
3. Disconnect the purge tubing from the Impella® Catheter.
4. Press **OK** to initiate the de-air function. A progress bar shows the progress of the de-air procedure. Once complete, the system advances to the next screen.
5. Confirm that no air remains in the purge tubing. If air remains, press BACK to repeat the air removal process.
6. Connect the purge tubing to the luer(s) on the Impella® Catheter to complete the de-air procedure.

TROUBLESHOOTING THE PURGE SYSTEM

LOW PURGE PRESSURE

If at any time during the course of support with the Impella® Catheter, the Automated Impella® Controller alarms "Purge Pressure Low," follow the instructions below.

1. Inspect the purge system for leaks.
2. If there are no leaks, change to a purge fluid with a higher dextrose concentration. To do this, open the **PURGE SYSTEM** menu and select "Change Purge Fluid." Follow the instructions on the screen. (Refer to "Purge Cassette Procedures" earlier in this section of the manual.)
3. If the pressure stabilizes, no other action is required.
   If the purge pressure is not stable, proceed to Step 4.
4. If the low purge pressure alarm remains unresolved for more than 20 minutes, there may be a problem with the purge cassette. Replace the purge cassette. (Refer to "Change Purge Cassette" instructions earlier in this section.)
5. If the low purge pressure alarm still remains unresolved for more than 20 minutes, this may be a sign of Impella® Catheter damage. Complete the following steps immediately:

a. Open the **FLOW CONTROL** menu and reduce the P-level to P-2.

b. Slowly pull back on the Impella® Catheter until it is in the descending aorta (approximately 20 cm for an average size patient; 1 cm marks are available on the catheter).

c. Turn off the Impella® Catheter by opening the **FLOW CONTROL** menu and reducing the P-level to P-0.

d. Disconnect the catheter from the Automated Impella® Controller.

e. Remove the Impella® Catheter with the use of fluoroscopic imaging. If no fluoroscopy is available, leave the catheter in the descending aorta until fluoroscopy is available for visual assistance during removal of the Impella® Catheter.

Purge Pressure

In the initial set-up configuration, the purge pressure is set to 600 mmHg, although it may not reach 600 mmHg in low resistance catheters in this configuration.

In the standard configuration, optimal purge pressure is different for every Impella® Catheter. Purge pressure can range from 300 mmHg to 1100 mmHg. While purge pressure varies during operation, the Automated Impella® Controller automatically maintains purge pressure within an acceptable range for each Impella® Catheter.

PURGE SYSTEM OPEN

If at any time during the course of support with the Impella® Catheter, the Automated Impella® Controller alarms "Purge System Open," follow the instructions below.

1. Inspect the purge system for leaks.
2. If no leaks are visible, there may be a problem with the purge cassette. Replace the purge cassette. (Refer to instructions earlier in this section of the manual.)
3. If the Purge System Open alarm remains unresolved, this may be a sign of Impella® Catheter damage. Complete the following steps immediately:

a. Open the **FLOW CONTROL** menu and reduce the P-level to P-2.

b. Slowly pull back on the Impella® Catheter until it is in the descending aorta (approximately 20 cm for an average size patient; 1 cm marks are available on the catheter).

c. Turn off the Impella® Catheter by opening the **FLOW CONTROL** menu and reducing the P-level to P-0.

d. Disconnect the catheter from the Automated Impella® Controller.

e. Remove the Impella® Catheter with the use of fluoroscopic imaging. If no fluoroscopy is available, leave the catheter in the descending aorta until fluoroscopy is available for visual assistance during removal of the Impella® Catheter.

Purge System Open Alarm

This alarm may occur if purge pressure is less than 100 mmHg.

Unresolved High Purge Pressure / Purge Flow Low Alarm

If not resolved by the recommendations provided, high purge pressure—which triggers the "Purge Flow Low" alarm message—could be an indication of a kink in the Impella® Catheter. In this case, the motor is no longer being purged and may eventually stop. Clinicians should monitor motor current and consider replacing the Impella® Catheter whenever a rise in motor current is seen.

HIGH PURGE PRESSURE

If the purge pressure exceeds 1100 mmHg, the Automated Impella® Controller displays the "Purge Flow Low" alarm message.

1. Inspect the purge system and check the Impella® Catheter for kinks in the tubing.
2. If pressure remains high, decrease the concentration of dextrose in the purge solution (e.g., change from 20% dextrose to 10% dextrose).

De-air Procedure

You may run the de-air procedure (described earlier in this section) after changing the dextrose concentration to decrease the amount of time it takes for a change to occur.

PURGE SYSTEM BLOCKED

If a "Purge System Blocked" alarm occurs, the purge fluid flow stops.

1. Check the purge system tubing and the Impella® Catheter for kinks or blockages.
2. Decrease the concentration of dextrose in the purge solution.
3. Replace the purge cassette.

PATIENT WEANING

Weaning the patient from the Impella® Catheter is at the discretion of the physician. The Impella 2.5 System has not been approved for > 6 hours of use, however, weaning could be delayed beyond the normal use for temporary support (≤ 6 hours), as an unintended consequence of a post-procedure instability of the patient's hemodynamics. Inability to wean the patient from the device within a reasonably short time frame should result in consideration of a more durable form of left ventricular support.

The following weaning instructions are provided as guidance only.

1. To initiate weaning, press **FLOW CONTROL** and reduce P-level by 2 level increments over time intervals as cardiac function allows.
2. Keep Impella® Catheter P-level at P-2 or above until the catheter is ready to be explanted from the left ventricle.
3. When the patient's hemodynamics are stable, reduce the P-level to P-2 and pull the Impella® Catheter back across the aortic valve into the aorta.
4. If the patient's hemodynamics remain stable, follow instructions in the next section for removing the Impella® Catheter.

REMOVING THE IMPELLA® CATHETER

Remove the Impella® Catheter With Care

Removal of the Impella® Catheter must be completed with care to avoid damage to the catheter assembly.

The Impella® Catheter can be removed after weaning when the introducer is still in place or when the catheter is secured with the repositioning sheath.

REMOVING THE IMPELLA® WITH THE INTRODUCER IN PLACE

1. Wean the patient by following the steps in the previous section for weaning instructions.
2. Once the Impella® Catheter is out of the left ventricle, reduce the P-level to P-0.
3. Remove the Impella® Catheter through the introducer.
4. Wait until ACT drops below 150 seconds.
5. When ACT is below 150 seconds, remove the introducer.
6. Disconnect the connector cable from the Automated Impella® Controller and turn the controller off by pressing the power switch on the side of the controller for 3 seconds.
7. Apply manual compression for 40 minutes or per hospital protocol.

REMOVING THE IMPELLA® SECURED WITH THE REPOSITIONING SHEATH

1. Wean the patient by following the steps in the previous section for weaning instructions.
2. Leave the Impella® Catheter in the ventricle at a P-level of P-2 until ACT drops below 150 seconds

   OR

   Reduce the P-level to P-2, pull the Impella® Catheter into the aorta (approximately 30 to 40 cm), and wait until ACT drops below 150 seconds.
3. When ACT is below 150 seconds, press FLOW CONTROL and reduce the P-level to P-0.
4. Remove the Impella® Catheter and repositioning sheath together (the catheter will not come through the repositioning sheath).
5. Disconnect the connector cable from the Automated Impella® Controller and turn the controller off by pressing the power switch on the side of the controller for 3 seconds.
6. Apply manual compression for 40 minutes or per hospital protocol.

6 CLINICAL EXPERIENCE

The totality of the US human clinical data for the Impella 2.5 System includes an initial safety study (PROTECT I), a multi-center, prospective, randomized controlled clinical trial (PROTECT II) and data from a retrospective registry, USpella, along with a literature review. This section is focused primarily on PROTECT II, conducted in a FDA approved trial. Data from this clinical trial and the other data were the basis for the FDA's approval decision.

Table 6.1 Summary of Primary Clinical Studies Reviewed by the FDA (Prior to Approval)

Clinical Study	Study Design	Objective	Number of Sites	Number of Subjects
PROTECT I	Prospective, multi-center, single arm, study	To examine the safety and feasibility of Impella 2.5 in patients undergoing high risk angioplasty procedures	7	20 patients enrolled and available for 30 day follow up
PROTECT II	Prospective, multi-center, randomized controlled trial	To assess the safety and efficacy of the Impella 2.5 compared to intra-aortic balloon pump when used in subjects undergoing non-emergent high risk PCI	112	452 patients enrolled; 448 patients in Intent-to-Treat population; 427 patients in Per-Protocol population
USpella Registry	Retrospective, multi-center voluntary registry	To examine the safety and effectiveness of the Impella 2.5 when used in routine clinical practice for high risk PCI	49	637 patients in high risk PCI cohort

PROTECT I CLINICAL STUDY

PROTECT I was a prospective, single arm, multi-center feasibility study designed under FDA guidance to examine the safety and feasibility of Impella 2.5 in patients undergoing high risk angioplasty procedures. Patients presenting with a left ventricular ejection fraction (LVEF) ≤35% and scheduled to undergo PCI on an unprotected left main lesion or last patent conduit were considered for enrollment. Safety endpoints included 30 day rate of major cardiac and cerebral events (MACCE) and other vascular, thromboembolic, and hemorrhagic safety endpoints. Efficacy endpoints included hemodynamic benefit and freedom from intra-procedural ischemia driven ventricular fibrillation or tachycardia requiring cardioversion. The study showed an excellent safety profile of the device when used as temporary ventricular support in high risk PCI. The FDA reviewed this data in consideration for approval of the PROTECT II trial based on PROTECT I meeting its primary and secondary endpoints.

PROTECT II PIVOTAL CLINICAL STUDY DESIGN

The main clinical study (PROTECT II) was a prospective, multi-center, randomized, controlled clinical study. The objective of the PROTECT II study was to assess the safety and efficacy of the Impella 2.5 compared to the intra-aortic balloon pump (IABP) when used in subjects undergoing non-emergent high risk PCI. The hypothesis of the study was to demonstrate that prophylactic use of Impella 2.5 was superior to IABP in preventing intra- and post-procedural major adverse events (MAE) in this patient population.

The pre-specified primary endpoint was a composite clinical endpoint of major adverse events (10 component major adverse event [MAE] rate) through 30 days or hospital discharge, whichever was longer, following the PCI procedure. The outcomes were to be compared to the control group treated with an intra-aortic balloon pump (IABP). To assess the durability of potential benefit (i.e., the primary endpoint), the same 10 component MAE rate was also evaluated at 90 days.

The secondary safety endpoints were the same 10 individual components of the composite primary clinical endpoint. Specifically, these were:

- Death
- Stroke/TIA
- Myocardial infarction
- Repeat revascularization
- Need for cardiac operation or thoracic or abdominal vascular operation or vascular operation for limb ischemia
- Acute renal dysfunction
- Cardiopulmonary resuscitation or Ventricular arrhythmia requiring cardioversion
- Increase in aortic insufficiency by more than one grade
- Severe hypotension, defined as: systolic blood pressure or augmented diastolic pressure (whichever is greater) <90 mmHg for ≥5 min requiring inotropic/pressor medications or IV fluid
- Failure to achieve angiographic success defined as residual stenosis <30% after stent implantation.

Follow-up assessments were performed at 30 days or at discharge (whichever was longer), and at 90 days following the PCI procedure.

There were four secondary effectiveness endpoints:

- Maximum cardiac power output (CPO) decrease from baseline. CPO was defined as the product of simultaneously measured cardiac output (CO) and mean arterial pressure (MAP). The hypothesis was that the Impella 2.5 is superior to IABP in preserving hemodynamic status, defined by a lesser degree of CPO decrease during the high risk PCI procedure.
- Creatinine clearance within 24 hours post procedure
- Failure of the Impella 2.5 device to maintain a pump output of > 1.0 L/min for more than five minutes while at a performance level P5 or higher in the Impella patients during the procedure
- Failure of the IABP to augment diastolic pressure above the peak systolic pressure for more than five minutes in the IABP patients.

EXTERNAL EVALUATION GROUPS

The study was sponsored by ABIOMED. The sponsor contracted with Harvard Clinical Research Institute (“HCRI”), an academic research organization to provide study management activities including randomization via Interactive Voice Recognition System (IVRS), site management, site monitoring, data management, statistical analysis, and oversight of safety processes including the Data Safety Management Board (DSMB) and the Clinical Events Committee (CEC).

The study included two independent Core Labs: Beth Israel Deaconess Medical Center Angiographic Core Laboratory, Boston M.A. for angiographic analyses and Duke Clinical Research Institute, Durham N.C. for echocardiographic analyses. The study protocol was approved by the sponsor, HCRI and the FDA. The protocol pre-specified an interim analysis with stopping rules and a Statistical Analysis Plan (SAP).

PRE-SPECIFIED STATISTICAL ANALYSIS PLAN

The pre-specified study hypothesis was that the Impella 2.5 would be superior to IABP in reducing the composite rate of intra- and post-procedural major adverse events (MAEs) at 30 days or hospital discharge, whichever is longer post index procedure.

The IABP was the *only* 510k cleared FDA device for cardiac support for high risk PCI indication. Therefore, the IABP was chosen as the control device for PROTECT II.

The protocol stipulated that the detailed classification and description of the subgroup variables would be defined in the SAP. The following 4 subgroups were pre-specified in the SAP:

- Assessment of any potential learning curve effect: Evaluate the primary endpoint with and without the first Impella case at each site in order to assess the impact of the learning curve for the protocol and for use of the device.
- Assessment of the primary endpoint for procedural characteristics or adjunctive therapies not equivalent between the two arms (i.e., rotational atherectomy).
- Assessment of the primary endpoint stratified by angioplasty indication (last remaining vessel/left main vs. triple vessel disease).
- Assessment of the primary endpoint stratified by the severity of the patient using the STS mortality risk score.

CLINICAL INCLUSION AND EXCLUSION CRITERIA

Patients enrolled in PROTECT II were considered at high risk for hemodynamic instability during non-emergent percutaneous coronary intervention due to a combination of depressed left ejection fraction and complex coronary lesions and deemed to require prophylactic hemodynamic support by the treating physician. Patients were required to meet all inclusion criteria and none of the exclusion criteria in order to be enrolled in PROTECT II.

Inclusion Criteria

1. Signed Informed Consent
2. Subject is indicated for a non-emergent percutaneous treatment of at least one *de novo* or restenotic lesion in a native coronary vessel or bypass graft
3. Age eligible (18 ≤ Age ≤ 90)
4. Subject presents with:
    a) Ejection Fraction ≤ 35% AND at least one of the following criteria:
        - Intervention on the last patent coronary conduit, or
        - Intervention on an unprotected left main coronary artery

        Or
    b) Ejection Fraction ≤ 30% and intervention in patient presenting with triple vessel disease.

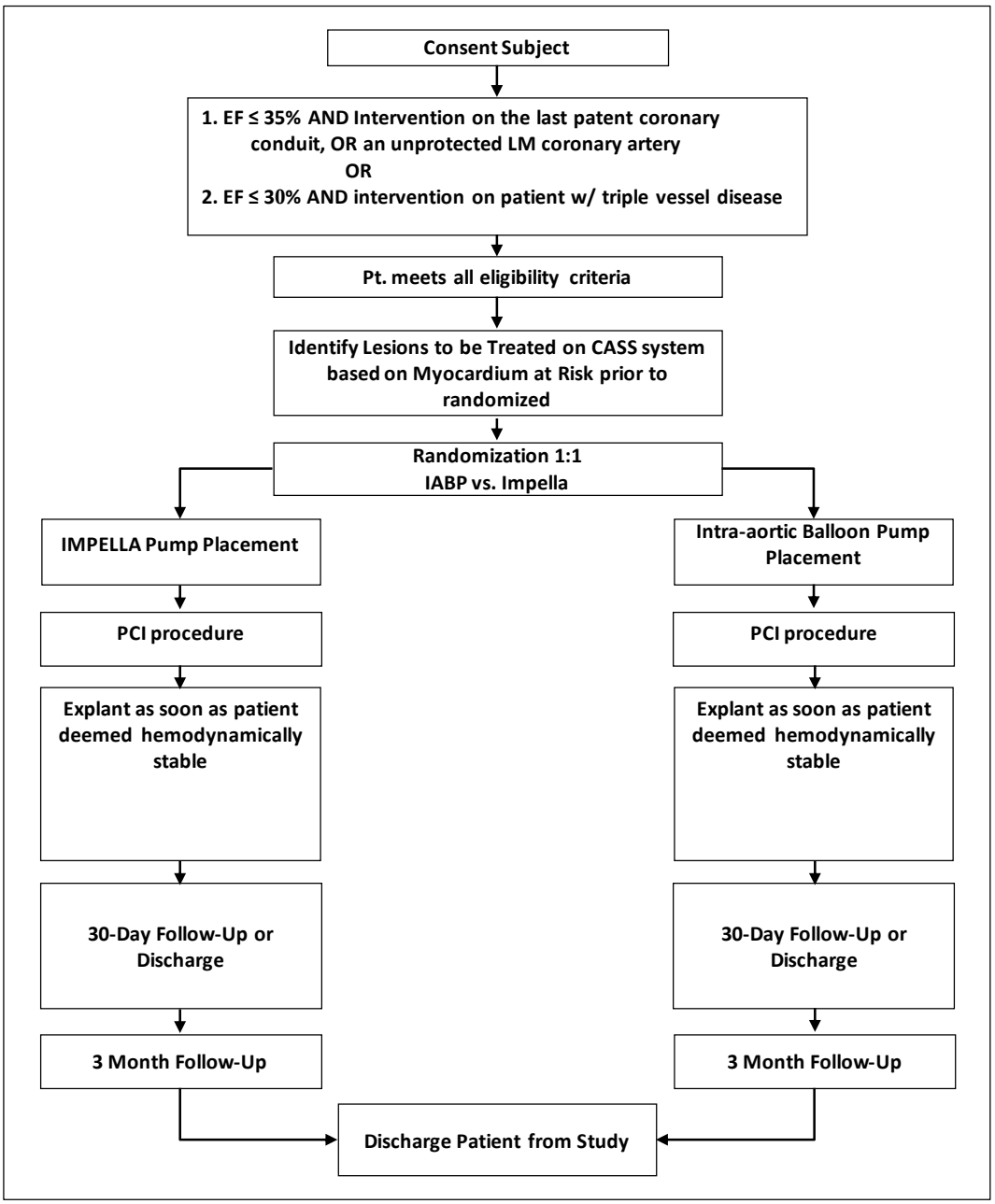
    Three-vessel or triple vessel disease was defined as at least one significant stenosis (i.e. ≥ 50% stenosis by diameter) in all three major epicardial territories: left anterior descending artery (LAD) and/or side branch, left circumflex artery (LCX) and/or side branch, and right coronary artery (RCA) and/or side branch. In the case of left coronary artery dominance, a lesion in the LAD and the proximal LCX qualified as three-vessel disease.

Exclusion Criteria

1. ST Myocardial Infarction within 24 hours or CK-MB that have not normalized
2. Pre-procedure cardiac arrest within 24 hours of enrolment requiring CPR
3. Subject is in cardiogenic shock defined as:
    - CI < 2.2 l/min/m2 and PCWP > 15 mmHg
    - Hypotension (systolic BP < 90 mmHg for >30 minutes or the need for supportive measures to maintain a systolic BP of greater than or equal to 90 mmHg) AND end organ hypoperfusion (cool extremities OR [a urine output of < 30 ml/hour AND a HR > 60 BPM])
4. Mural thrombus in the left ventricle
5. The presence of a mechanical aortic valve or heart constrictive device
6. Documented presence of aortic stenosis (aortic stenosis graded as ≥ +2 equivalent to an orifice area of 1.5cm^2 or less)
7. Documented presence of moderate to severe aortic insufficiency (echocardiographic assessment of aortic insufficiency graded as ≥ +2)
8. Severe peripheral arterial obstructive disease that would preclude the placement of the IMPELLA® System or IABP device placement
9. Abnormalities of the aorta that would preclude surgery, including aneurysms and extreme tortuosity or calcifications
10. Subject with renal failure (creatinine ≥ 4mg/dL)
11. Subject has history of debilitating liver dysfunction with elevation of liver enzymes and bilirubin levels to ≥ 3x ULN or Internationalized Normalized Ratio (INR) ≥ 2
12. Subject has uncorrectable abnormal coagulation parameters (defined as platelet count ≤75,000/mm3 or INR ≥2.0 or Fibrinogen ≤ 1.50 g/l.)
13. History of recent (within 1 month) stroke or TIA
14. Allergy or intolerance to heparin, aspirin, ADP receptor inhibitors (clopidogrel and ticlid) or contrast media
15. Subject with documented heparin induced thrombocytopenia
16. Participation in the active follow-up phase of another clinical study of an investigational drug or device

The study design is illustrated in Figure 6.1.

Figure 6.1 PROTECT II Study Schematic



ACCOUNTABILITY OF PROTECT II COHORT

A total of 452 subjects were enrolled into the trial: 226 subjects enrolled in the Impella arm and 226 subjects enrolled in the IABP arm. This number represents 69% of the original planned enrollment (654 subjects). The PROTECT II trial was stopped prematurely by the company due to the Data Safety and Monitoring Board (DSMB) recommendation for futility after completing its pre-specified interim analysis at 50% enrollment for each group. More details are below.

INTENT-TO-TREAT POPULATION

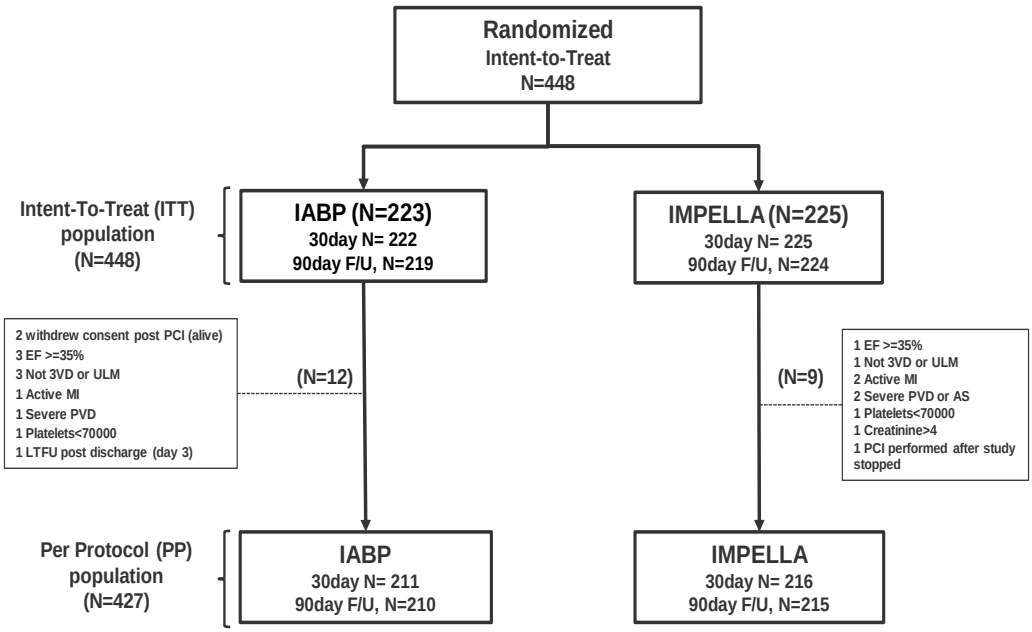
Out of the 452 patients enrolled into the study, three subjects (all in IABP arm) withdrew consent before PCI and device insertion. One patient expired in the Impella arm prior to undergoing PCI treatment and device insertion. Thus, the primary analysis includes 448 Intent-to-Treat (ITT) patients randomized to either Impella 2.5 (n=225) or IABP (n=223), regardless of whether or not they received the device and the duration of follow-up.

PER-PROTOCOL ANALYSIS POPULATION

Prior to accessing the data, the monitoring of the patient eligibility criteria by HCRI identified a total of twenty-one (21) subjects who did not meet the study inclusion or exclusion criteria. These cases were to be excluded from the ITT. The remainder formed the Per-Protocol (PP) population. Nine of the subjects excluded from the ITT population were in the Impella arm and twelve subjects excluded from the ITT population were in the IABP arm. The PP analysis population consists then of 427 subjects, of which 216 subjects were randomized to the Impella arm and 211 subjects were randomized to the IABP arm.

The study flow is represented in Figure 6.2 below, showing the ITT and PP populations and the sample sizes of each population at 30 day and 90 day follow-up.

Figure 6.2 Study Flow Schematic



LIMITATIONS OF INTERPRETATION OF STUDY RESULTS

Fifty percent (50%) enrollment was achieved on February 26, 2010 with the enrollment of the 327th subject. This subject completed the study (3 month visit) on May 27, 2010. Approximately 7 months later, HCRI completed the study activities necessary to lock the database for the interim analysis and prepare an interim analysis report for the DSMB. In these 7 months of intervening time, 125 additional subjects were enrolled into the study (n=452). The results from the additional patients were excluded from the interim analysis.

The DSMB met on November 22, 2010 and recommended that the trial be halted due to a futility determination based on the pre-specified primary endpoint (composite MAE at 30 days), which was calculated on the first 327 patients enrolled in the study. The DSMB also expressed concern regarding safety trends identified in 3 of the pre-specified patient cohorts:

1) Patients receiving rotational atherectomy;
2) Patients undergoing PCI on an unprotected left main/last patent conduit; and
3) Patients judged to be in the highest risk based on STS score

The study was formally ended on December 6, 2010, at which time the data were then unlocked.

STUDY POPULATION DEMOGRAPHICS AND BASELINE CHARACTERISTICS

Patient baseline characteristics for all enrolled patients (ITT N=448, 69% of planned cohort) are summarized in Table 6.2 below. Overall, patients had depressed ventricular function, multi-vessel disease (76% of patients), unprotected left main disease (24% of patients), and at least one of the following additional risk factors: advanced age, female, diabetes, peripheral vascular disease, history of angina, heart failure or complex lesion anatomy (type B or C lesions).

Two thirds of the patients were deemed inoperable. Subjects presented with an average LVEF of 24%±6%, a Syntax score of 30±13, an STS mortality score of 6%±6% and an STS combined mortality and morbidity score of 30%±15%. Only one third of this population had received implantable defibrillators despite the low LVEF.

Of note, Impella patients presented more frequently with chronic heart failure (91.1% vs. 83.4%,) and had more often prior CABG (38.2% vs. 28.7%,) compared to IABP patients, respectively.

Table 6.2 Patient Baseline Characteristics (ITT Population)

	All Patients (n=448)	Impella Patients (n=225)	IABP Patients (n=223)
Age Mean±SD (N) Range (Min,Max)	67.3±10.8 (448) (37,90)	67.7±10.8 (225) (40,90)	67.0±10.7 (223) (37,90)
Gender - Male	80.4% (360/448)	79.6% (179/225)	81.2% (181/223)
Ethnicity and Race			
Hispanic/Latino	7.6% (34/448)	8.4% (19/225)	6.7% (15/223)
American Indian	0.4% (2/448)	0.9% (2/225)	0.0% (0/223)
Asian	2.7% (12/448)	1.3% (3/225)	4.0% (9/223)
African American	13.4% (60/448)	10.7% (24/225)	16.1% (36/223)
Hawaiian; Pacific Islander	0.7% (3/448)	0.4% (1/225)	0.9% (2/223)
Caucasian	78.8% (353/448)	83.1% (187/225)	74.4% (166/223)
Other	4.0% (18/448)	3.6% (8/225)	4.5% (10/223)
Weight (lbs) Mean±SD (N) Range (Min,Max)	183.8±44.1 (448) (99.0,417.0)	183.2±41.3 (225) (100.0,320.0)	184.3±46.7 (223) (99.0,417.0)
Height (in) Mean±SD (N) Range (Min,Max)	67.7±3.7 (448) (58.0,78.0)	67.8±3.7 (225) (59.0,76.2)	67.6±3.7 (223) (58.0,78.0)
Cardiac History			
CAD in a first degree relative	58.7% (237/404)	59.5% (119/200)	57.8% (118/204)
Prior Myocardial Infarction	67.6% (302/447)	69.2% (155/224)	65.9% (147/223)
History of Angina	66.3% (295/445)	69.5% (155/223)	63.1% (140/222)
CHF	87.3% (391/448)	91.1% (205/225)	83.4% (186/223)
NYHA Class III or IV	66.1% (222/336)	67.4% (120/178)	64.6% (102/158)
Pacemaker/AICD	32.9% (147/447)	34.7% (78/225)	31.1% (69/222)
Cardiomyopathy	69.2% (310/448)	69.3% (156/225)	69.1% (154/223)
Arrhythmia	48.9% (218/446)	50.9% (114/224)	46.8% (104/222)
Prior Cardiac Procedures			
Thrombolytic Therapy	5.7% (25/442)	4.9% (11/223)	6.4% (14/219)
PCI	39.2% (175/446)	41.5% (93/224)	36.9% (82/222)
CABG	33.5% (150/448)	38.2% (86/225)	28.7% (64/223)
Valve Surgery	3.3% (15/448)	3.1% (7/225)	3.6% (8/223)
Other Cardiac Surgery	7.2% (32/446)	6.3% (14/224)	8.1% (18/222)
Other Cardiac Intervention	14.8% (66/446)	14.3% (32/224)	15.3% (34/222)
CABG Evaluation: Subject was evaluated for CABG as treatment	64.1% (287/448)	63.6% (143/225)	64.6% (144/223)

The reason for not performing a CABG:			
Subject refused surgery	19.2% (55/287)	22.4% (32/143)	16.0% (23/144)
Subject not a candidate for CABG based on medical condition	80.8% (232/287)	77.6% (111/143)	84.0% (121/144)
Other Medical History			
Peripheral Vascular Disease	26.1% (116/445)	25.7% (57/222)	26.5% (59/223)
Prior Stroke	14.7% (66/448)	12.9% (29/225)	16.6% (37/223)
Diabetes Mellitus	51.3% (230/448)	52.0% (117/225)	50.7% (113/223)
Hypertension	86.4% (387/448)	87.6% (197/225)	85.2% (190/223)
COPD	27.6% (123/445)	25.9% (58/224)	29.4% (65/221)
Renal Insufficiency	26.6% (119/447)	23.1% (52/225)	30.2% (67/222)
History of Tobacco Use	69.6% (307/441)	71.5% (158/221)	67.7% (149/220)
LVEF			
Mean±SD (N) Range (Min,Max)	23.79±6.32 (445) (10.00,35.00)	23.45±6.31 (224) (10.00,35.00)	24.14±6.33 (221) (10.00,35.00)
Mean±SD (N) Range (Min,Max) Median (IQ Range)	30.32±13.13 (144) (5.00,68.50) 30.50 (19.75 - 38.25)	29.31±13.50 (157) (3.00,85.50) 28.00 (19.00 - 36.50)	29.79±13.31 (301) (3.00,85.50) 29.00 (19.50 - 37.50)
STS Mortality Score			
Mean±SD (N) Range (Min,Max)	5.93±6.48 (448) (0.40,60.00)	5.86±5.98 (225) (0.40,41.20)	6.01±6.97 (223) (0.40,60.00)
STS Mortality and Morbidity Score			
Mean±SD (N) Range (Min,Max)	29.52±15.34 (448) (1.60,74.70)	28.80±14.97 (225) (1.60,74.50)	30.24±15.71 (223) (6.90,74.70)
Logistic EuroScore			
Mean±SD (N) Range (Min,Max)	18.39±17.44 (448) (0.82,94.53)	18.76±17.41 (225) (0.82,94.53)	18.03±17.49 (223) (1.33,91.15)

PROCEDURAL CHARACTERISTICS

In both study arms, more lesions were attempted than originally anticipated, as 27% of all patients had a lesion treated that was not identified as a target lesion in the pre-PCI revascularization treatment plan. The number of attempted lesions and deployed stents were similar between the two groups (Table 6.3).

Differences were observed between the two study arms with respect to the use of adjunctive therapies. In the Impella 2.5 arm, glycoprotein IIb/IIIa receptor antagonists were used less frequently, in 13.8% of Impella patients vs. 26% of IABP patients. Rotational atherectomy was used more frequently in Impella patients (14%) vs. IABP patients (9%). The use of rotational atherectomy was also more vigorous in the Impella arm with more runs per patient (p=0.003), more passes per lesion (p=0.001), longer treatment durations (p=0.004) and more frequently performed in unprotected left main lesions. More stents were deployed in the Impella arms compared to the IABP in patients that had atherectomy. Finally, the volume of contrast used was significantly greater in the Impella 2.5 arm. Patients randomized to IABP had longer duration of support compared with those on Impella 2.5 (8.4 hours vs. 1.9 hours). Instructions in the protocol called for device support to be discontinued after the PCI procedure if the patient was determined to be hemodynamically stable. In total, 36.7% of patients in the IABP arm required additional support post-PCI and were discharged from the catheterization laboratory (Cath Lab) on IABP support compared to 5.9% of patients in the Impella arm, who were discharged from the Cath Lab on Impella support.

Table 6.3 Procedural Characteristics

	All Patients (n=448)	Impella Patients (n=225)	IABP Patients (n=223)
Lesion and Rotational Atherectomy Characteristic			
Number of lesions treated			
Mean±SD (N) Range (Min,Max)	2.88±1.48 (448) (1.00,8.00)	2.86±1.43 (225) (1.00,8.00)	2.90±1.53 (223) (1.00,8.00)
% Patients with at least one lesion treated that was not a target lesion for the procedure			
Percent	26.7% (119/446)	27.7% (62/224)	25.7% (57/222)
Number of stents placed			
Mean±SD (N) Range (Min,Max)	3.01±1.83 (444) (0.00,12.00)	3.07±1.77 (222) (0.00,10.00)	2.94±1.90 (222) (0.00,12.00)
Total of longest duration of coronary balloon inflation (second)			
Mean±SD (N) Range (Min,Max)	58.23±93.67 (399) (0.00,1500.00)	63.86±125.69 (200) (0.00,1500.00)	52.58±41.17 (199) (0.00,252.00)
% Patients with chronic total occlusion (CTO) lesions treated			
Percent	9.6% (43/448)	9.3% (21/225)	9.9% (22/223)
Use of atherectomy rotablation during index procedure			
Percent	11.6% (52/448)	14.2% (32/225)	9.0% (20/223)
Total number of passes when atherectomy was used			
Median (IQ Range)	4.00 (2.00 - 8.00)	5.00 (3.50 - 9.50)	2.00 (2.00 - 4.00)

	All Patients (n=448)	Impella Patients (n=225)	IABP Patients (n=223)
Average number of passes per lesion when atherectomy was used			
Median (IQ Range)	2 (1 - 4)	3 (2 - 5)	1 (1 - 2)
Average duration/run time per lesion when atherectomy was used (second)			
Median (IQ Range)	47.50 (32.50 - 85.00)	60.00 (40.00 - 118.00)	40.00 (20.00 - 47.00)
Average number of stent placed when atherectomy was used			
Mean±SD (N)		3.44±1.61 (32) (1.00 – 8.0)	2.50±1.40 (20) (0.0 – 6.0)
Procedural Characteristics			
Volume for contrast administered during the index procedure (c.c.)			
Mean±SD (N) Range (Min,Max)	253.86±129.26 (443) (40.00,970.00)	266.73±141.80 (222) (40.00,970.00)	240.94±114.17 (221) (50.00,700.00)
Duration of device support (hour)			
Mean±SD (N) Range (Min,Max)	5.12±15.81 (439) (0.20,199.32)	1.87±2.69 (221) (0.28,26.38)	8.41±21.81 (218) (0.20,199.32)
Device support continued more than 3 hours post index procedure			
Percent	16.6% (73/440)	4.5% (10/221)	28.8% (63/219)
Patients discharged from Cath Lab on device support			
Percent	21.2% (93/438)	5.9% (13/220)	36.7% (80/218)
IV Fluid Volume subject received during procedure (cc)			
Mean±SD (N) Range (Min,Max)	486.10±518.26 (338) (0,5000)	555.65±623.07 (168) (0,5000)	417.38±377.38 (170) (0,2250)
Heparin administered during procedure			
Percent	88.4% (395/447)	93.3% (210/225)	83.3% (185/222)
IIb/IIIa Inhibitors used at baseline			
Percent	19.9% (89/448)	13.8% (31/225)	26.0% (58/223)
Periprocedural transfusion required			
Percent	2.7% (12/447)	3.6% (8/224)	1.8% (4/223)
Number of units transfused during the procedure or at pump removal combined			
Mean±SD (N) Range (Min,Max)	2.42±1.44 (12) (1.00,5.00)	2.25±1.49 (8) (1.00,5.00)	2.75±1.50 (4) (2.00,5.00)
Impella Pump flow during procedure (L/min)			
Mean±SD (N) Range (Min,Max)	1.90±0.27 (217) (1.10,2.50)	1.90±0.27 (217) (1.10,2.50)	N/A

SAFETY AND EFFECTIVENESS RESULTS

As discussed above, the pre-specified primary endpoint for the PROTECT II study was a 30-day composite MAE rate (10 components), where the study hypothesis was to demonstrate that prophylactic use of Impella 2.5 was superior to IABP in preventing intra- and post-procedural MAEs in this patient population. A pre-specified interim look by the Data Safety Monitoring Board (DSMB) at 50% enrollment (327 patients) concluded in a recommendation for early discontinuation of the study for futility as the *"Board found no statistically significant differences in major adverse events"* between the Impella and IABP arms, with some identified safety concerns as well.

ABIOMED formally terminated the study on December 6, 2010, at which point they unlocked all of the data (n=452) and performed additional analyses on the total cohort of patients enrolled into the PROTECT II study and available for analysis (n=448; 225 Impella subjects and 223 IABP subjects). These analyses concluded the following:

1. There was an imbalance between the two groups in the use of rotational atherectomy - more frequent and more vigorous in the Impella arm as compared to IABP.
2. The analysis of the data available for the 448 patient cohort (69% of planned enrollment) did not appear consistent with the futility statements made by the DSMB which were based on a review of 327 patients (50% enrollment).
3. Some of the negative trends in outcomes for the Impella arm observed at interim appear to be attenuated when the totality of the data was reviewed.
4. Contrary to the interim assumption, the analysis that includes the full patient cohort suggests that Impella 2.5 outcomes improved over the course of the trial (i.e., from 30-day follow-up to 90-day follow-up), while the outcomes for the IABP arm appear to remain about the same between the two follow-up periods.

These findings, in addition to the possibility that a learning curve was present and may have skewed the results of early interventions, led FDA to consider the possibility that the treatment effect may simply not have been realized in this terminated study. As such, the FDA review of PMA P140003 included the totality of all data available (descriptive only) for the Impella 2.5 System (when used in HRPCI patients) in its evaluation of the safety and effectiveness of the Impella 2.5 System when used as intended. The primary data set utilized for this evaluation came from the 452 patients enrolled into the PROTECT II study (30-day and 90-day data), as well as supporting/supplemental evidence from the literature and data from the USpella Registry.

The 10 component composite MAE rate (summarized in Table 6.4a and 6.4b) showed a numerical difference at 30 days in both the ITT and PP populations at 69% of the planned enrollment in favor of Impella. The numerical difference in MAE rates between the two groups, increases at 90 days for the PP population (the longest study follow-up).

INTENT-TO-TREAT POPULATION

At 69% of the planned enrollment, the 30 day MAE rate was 35.1% in the Impella arm compared to 40.1% in the IABP arm (Table 6.4a and Figure 6.3). The 90 day MAE rate showed trends in favor of Impella (40.6% vs. 49.3%, Table 6.4a, see Figure 6.3a).

PER PROTOCOL POPULATION

At 69% enrollment, 30 day MAE rate was 34.3% in the Impella arm compared to 42.2% in the IABP arm. Compared with IABP, the 90 day MAE rate was lower in the Impella arm (40.0% vs. 51.0%) yielding a relative risk reduction of 22% (Table 6.4b6.3b). The Kaplan-Meier analysis (Figure 6.3b) and the log-rank test through 90 days supports this result.

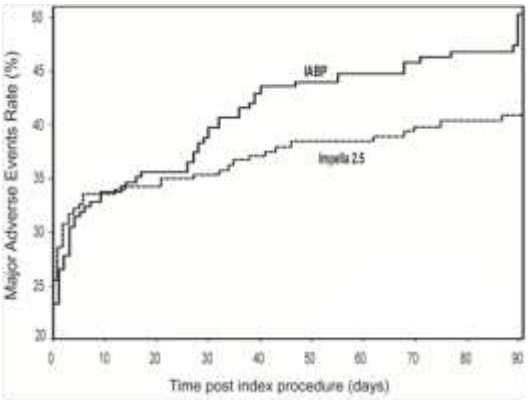
Table 6.4a Composite MAE at 30 Days and 90 Days (Intent-to-Treat Population)

Composite MAE (ITT Population)	Impella Patients	IABP Patients	Difference	Relative Reduction or Increase
30 days or Discharge	35.1% (79/225)	40.1% (89/222)	**- 5.0%**	**- 12.5%**
90 Day Follow-up	40.6% (91/224)	49.3% (108/219)	**- 8.7%**	**- 17.6%**

Table 6.4b Composite MAE at 30 Days and 90 Days (Per-Protocol Population)

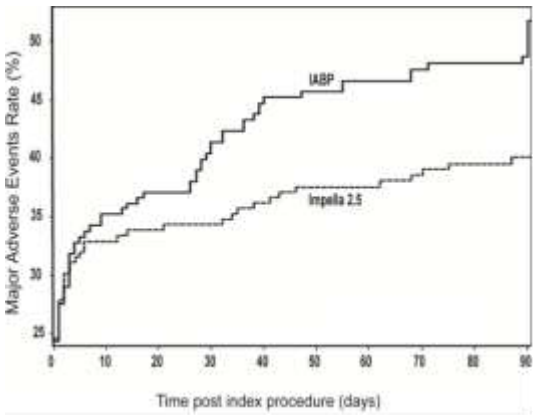
Composite MAE (PP Population)	Impella Patients	IABP Patients	Difference	Relative Reduction or Increase
30 days or Discharge	34.3% (74/216)	42.2% (89/211)	- 7.9%	- 18.7%
90 Day Follow-up	40.0% (86/215)	51.0% (107/210)	- 11.0%	- 21.6%

Figure 6.3a Kaplan-Meier Curves for Major Adverse Events (Intent-to-Treat Population)



ITT	Time after Initial Procedure (days)			
	0	30	60	90
Impella Patients At Risk	225	168	145	120
IABP Patients At Risk	223	171	133	107

Figure 6.3b Kaplan-Meier Curves for Major Adverse Events (Per-Protocol Population)



PP	Time after Initial Procedure (days)			
	0	30	60	90
Impella Patients At Risk	216	163	141	116
IABP Patients At Risk	211	160	124	99

PRE-SPECIFIED SUBGROUP ANALYSES ON THE PRIMARY ENDPOINT

Learning curve

The results of the pre-specified analysis without the Impella roll-in subject suggested the presence of a learning curve in the trial. Patients in the Impella arm, with the first subject excluded, had fewer MAEs at 30 days compared to the 30 day rate that was observed for all Impella patients (Tables 6.4a and 6.4b). This had the effect of enlarging the observed differences in MAE rates at 30 and 90 days when comparing the adjusted Impella cohort to IABP (Tables 6.5a and 6.5b).

Table 6.5a Subgroup Without Impella Roll-In Subject (Intent-to-Treat Population)

Subgroup Analysis – Without Impella Roll-In Subject (ITT)	Impella Patients (n=167)	IABP Patients (n=223)	Difference	Relative Reduction or Increase
30 days or Discharge	31.7%	40.1%	- 8.4%	- 20.9%
90 Day Follow-up	38.0%	49.3%	- 11.3%	- 22.9%

Table 6.5b Subgroup Without Impella Roll-In Subject (Per-Protocol Population)

Subgroup Analysis – Without Impella Roll-In Subject (PP)	Impella Patients (n=162)	IABP Patients (n=211)	Difference	Relative Reduction or Increase
30 days or Discharge	32.1%	42.2%	- 10.1%	- 23.9%
90 Day Follow-up	38.5%	51.0%	- 12.5%	- 24.5%

Atherectomy/Non-atherectomy

Atherectomy was not used as a part of the PCI procedure in 88% of the enrolled patients. In this subgroup, a relative reduction of MAE risk for ITT patients at 30 days favoring Impella 2.5 that was similar in magnitude to the reduction observed when the first Impella patient was removed was observed at 30 days. Relative reductions in the MAE rate for PP treated patients were observed at 30 and 90 days (Tables 6.6a and 6.6b).

Table 6.6a Subgroup Without Rotational Atherectomy (Intent-to-Treat Population)

Subgroup Analysis – No Rotational Atherectomy (ITT)	Impella Patients (n=193)	IABP Patients (n=203)	Difference	Relative Reduction or Increase
30 days or Discharge	30.6%	39.6%	- 9.0%	- 22.7%
90 Day Follow-up	38.5%	48.7%	- 10.2%	- 20.9%

Table 6.6b Subgroup Without Rotational Atherectomy (Per-Protocol Population)

Subgroup Analysis – No Rotational Atherectomy (PP)	Impella Patients (n=184)	IABP Patients (n=191)	Difference	Relative Reduction or Increase
30 days or Discharge	29.3%	41.9%	- 12.6%	- 30.1%
90 Day Follow-up	35.5%	50.5%	- 15.0%	- 29.7%

An analysis of the composite MAE for the subjects treated with rotational atherectomy is summarized in Tables 6.7a (ITT Population) and 6.7b (PP Population). This was a small subgroup consisting of 32

Impella subjects and 20 IABP subjects in the ITT and PP groups. There was a numerically higher observed rate of MAE in Impella subjects compared to IABP treated with rotational atherectomy for both the ITT and PP populations.

Table 6.7a Subgroup with Rotational Atherectomy (Intent-to-Treat Population)

Subgroup Analysis – With Rotational Atherectomy (ITT)	Impella Patients (n=32)	IABP Patients (n=20)	Difference	Relative Reduction or Increase
30 days or Discharge	62.5%	45.0%	+ 17.5%	+ 38.9%
90 Day Follow-up	65.6%	55.0%	+ 10.6%	+ 19.3%

Table 6.7b Subgroup with Rotational Atherectomy (Per-Protocol Population)

Subgroup Analysis – With Rotational Atherectomy (PP)	Impella Patients (n=32)	IABP Patients (n=20)	Difference	Relative Reduction or Increase
30 days or Discharge	62.5%	45.0%	+ 17.5%	+ 38.9%
90 Day Follow-up	65.6%	55.0%	+ 10.6%	+ 19.3%

Angioplasty Indication

An analysis of the composite MAE for the subgroup whose indication for angioplasty was unprotected left main or last patent coronary conduit (24% of the entire PROTECT II cohort) is summarized in Tables 6.8a and 6.8b (ITT and PP Populations respectively).

The composite MAE rate was similar between the study arms at 30 days in the ITT group (41.5% for Impella vs. 40.7% for IABP). There were numerically fewer MAEs in the Impella arm compared to the IABP arm in the ITT population (44.2% vs. 50.0%) and PP population (41.7% vs. 50.9%) at 90 days.

Table 6.8a Subgroup of Unprotected Left Main/Last Patent Conduit (Intent-to-Treat Population)

Subgroup Analysis – Unprotected Left Main (ITT)	Impella Patients (n=53)	IABP Patients (n=54)	Difference	Relative Reduction or Increase
30 days or Discharge	41.5%	40.7%	+0.8%	+2.0%
90 Day Follow-up	44.2%	50.0%	- 5.8%	- 11.6%

Table 6.8b Subgroup of Unprotected Left Main/Last Patent Conduit (Per-Protocol Population)

Subgroup Analysis – Unprotected Left Main (PP)	Impella Patients (n=49)	IABP Patients (n=53)	Difference	Relative Reduction or Increase
30 days or Discharge	38.8%	41.5%	- 2.7%	- 6.5%
90 Day Follow-up	41.7%	50.9%	- 9.2%	- 18%

An analysis of the composite MAE for the subgroup whose indication for angioplasty was three-vessel disease is summarized in Tables 6.9a (ITT Population) and 6.9b (PP Population). The observed composite MAE rate was numerically lower for Impella vs. IABP at 30 and 90 days in the ITT group. In the Per-Protocol population, a trend in favor of Impella was observed at 90 days (39.5% MAE for Impella vs. 51.0% MAE for IABP).

Table 6.9a Subgroup of Three Vessel Disease (Intent-to-Treat Population)

Subgroup Analysis – Three Vessel Disease (ITT)	Impella Patients (n=169)	IABP Patients (n=172)	Difference	Relative Reduction or Increase
30 days or Discharge	33.1%	39.9%	- 6.8%	- 17.0%
90 Day Follow-up	39.5%	49.1%	- 9.6%	- 19.6%

Table 6.9b Subgroup of Three Vessel Disease (Per-Protocol Population)

Subgroup Analysis – Three Vessel Disease (PP)	Impella Patients (n=158)	IABP Patients (n=167)	Difference	Relative Reduction or Increase
30 days or Discharge	32.9%	42.4%	- 9.5%	- 22.4%
90 Day Follow-up	39.5%	51.0%	- 11.5%	- 22.5%

Outcomes as a function of morbidity: STS mortality score

An analysis of the composite MAE for the subgroup with STS mortality scores < 10 is summarized in Tables 6.10a (ITT Population) and 6.10b (PP Population). The composite MAE rate in the ITT group is numerically lower for Impella vs. IABP at 30 days (33.2% for Impella vs. 38.7% for IABP) and at 90 days (37.4% for Impella vs. 48.6% for IABP). In the PP population, there was a numerical trend favoring Impella at 90 days (36.1% MAE for Impella vs. 50.6% MAE for IABP).

Table 6.10a Subgroup of STS Mortality Score < 10 (Intent-to-Treat Population)

Subgroup Analysis – STS Mortality Score < 10 (ITT)	Impella Patients (n=187)	IABP Patients (n=187)	Difference	Relative Reduction or Increase
30 days or Discharge	33.2%	38.7%	- 5.5%	- 14.2%
90 Day Follow-up	37.4%	48.6%	- 11.2%	- 23.0%

Table 6.10b Subgroup of STS Mortality Score < 10 (Per-Protocol Population)

Subgroup Analysis – STS Mortality Score < 10 (PP)	Impella Patients (n=180)	IABP Patients (n=175)	Difference	Relative Reduction or Increase
30 days or Discharge	31.7%	41.1%	- 9.4%	- 22.9%
90 Day Follow-up	36.1%	50.6%	- 14.5%	- 28.7%

An analysis of the composite MAE for the subgroup with STS mortality scores ≥ 10 is summarized in Tables 6.11a (ITT Population) and 6.11b (PP Population). This subgroup represents the highest risk patients enrolled in the trial. The composite MAE rate is similar for Impella vs. IABP at 30 days in the ITT group (44.7% for Impella vs. 47.2% for IABP) and the PP population (47.2% for Impella vs. 47.2% for IABP). The rates remain similar between the two arms at 90 days for both the ITT (56.8% for Impella vs. 52.8% for IABP) and PP populations (60.0% for Impella vs. 52.8% for IABP).

Table 6.11a Subgroup of STS Mortality Score ≥ 10 (Intent-to-Treat Population)

Subgroup Analysis – STS Mortality Score ≥ 10 (ITT)	Impella Patients (n=38)	IABP Patients (n=36)	Difference	Relative Reduction or Increase
30 days or Discharge	44.7%	47.2%	- 2.5%	- 5.3%
90 Day Follow-up	56.8%	52.8%	+ 4.0%	+ 7.6%

Table 6.11b Subgroup of STS Mortality Score ≥ 10 (Per-Protocol Population)

Subgroup Analysis – STS Mortality Score ≥ 10 (PP)	Impella Patients (n=36)	IABP Patients (n=36)	Difference	Relative Reduction or Increase
30 days or Discharge	47.2%	47.2%	0%	0%
90 Day Follow-up	60.0%	52.8%	+ 7.2%	+ 13.6%

The above results show that: 1) patients supported with Impella tend to have a lower composite MAE rate than those supported with IABP in most of the subgroups; 2) there appears to be a learning curve associated with the use of the device that can be seen when removing from the analysis the first Impella subject at each site, and 3) the use of atherectomy appears to be potentially a confounding variable that may have affected the results of the trial (including the high STS group patient subgroup).

SECONDARY SAFETY RESULTS

The ten major adverse events components of the primary endpoint were analyzed separately, in both a non-hierarchical and hierarchical manner. Tables 6.12a and 6.12b below summarize the individual major adverse events components in a non-hierarchical manner, in which all the MAEs for all the subjects are represented in the components. Table 6.12a gives the results for the MAE components for the Intent-to-Treat population to 30 days or discharge, whichever is longer, and at 90 days. None of the differences between the IABP and Impella study arms for the individual MAE components were numerically different at any time point for the ITT with the exception of repeat revascularization at 90 days, where 26 IABP subjects vs. 14 Impella subjects required repeat revascularization.

Table 6.12b summarizes the results for the MAE components for the Per-Protocol population to 30 days or discharge whichever was longer, and at 90 days. None of the numerical differences between the study arms for the individual MAE components days were significant at any time point with the exception of repeat revascularization at 90 days, where 26 IABP subjects vs. 13 Impella subjects required repeat revascularization.

Table 6.12a Individual MAE Components (ITT Population) Non-Hierarchical

MAE to 30 Days or Discharge	30 Days		90 Days	
	Impella Patients (n=225)	IABP Patients (n=222)	Impella Patients (n=224)	IABP Patients (n=219)
Death	7.6% (17/225)	5.9% (13/222)	12.1% (27/224)	8.7% (19/219)
Stroke/TIA	0.4% (1/225)	1.8% (4/222)	1.3% (3/224)	2.7% (6/219)
Myocardial Infarction	17.8% (40/225)	12.2% (27/222)	18.8% (42/224)	16.0% (35/219)
Repeat Revascularization	3.6% (8/225)	5.9% (13/222)	6.3% (14/224)	11.9% (26/219)
Need for Cardiac or Vascular Operation or Limb ischemia	1.8% (4/225)	2.3% (5/222)	2.2% (5/224)	3.7% (8/219)
Acute Renal Dysfunction	7.1% (16/225)	7.7% (17/222)	9.4% (21/224)	11.0% (24/219)
CPR or Ventricular Arrhythmia requiring Cardioversion	10.2% (23/225)	7.2% (16/222)	12.5% (28/224)	10.0% (22/219)
Increase in Aortic Insufficiency	0.0% (0/225)	0.0% (0/222)	0.0% (0/224)	0.0% (0/219)
Severe Hypotension	10.7% (24/225)	11.7% (26/222)	10.7% (24/224)	11.9% (26/219)
Angiographic Failure	3.6% (8/225)	1.8% (4/222)	3.6% (8/224)	1.8% (4/219)

Table 6.12b Individual MAE Components (PP Population) - Non-Hierarchical

MAE to 30 Days or Discharge	30 Days		90 Days	
	Impella Patients (n=216)	IABP Patients (n=211)	Impella Patients (n=215)	IABP Patients (n=210)
Death	6.9% (15/216)	6.2% (13/211)	11.6% (25/215)	9.0% (19/210)
Stroke/TIA	0.5% (1/216)	1.9% (4/211)	1.4% (3/215)	2.4% (5/210)
Myocardial Infarction	17.1% (37/216)	12.8% (27/211)	18.1% (39/215)	16.7% (35/210)
Repeat Revascularization	3.2% (7/216)	6.2% (13/211)	6.0% (13/215)	12.4% (26/210)
Need for Cardiac or Vascular Operation or Limb ischemia	1.9% (4/216)	2.4% (5/211)	2.3% (5/215)	3.8% (8/210)
Acute Renal Dysfunction	7.4% (16/216)	8.1% (17/211)	9.8% (21/215)	11.4% (24/210)
CPR or Ventricular Arrhythmia requiring Cardioversion	9.7% (21/216)	7.6% (16/211)	12.1% (26/215)	10.5% (22/210)
Increase in Aortic Insufficiency	0.0% (0/216)	0.0% (0/211)	0.0% (0/215)	0.0% (0/210)
Severe Hypotension	10.2% (22/216)	12.3% (26/211)	10.2% (22/215)	12.4% (26/210)
Angiographic Failure	3.7% (8/216)	1.9% (4/211)	3.7% (8/215)	1.9% (4/210)

SECONDARY EFFECTIVENESS RESULTS

CARDIAC POWER OUTPUT (CPO)

When measured by maximal drop in CPO from baseline, Impella appeared to provide better hemodynamic support compared to IABP (-0.04±0.24 vs. -0.14±0.27 Watts, respectively).

CREATININE CLEARANCE

The mean change in creatinine clearance from baseline to 24 hours post-procedure was equivalent for the two study arms: 4.64 ± 15.06 ml/min for the Impella arm and 4.66 ± 13.55 ml/min for the IABP arm.

IMPELLA PUMP OUTPUT

A secondary effectiveness endpoint was defined as the failure of the Impella 2.5 device to maintain a pump output of > 1.0 L/min for more than five minutes while at a performance level P5 or higher in the Impella patients during the procedure. Analysis of the data of flow vs. P-level for Impella subjects showed no failures (0%). In all cases the Impella 2.5, when set at performance level P5 or higher, was able to maintain flows above 1.0 L/min.

IABP PRESSURE AUGMENTATION

A secondary effectiveness endpoint was the failure of the IABP to augment diastolic pressure above the peak systolic pressure for more than five minutes in the IABP patients. This endpoint was unable to be measured for the study, as the data analysis required access to IABP console data, which was not possible without the IABP manufacturer's approval. Alternative sources of data (i.e., analysis of IABP device failures and the MAE rate for hypotension for the IABP arm) do not suggest that there would have been significant failures of the IABP to augment diastolic pressure above the peak systolic pressure for more than five minutes in the IABP patients.

SUMMARY OF SUPPLEMENTAL CLINICAL INFORMATION

FURTHER PROTECT II ANALYSIS

An additional *post hoc* analysis was conducted on the primary endpoint of the PROTECT II data set and provided additional clinical information.

This analysis used a different, prognostically relevant definition of peri-procedural myocardial infarction. Specifically, the 2007 universal definition of MI used in the trial has since changed to reflect current knowledge. The additional analysis incorporated the identical data from PROTECT II but was conducted using an 8x Upper Limit of Normal (ULN) threshold for cardiac biomarker release to define peri-procedural MI in order to reflect a contemporary and prognostically relevant definition of MI.

At 90 days, lower MAE (same 10 components as defined in the PROTECT II Study) and major adverse cardiac and cerebrovascular events (MACCE – a subset of the components used in the MAE definition) rates were observed in the Impella group compared to IABP when this contemporary definition of peri-procedural myocardial infarction (8x ULN) was used (Tables 6.13a and 6.13b).

Table 6.13a Composite MAE at 30 and 90 Days Using Contemporary Definition for Peri-Procedural MI (8x ULN) (Intent-to-Treat Population and Per-Protocol Population)

MAE at 30 Days	Impella	IABP	Difference	Relative Reduction or Increase
ITT (N=448)	31%	38%	- 7%	- 18.4%
PP (N=427)	30%	40%	- 10%	- 25.0%

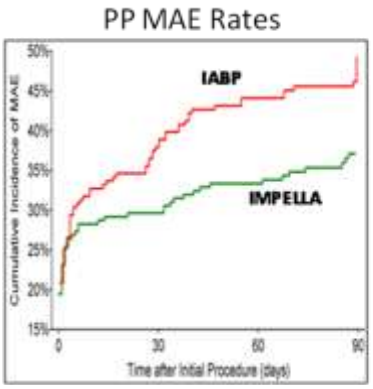
MAE at 90 Days	Impella	IABP	Difference	Relative Reduction or Increase
ITT (N=448)	37%	47%	- 10%	- 21.3%
PP (N=427)	37%	49%	- 12%	- 24.5%

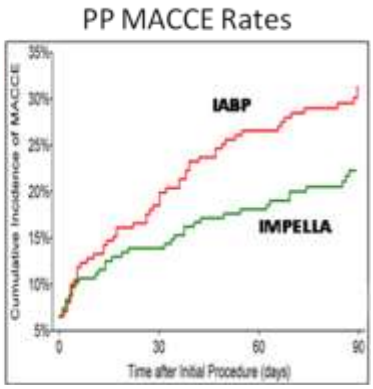
Table 6.13b Composite MACCE at 30 and 90 Days Using a Contemporary Definition For peri-Procedural MI (8x ULN) (Intent-to-Treat Population and Per-Protocol Population)

MACCE at 30 Days	Impella	IABP	Difference	Relative Reduction or Increase
ITT (N=448)	15%	19%	- 4%	- 21.1%
PP (N=427)	14%	20%	- 6%	- 30.0%

MACCE at 90 Days	Impella	IABP	Difference	Relative Reduction or Increase
ITT (N=448)	22%	30%	- 8%	- 26.7%
PP (N=427)	22%	31%	- 9%	- 29.4%

Figure 6.4a Additional Analysis of the Composite MAE and MACCE Rates in the Per-Protocol Population Using a Meaningful, Contemporary Definition for Peri-Procedural MI (8x ULN)

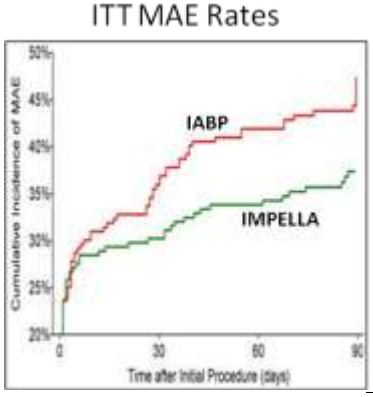


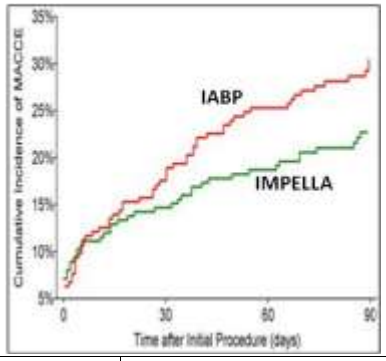


MAE	Time after Initial Procedure (days)			
PP	0	30	60	90
Impella Patients At Risk	216	174	151	124
IABP Patients At Risk	211	167	129	103

MACCE	Time after Initial Procedure (days)			
PP	0	30	60	90
Impella Patients At Risk	216	202	185	153
IABP Patients At Risk	211	197	169	135

Figure 6.4b Additional Analysis of the Composite MAE and MACCE Rates in the Intent-to-Treat Population Using a Meaningful, Contemporary Definition for Peri-Procedural MI (8x ULN)





MAE	Time after Initial Procedure (days)			
ITT	0	30	60	90
Impella Patients At Risk	225	180	156	129
IABP Patients At Risk	223	178	138	111

MACCE	Time after Initial Procedure (days)			
ITT	0	30	60	90
Impella Patients At Risk	225	209	191	159
IABP Patients At Risk	223	208	178	143

USPELLA REGISTRY

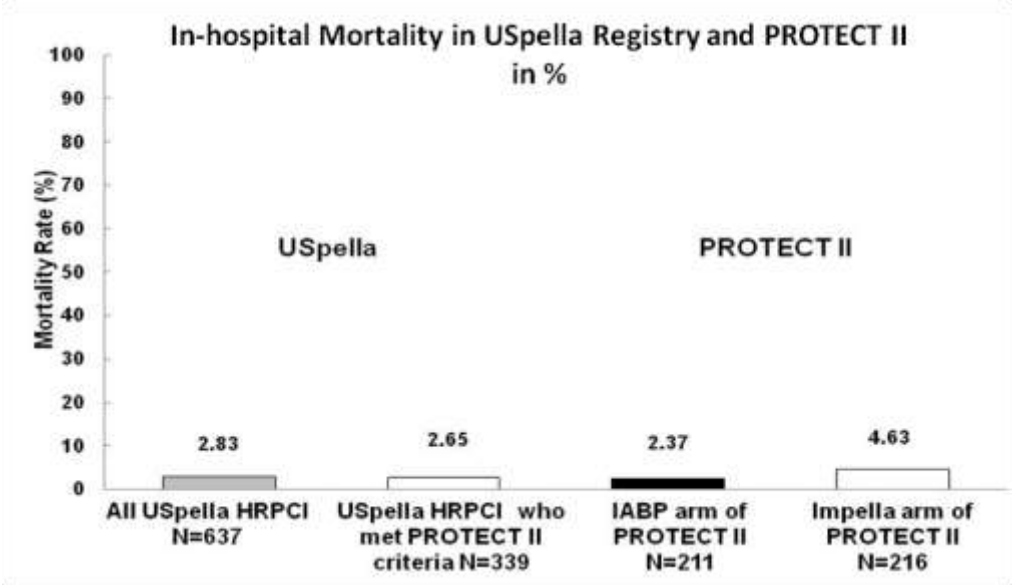
ABIOMED opened a voluntary registry (USpella) for Impella use in the U.S. for all of its Impella devices, including the Impella 2.5. Data is collected at all participating sites retrospectively without pre-selection of patients, and included high risk PCI patients treated with the Impella 2.5 System (albeit from a broader high risk PCI patient population than defined in the PROTECT II Study). The PROTECT II criteria was superimposed on this group of data and yielded an analysis containing 637 patients. These Impella 2.5 System registry data were used as supplemental informative clinical data for FDA review of the Impella 2.5 System PMA P140003, within context of the indications for use.

Outcomes and Limitations

Considering the retrospective nature of the registry design, there is a risk for some adverse events to not be documented. This is particularly true for adverse events that were defined based on temporal profile of biomarkers (such as cardiac or renal biomarkers) that require, regular, and periodic monitoring of the blood samples which may not be performed as frequently (if at all) during routine care across institutions. Other events such as the frequency of hypotensive events may also be not properly documented if accounted for retrospectively based on patient chart review.

However, mortality outcomes are relevant to report and compare to the PROTECT II trial for the following reasons: 1) USpella outcomes to discharge were obtained for 100% of the patients; and 2) death is very likely to be known and reported if the patient expired within the index hospitalization; and 3) USpella data could provide a real word estimate of the potential expected mortality for patients that are deemed to require hemodynamic support with the Impella 2.5 while undergoing high risk PCI. Mortality outcomes in USpella are depicted in Figure 6.5. Benchmark with PROTECT II data is also provided.

Figure 6.5 In-Hospital Mortality for "All USpella HRPCI Patients", "All USpella HRPCI Patients who met PROTECT II Criteria" and PROTECT II Patients for Both IABP and Impella 2.5 Arm



Mortality was similar between the USpella subsets and PROTECT II Impella 2.5 arm and IABP arm. This supports the observation in the PROTECT II trial (448 patient cohort) that there was no increased risk for mortality associated with the use of Impella and large bore access sheath compared to IABP.

Conclusion

In conclusion, given the totality of the information available for the Impella 2.5 System, the data suggests that an observed beneficial therapeutic effect at 90 days likely exists in patients undergoing high risk interventions (i.e., patientshave few, if any other treatment options due to the severity of the underlying coronary artery disease and co-morbidities). This beneficial effect is possibly attributable to the ability to perform more aggressive percutaneous revascularization procedures while being supported by the Impella 2.5 System without significantly increasing safety risks, thereby decreasing the late need for symptom driven coronary artery re-intervention.

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7 PATIENT MANAGEMENT TOPICS

PATIENT SELECTION AND THE HEART TEAM

INITIAL PATIENT DECISION: PCI VS. CABG

Per the ACC/AHA guidelines, there should be an initial overall decision around patient selection relative to the index procedure being CABG or PCI. The PCI indication is a medical decision and should be made by a Heart Team according to institution standards, current practice of medicine and societal ACC/AHA guidelines. This involves a multidisciplinary approach composed of an interventional cardiologist, a cardiac surgeon and maybe others, as deemed appropriate. The cardiac surgeon does not have to be on-site to participate in this decision.

IMPELLA PATIENT DECISION

For the use of the Impella 2.5, the patient would be deemed an appropriate candidate for high risk PCI as defined by the inclusion/exclusion criteria contained in this IFU.

PATIENT MANAGEMENT OVERVIEW

The information and instructions in this section of the manual are not intended to supersede established medical procedures concerning patient care. Best practice, as determined by the medical community, should always be observed. In each case, the clinician must determine whether the application of information provided is appropriate for the particular clinical setting

GENERAL PATIENT CARE CONSIDERATIONS

- Use knee immobilizer as needed to maintain access site straight
- Access site management should be done in accordance with hospital protocol, using aseptic technique.
- Assess access site for bleeding and hematoma
- Monitor pedal pulses
- To prevent the purge tubing from kinking, do not allow the red Impella® plug to hang freely from the catheter and do not bend the catheter near the red Impella® plug
- Consider attaching the red Impella® plug and catheter to a short armboard to prevent the catheter from kinking near the plug
- Failure to wean the device in the cath lab may require transfer of the patient with the device in place into the ICU setting. As such, the following will apply:
    - Be careful not to pull on the Impella® Catheter when transferring a patient from one bed to another
    - Do not raise the head of the bed to higher than a 30-degree angle
    - Use care when moving or turning a patient; the Impella® Catheter may move out of position and cause a positioning alarm

TRANSPORT WITHIN THE HOSPITAL

Failure to wean the device in the cath lab may require transfer of the patient with the device in place into the ICU setting. While weaning the patient from the Impella® Catheter is at the discretion of the physician, the Impella 2.5 System has not been approved for > 6 hours of use, Inability to wean the patient from the device within a reasonably short time frame should result in consideration of a more durable form of left ventricular support.

Considerations for transport within the hospital:

- The Automated Impella® Controller and Impella® Catheter are designed to operate on battery power for at least 1 hour.
- Confirm that the battery capacity displayed on the controller is 100%.
- If transport time might be longer than 1 hour, bring an extension cord or confirm that you will be able to connect the controller to AC power once you arrive at your destination.
- When rolling the Automated Impella® Controller cart across a threshold, firmly grasp the cart handle and pull it over the threshold.
- Pay close attention to all system components and connections when rolling the Automated Impella® Controller cart over thresholds and through elevator doors.
- Do not stress the connector cable from the controller to the Impella® Catheter.

RIGHT HEART FAILURE

Weaning may be delayed beyond the intended use for temporary support (<6 hours), as an unintended consequence of a post-procedure inability to wean for the initial intended use.

During this time, caregivers should monitor patients being supported by the Impella® 2.5 Catheter for signs of right heart failure:

- Reduced output from the Impella® Catheter
- Suction alarms
- Elevated filling pressures (CVP)
- Signs of liver failure
- Elevated pulmonary pressures

If the patient is exhibiting signs of right heart failure, the clinical team should assess the need for a more durable form of support.

ECG INTERFERENCE

Operating the Automated Impella® Controller may cause interference with electrocardiogram (ECG) signals. Please check the electrode pads and leads for good fixation and contact. If interference persists, activate the 50/100 Hz band-elimination filter or the 60/120 Hz band-elimination filter (also known as notch filter) on your ECG device. The filter frequency will be based on the AC power frequency for the country in which you are operating the equipment.

If your ECG device does not have the appropriate filters, disconnect the Automated Impella® Controller temporarily from AC power to obtain an undisturbed signal. Please observe the battery status while running the Automated Impella® Controller on battery power.

LATEX

The Automated Impella® Controller and Impella® Catheter, including all accessories, are not made with natural rubber latex.

UNDERSTANDING AND MANAGING IMPELLA® CATHETER POSITION ALARMS

The Automated Impella® Controller continuously monitors the catheter based on the placement signal and the motor current.

- Placement signal: Is the signal characteristic of aortic or ventricular pressure?
- Motor current: Is the signal "pulsatile" or "flattened"?

If the system alarms with one of the positioning alarms described in this section, fluoroscopic imaging is the best method for confirming position. You can also use TEE, TTE, or a standard chest x-ray.

If the Impella® Catheter is either partly (just the pigtail) or completely in the ventricle, reposition the catheter under imaging guidance.
If the Impella® Catheter is completely out of the ventricle, do not attempt to reposition the catheter across the valve without a guidewire.

The following pages describe possible placement conditions and the associated signal characteristics and alarm messages as well as actions to take for each.

CORRECT POSITION

If the Impella® Catheter is in the correct position, the placement screen will appear as shown in Figure 7.5.

Figure 7.5 Correct Impella® Catheter Position

IMPELLA® CATHETER FULLY IN VENTRICLE

If the Impella® Catheter is fully in the ventricle, the following alarm will appear:

Impella Position In Ventricle

In this situation, the placement screen will appear as shown in Figure 7.6.

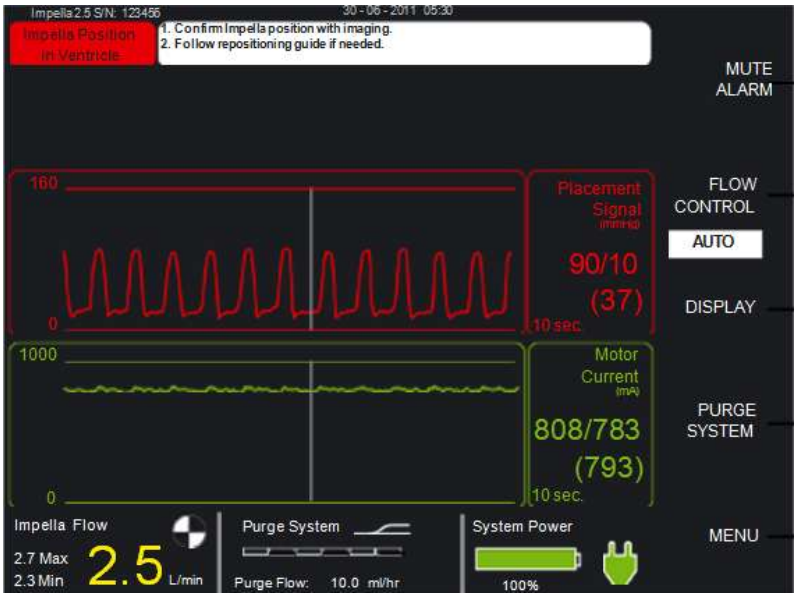


Figure 7.6 Impella® Catheter Fully in Ventricle

Actions to take:

1. Under fluoroscopic guidance, reduce the P-level to P-2 and carefully pull back the Impella® Catheter until the aortic waveform signal is showing.
2. When you see the aortic waveform signal, pull the catheter back an additional 4 cm.

IMPELLA® CATHETER COMPLETELY IN THE AORTA or INLET AND OUTLET AREAS IN VENTRICLE AND OPEN PRESSURE AREA IN AORTA

If the Impella® Catheter is completely in the aorta or if the inlet and outlet areas are in the ventricle and the open pressure area is in the aorta, the following alarm will appear:

Impella Position Wrong

In this situation, the placement screen will appear as shown in Figure 7.7.

Figure 7.7 Impella® Catheter Completely in the Aorta or Inlet and Outlet Areas in Ventricle and Open Pressure Area in Aorta

Actions to take:

1. Under fluoroscopic guidance, determine the Impella® Catheter position.
2. Reduce the P-level to P-2 and reposition the catheter as necessary.

LOW NATIVE HEART PULSATILITY

The planned temporary coronary occlusions during the high risk percutaneous coronary interventions may result in reduced left ventricular function. If this occurs as an unintended consequence, the placement signal may remain pulsatile; however, the amplitude will be dampened.

In a situation of low native heart pulsatility, the Automated Impella® Controller may not be able to determine the catheter position. You may see the following indication on the home screen:

Impella Position Unknown

In this situation, the screen will appear as shown in Figure 7.8.

Figure 7.8 Impella® Catheter Position Unknown

Actions to take:

1. Assess cardiac function.

IMPELLA® CATHETER OUTLET AREA ON OR NEAR AORTIC VALVE

If the Impella® Catheter outlet area is on or near the aortic valve, the catheter may be too deep in the ventricle.

Actions to take:

1. Assess and adjust Impella® Catheter position under fluoroscopic guidance.
2. If unsuccessful, reduce the P-level to P-2 and gently pull the catheter back 2 cm to see if the condition resolves.

IMPELLA STOPPED

If the Impella® Catheter has stopped suddenly:

1. Try to restart the catheter at P-8.
2. If the Impella® does not restart at P-8, try to restart at P-2.
3. If the Impella® does not restart or stops again, wait 1 minute and try to restart again.
4. If the Impella® restarts, wean down to P-2 as the patient can tolerate. Under these circumstances, catheter function is not reliable and the Impella® may stop again.
5. If the Impella® does not restart, remove the Impella® from the ventricle as soon as possible to avoid aortic insufficiency.

SUCTION

Suction may occur if the blood volume available for the Impella® Catheter is inadequate or restricted. Suction limits the amount of support that the Impella® Catheter can provide to the patient and results in a decrease in arterial pressure and cardiac output. It can damage blood cells, leading to hemolysis. It may also be an indicator of right heart failure.

If the Automated Impella® Controller detects suction while running in AUTO mode, it automatically reduces motor speed to lower the flow rate to resolve the suction and displays the "Impella Flow Reduced" advisory alarm. If the suction is cleared, the controller returns the flow rate to the desired setting. If suction is still detected at the lowest motor speed, the controller displays the "Suction" alarm.

If the “Suction” or “Impella Flow Reduced” alarm occurs, follow the recommended actions:

1. Check the Impella® Catheter for correct positioning using imaging. Reposition the catheter by rotating or moving it into or out of the ventricle slightly. Either or both of these actions could help move the inlet of the Impella® Catheter away from the interior ventricular wall.
2. Ensure patient has adequate volume.
3. Confirm right ventricular function by assessing CVP or right side function with echocardiography or fluoroscopy. If CVP is not an option, check the pulmonary artery diastolic pressure to assess the patient volume status.
4. Return P-level to pre-alarm setting.

If the Impella® Catheter has sudden low flows or suction at startup:

1. Remove the catheter from the patient and ensure that ACT is 250 seconds or above.
2. Closely inspect the inlet and outlet areas and remove any thrombus or other foreign materials.
3. If materials have been removed, run the Impella® at P-8 or AUTO in a basin.
4. If flows are still above 2.2 L/min, reinsert the Impella® Catheter into the patient.
5. If no material is visible or if the flows are still low, there could be a clot inside the device. An assessment (fluoroscopic or echocardiography) of the left ventricle is recommended to rule out left ventricular thrombus before inserting another device.

HEMOLYSIS

When blood is pumped, it is subjected to mechanical forces. Depending on the strength of the blood cells and the amount of force applied, the cells may be damaged, allowing hemoglobin to enter the plasma. Similar pumping forces can be generated by a variety of medical procedures including heart lung bypass, hemodialysis, or ventricular assist device (VAD) support. Patient conditions—including catheter position, pre-existing medical conditions, and small left ventricular volumes—may also play a role in patient susceptibility to hemolysis.

Although unexpected during the short duration of the case, hemolysis should be monitored during the procedure. Patients who develop high levels of hemolysis may show signs of decreased hemoglobin levels, dark or blood-colored urine, and in some cases, acute renal failure. Plasma-free hemoglobin (PfHgb) is the best indicator to confirm whether a patient is exposed to an unacceptable level of hemolysis.

Management technique may differ depending on the underlying cause of hemolysis. Table 7.1 provides guidance for various circumstances.

Table 7.1 Guide for Managing Hemolysis in Various Circumstances

Condition	Controller Indicators	Clinical Indicators	Management
Impella® inlet area in close proximity to intraventricular wall	• "Impella Flow Reduced" or "Suction" alarms • Lower than expected flows	Imaging (see note)	• Reposition the catheter by rotating or moving the catheter into or out of the ventricle slightly. Either or both of these actions could help move the inlet of the catheter away from the intraventricular wall. • If repositioning will be delayed, reduce the P-level if tolerated by patient hemodynamics. Return to the previous P-level after repositioning. • Reassess position after low rate has returned to desired target value.
Wrong pump position	• Position alarms with higher than expected flows • "Impella Flow Reduced" or "Suction" alarms with lower than expected flows • Pump outlet blocked alarms	Imaging (see note)	• Reposition the catheter by rotating or moving the catheter into or out of the ventricle slightly. Either or both of these actions could help move the inlet of the catheter away from the intraventricular wall. • If repositioning will be delayed, reduce the P-level if tolerated by patient hemodynamics. Return to the previous P-level after repositioning. • Reassess position after low rate has returned to desired target value.
Higher than needed flow setting	• There may be no controller indicators • "Impella Flow Reduced" or "Suction" alarms	• Normal hemodynamics • Native recovery	• Reduce P-level until patient pressure starts to drop. • Slowly increase P-level.
Inadequate filling volume	• Position alarms • "Impella Flow Reduced" or "Suction" alarms • Lower than expected flows	• Low CVP • Low PCWP • Low AOP • High PA pressures • Right heart failure • High urine output	• Reduce the P-level if tolerated by patient hemodynamics. • Correct I and O balance. • Consider giving volume; additional volume will expand the end systolic ventricular volume. • Reduce PA pressure. • Improve right heart function.
Pre-existing patient conditions or other medical procedures	N/A	• Increased bleeding or chest tube drainage • Patient past medical history • Current procedures or treatments	

***Note on imaging**: All imaging technology represents the anatomy in two dimensions (2D). It is not possible to assess the interactions between the catheter and the intraventricular anatomy that occur in three dimensions (3D). Abiomed strongly recommends that the catheter be repositioned, even if the imaging view shows correct position.*

OPERATING THE IMPELLA® CATHETER WITHOUT HEPARIN IN THE PURGE SOLUTION

Operation of the system without heparin in the purge solution has not been tested. In the event that a patient is intolerant to heparin, due to heparin-induced thrombocytopenia or bleeding, physicians should use their clinical judgment to assess the risks versus benefits of operating the Impella® System without heparin. If it is in the best interest of the patient to operate the system without heparin, the dextrose solution is still required, and physicians should consider systemic delivery of an alternative anticoagulant. Do ***NOT*** add any alternative anticoagulant (such as a direct thrombin inhibitor) to the purge fluid. The Impella® Catheter has not been tested with any alternative anticoagulants in the purge solution.

The Impella® Catheter is designed to be operated with a purge solution that contains heparin. Operation of the system without heparin in the purge solution has not been tested. In the event that a patient is intolerant to heparin, due to heparin-induced thrombocytopenia (HIT) or bleeding, physicians should use their clinical judgment to assess the risks versus benefits of operating the Impella® System without heparin.

If it is in the best interest of the patient to operate the system without heparin, the dextrose solution is still required, and physicians should consider systemic delivery of an alternative anticoagulant. DO NOT add any alternative anticoagulant (such as a direct thrombin inhibitor) to the purge fluid. The Impella® Catheter has not been tested with any alternative anticoagulants in the purge solution.

PLACEMENT SIGNAL LUMEN

BACKGROUND

The Impella® Catheter uses a fluid-filled pressure lumen with an inlet at the proximal end of the motor housing and the pressure sensor located in the red Impella® plug. The Automated Impella® Controller software monitors both the pressure waveform characteristics and motor current to determine the placement of the Impella® Catheter inlet and outlet areas relative to the aortic valve.

Table 7.2 provides recommended standards for maintaining the placement signal.

Restoring Placement Signal Quality

You may get a sensor or position alarm if you pinch the white flush valve to restore placement signal quality.

Table 7.2 Recommended Standards for Maintenance of the Placement Signal

Periodic flushing of the placement signal lumen. Note: Either of these actions may result in sensor or position alarms.	Slight dampening If you observe a dampened placement signal, pinch the white flush valve located on the red sidearm for a few seconds to restore the placement signal quality. Severe or lost pressure 1. Close the roller clamp and disconnect the IV tubing connected to the red pressure sidearm. 2. Connect a syringe of saline to the port and squeeze the white low valve as you draw negative pressure. 3. Continue aspiration of the port until blood is visualized in the syringe. 4. Disconnect the syringe and open the roller clamp until slow drips of saline exit the tubing. 5. Flood the open port of the red pressure sidearm and then reconnect. 6. Squeeze the white wings of the low valve for 15 to 20 seconds to flush the pressure lumen to remove all blood from the pressure lumen.
Pressure bag inflation pressure	Maintain pressure bag inflation pressure between 300 mmHg and 350 mmHg.

FLUSH SOLUTION CHANGE OUT PROCEDURE

1. Prime the new NaCl flush solution setup and close the roller clamp.
2. Place the NaCl bag in a pressure bag and inflate to between 300 mmHg and 350 mmHg.
3. Close the roller clamp and disconnect the old flush solution connected at the red sidearm port.
4. Open the roller clamp on the new flush solution setup until you get a slow drip.
5. Position the male luer connector over the female luer connector and fill to overflow, displacing any air, as shown in Figure 7.13.

Figure 7.13 Displacing Air During Flush Solution Change Out Procedure

6. Connect and secure luer fittings.
7. Fully open the roller clamp and squeeze the white wings for approximately 5 to 10 seconds to complete the internal prime. This final prime should eliminate any risk of lost or dampened pressure caused by blood tracking into the pressure lumen during the pressure tubing change.

TIMED DATA RECORDING

The Automated Impella® Controller is a durable component designed for use in multiple temporary support (<6 hours) cases. For the user's convenience, the Automated Impella® Controller's memory can hold up to 24 hours of real time data. Once memory is full, the controller starts overwriting the old data. The timed data recording feature allows you to permanently save real-time operating data for later analysis. Timed data recording is automatically turned on during certain alarm conditions to capture data for analysis. You can also manually turn on the feature at any time to capture data for later analysis.

To manually access the timed data recording feature:

1. Press **MENU** and scroll to "Start Data Snapshot." Press the selector knob.
2. The controller records data for a predefined period of 10 minutes.

OPERATING THE IMPELLA® CATHETER IN ELECTROMAGNETIC FIELDS

The Impella® Catheter contains a permanent magnet motor that emits an electromagnetic field. This field may produce electromagnetic interference with other equipment. In addition, other equipment that emits a strong electromagnetic field may affect the operation of the Impella® Catheter motor.

TRANSFERRING FROM THE AUTOMATED IMPELLA® CONTROLLER TO A NEW AUTOMATED IMPELLA® CONTROLLER

TRANSFER STEPS

Change Purge Fluid to Obtain Accurate Purge Values

To get accurate purge values after changing to a backup controller, perform the Change Purge Fluid procedure (described in section 5 of this manual) and replace the purge fluid bag.

A backup Automated Impella® Controller should be available at all times when a patient is on support. In the event that the controller fails, follow the steps below to transition the Impella® Catheter to the backup controller.

1. Confirm that the backup controller is powered on and ready.
2. Press PURGE SYSTEM on the original controller, select Change Purge Fluid, and complete the step to bolus the purge system. (Do NOT flush the purge fluid from the cassette.)
3. Disconnect the yellow luer connector from the Impella® Catheter to release the pressure in the purge cassette.
4. Transfer the purge cassette and purge solution from the original controller to the backup controller.
5. Reconnect the yellow luer connector to the Impella® Catheter.
6. Remove the white connector cable from the original controller and plug it into the catheter plug on the front of the backup controller.
7. Once the Impella® Catheter is connected to the backup controller, wait for a message to appear on the screen asking you to confirm re-starting the Impella® Catheter at the previously set P-level.
8. Press OK within 10 seconds to confirm restarting the Impella® Catheter at the previously set P-level.
9. If the message to restart the Impella® Catheter does not appear within 1 minute, restart the Impella® Catheter using the FLOW CONTROL soft button.

PATIENT MANAGEMENT CHECKLIST FOLLOWING TRANSFER OF SUPPORT

After transferring patient support to or from the Automated Impella® Controller, perform each of the following patient management checklist items:

1. Confirm Impella® Catheter placement using echocardiography or fluoroscopy.
2. Tighten the Tuohy-Borst valve (tighten all the way to the right) on the Impella® Catheter to prevent catheter migration.
3. For patients supported with the Impella® 2.5 Catheter, attach a saline pressure bag pressurized to 350 mmHg to the red sidearm and complete the "Transfer to Standard Configuration" procedure under the **PURGE SYSTEM** menu if not already completed.

Questions or Concerns?

Contact the local Abiomed team or call the 24 hour clinical support line at 1-800-422-8666.

EMERGENCY SHUTDOWN PROCEDURE

In the unlikely event that the Automated Impella® Controller software stops responding, follow the procedure below to restart the controller without stopping the Impella® Catheter.

1. Press and hold the power switch for 30 seconds.
2. An "Emergency Shutdown Imminent" alarm will sound at 15 seconds.
3. The controller will shut down after 30 seconds.
4. Restart the controller.

8 AUTOMATED IMPELLA® CONTROLLER ALARMS

ALARMS OVERVIEW

The Automated Impella® Controller monitors various functions to determine whether specific operational parameters are within expected limits. When a parameter goes outside of its specified limits, the Automated Impella® Controller sounds an alarm tone and displays an alarm message that can be viewed on the display screen on the front of the controller. The alarm tone indicates the severity of the alarm. The alarm message on the display screen is color-coded for severity and provides details on the cause of the alarm and how to resolve the alarm. After muting an alarm, if another alarm occurs it will only be heard and displayed if it is a higher priority alarm than the one that was muted.

ALARM LEVELS

Alarms are divided into three levels of severity:

- Advisory (white)
- Serious (yellow)
- Critical (red)

Table 8.1 Alarm Levels

Category	Description	Audible Indicator*	Visual Indicator
Advisory	Notification	1 beep every 5 minutes	Alarm header on white background
Serious	May become harmful or life-threatening if not addressed immediately	3 beeps every 15 seconds	Alarm header on yellow background
Critical	Immediately harmful or life-threatening	10 beeps every 6.7 seconds	Alarm header on red background

* Sound pressure of audible alarm indicators is >80 dBA

For some alarms, there is a short delay between the triggered event and the audible annunciation and visual display of the alarm. (For more information, refer to the “Alarm Delay Information” discussion in Section 9 of this manual.)

ALARM DISPLAY

The alarm window is located in the upper left region of the display screen on the front of the Automated Impella® Controller (see Figure 8.1). Alarms are listed in order of priority, with the highest priority alarm at the top. Up to three alarms may be displayed at one time. The colored background behind the highest priority alarm will alternate between two shades of that color. The white panel displayed to the right of the alarm header contains instructions for resolving the alarm condition. The instructions should be followed in the order given.

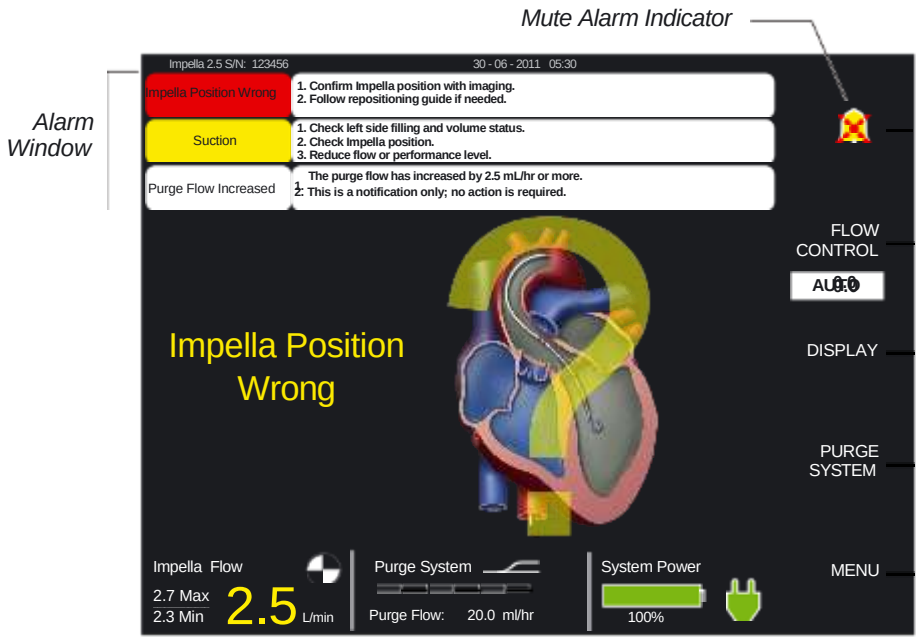


Figure 8.1 Alarm Window

Alarms That Resolve On Their Own

*The audible indicator will shut off if an alarm condition is resolved before you press **MUTE ALARM**. The visual message, however, will continue to be displayed, with the alarm header on a gray background, for 20 minutes or until you press **MUTE ALARM**. This allows you to identify the alarm that occurred.*

MUTE ALARM FUNCTION

Pressing the **MUTE ALARM** button on the upper right of the Automated Impella® Controller display screen will silence the audible alarm indicator for 2 minutes (for red or yellow alarms) or 5 minutes (for white advisory alarms). When an alarm is silenced, the words “MUTE ALARM” next to the button are replaced by the mute alarm indicator, a crossed-out bell icon (as shown in Figure 8.1).

ALARM HISTORY SCREEN

The alarm history screen may be accessed through the MENU. This screen contains a log of the alarms that occurred during the case. This log is not maintained when the Automated Impella® Controller is powered down or after a power failure. The controller does, however, maintain a long-term log that is saved after the Automated Impella® Controller is powered down or after a power failure and this information may be downloaded by Abiomed personnel.

ALARM MESSAGE SUMMARY

Table 8.2 briefly describes all of the alarm messages that may appear on the Automated Impella® Controller when used with the Impella® 2.5 Catheter.

Table 8.2 Automated Impella® Controller Alarm Messages

Severity	Alarm Header	Action	Cause
Critical Alarms	**Air in Purge System**	The purge system has stopped. Initiate the De-air Tool and follow instructions to remove the air from the system.	There is air in the purge tubing.
	Battery Critically Low	Plug controller into AC power.	Battery power has 15% remaining capacity.
	Battery Failure	Plug controller into AC power.	One of the batteries has failed.
	Battery Failure	1. Plug controller into AC power. 2. Press switch located on the underside of the controller. 3. Switch to backup controller.	A battery switch is turned off or there is a malfunction of the switch.
	Battery Temperature High	Switch to backup controller.	Battery temperature is greater than 60°C.
	Complete Procedure	1. Follow the steps on the screen or 2. Exit the procedure	Complete Procedure serious alarm (yellow; see next page) is active and the user has not responded for an additional 2 minutes.
	Controller Failure	Switch to backup controller.	There is a problem with the controller electronics.
	Controller Failure	The purge system has stopped. Switch to backup controller.	The controller has detected a purge pressure sensor defect and has stopped the purge system.
	Emergency Shutdown Imminent	Release ON/OFF push button.	Power switch pressed for 15 seconds while Impella® is still connected.
	Impella Disconnected	1. Check cable connection to console. 2. Check Impella connection to cable.	Running Impella® Catheter disconnected.
	Impella Failure	Replace Impella.	There is a problem with the Impella® Catheter motor.

Table 8.2 Automated Impella® Controller Alarm Messages (continued)

Severity	Alarm Header	Action	Cause
Critical Alarms	**Impella Position In Ventricle**	1. Confirm Impella position with imaging. 2. Follow repositioning guide if needed.	Controller has detected that Impella® Catheter is fully in the ventricle.
	Impella Position Wrong	1. Confirm Impella position with imaging. 2. Follow repositioning guide if needed.	Controller has detected that Impella® Catheter is in the wrong position.
	Impella Stopped	1. Restart Impella. 2. Replace Impella after 3rd unsuccessful restart attempt.	There may be a mechanical or electrical problem in the Impella® Catheter.
	Impella Stopped	1. Replace white connector cable. 2. Switch to backup controller. 3. Replace Impella Catheter.	There is a problem with the electronics.
	Impella Stopped **Controller Failure**	Switch to backup controller.	There is a problem with the controller electronics.
	Impella Stopped **Motor Current High**	1. Restart Impella. 2. Replace Impella after 3rd unsuccessful restart attempt.	There is a problem with the Impella® Catheter motor.
	Impella Stopped **Reverse Flow**	Restart Impella, or remove Impella from ventricle.	Impella® Catheter is not running; possible reverse flow through Impella® Catheter.
	Purge Flow Low	1. Check purge system tubing for kinks. 2. Decrease concentration of dextrose in the purge solution.	Purge pressure is ≥1100 mmHg with the purge low <2 mL/hr.
	Purge Line Click-On Not Detected	Check the purge line click-on and make sure it is fully inserted.	The controller is not detecting that the purge pressure transmitter is clicked into the front of the controller.
	Purge Pressure Low	1. Check purge system tubing for leaks. 2. Increase concentration of dextrose in the purge solution. 3. Replace purge cassette.	Purge pressure has dropped below 300 mmHg with the purge low ≥30 mL/hr for 30 seconds or longer.
	Purge System Blocked	1. Check all purge system tubing for kinks or blockages. 2. Decrease concentration of dextrose in the purge solution.	Purge low has dropped below 1 mL/hr. Kinked or blocked purge connecting tube. Kinked or blocked purge lumen in Impella® Catheter.

Table 8.2 Automated Impella® Controller Alarm Messages (continued)

Severity	Alarm Header	Action	Cause
Critical Alarms	**Purge System Failure**	1. Replace purge cassette. 2. Switch to backup controller.	There is a problem with the purge cassette or purge unit driver.
	Purge System Open	1. Check the purge system tubing for open connections or leaks. 2. Replace purge cassette.	Purge pressure has dropped below 100 mmHg for 20 seconds or longer.
	Reverse Flow	Check for high afterload pressure.	Reverse low detected at high motor speed.
Serious Alarms	**Battery Comm. Failure**	Plug controller into AC power.	Loss of communication to the battery.
	Battery Level Low	Plug controller into AC power.	Battery has 50% remaining capacity.
	Battery Temperature High	1. Check controller for blocked air vents. 2. Switch to backup controller.	Battery temperature is greater than 50°C and less than or equal to 60°C.
	Complete Procedure	1. Follow the steps on the screen or 2. Exit the procedure	User has not responded to a de-air or purge procedure screen for more than 1 minute or a transfer to standard configuration screen for more than 5 minutes.
	Controller Error	Switch to backup controller.	There is a problem with the controller electronics.
	Impella Catheter Not Supported	1. Replace Impella with supported catheter (2.5, CP, 5.0, LD, RP). 2. Contact Abiomed Service to upgrade Impella Controller.	The Impella® Catheter is not supported to operate with the current version of controller software and/or hardware.
	Impella Defective	Do not use Impella. Replace Impella.	There is a problem with the Impella® Catheter electronics.
	Impella Flow Low	1. Check for suction. 2. Check for high afterload pressure.	Actual low is below 1.0 L/min.
	Impella Outflow Blocked	1. Confirm Impella position with imaging. 2. Pull Impella back 2 cm. 3. Follow repositioning guide if needed.	Flow to Impella Catheter outlet area obstructed.
	Impella Position Wrong	1. Confirm Impella position with imaging. 2. Pull Impella back 2 cm. 3. Follow repositioning guide if needed.	Controller has detected that the Impella® Catheter is in the wrong position, with the outlet area too close to the aortic valve.

Table 8.2 Automated Impella® Controller Alarm Messages (continued)

Severity	Alarm Header	Action	Cause
Serious Alarms	**Impella Sensor Failure**	Placement Monitoring and Suction are suspended. 1. Monitor patient hemodynamics. 2. Monitor Impella position with imaging.	There is a problem with the Impella® Catheter sensor signal.
	Purge Cassette Failure	Replace purge cassette.	There is a problem with the purge cassette software.
	Purge Volume Critically Low	1. Open the PURGE SYSTEM menu and select Change Purge Fluid. 2. Follow the instructions to change the purge fluid.	There are 15 mL (in addition to 5% of the starting bag volume) or fewer remaining in the purge fluid bag.
	Suction	1. Check filling and volume status. 2. Check Impella position. 3. Reduce flow or performance level.	Suction is detected.
Advisory Alarms	**AC Power Disconnected**	Controller is running on battery power.	AC power was disconnected.
	Audio Off	The auditory signal for the following alarm has been disabled. <Alarm will be listed here>	User has disabled audio for Impella Sensor Failure, Purge Flow Low, or Purge System Blocked alarm.
	Impella Flow High	Check for high afterload pressure.	Reverse low has been detected and minimum motor speed has been increased to more than target P-level
	Impella Flow Reduced	1. Check Impella position. 2. Check left side filling and volume status. 3. Reduce low setting.	Motor speed has been reduced in response to suction.
	Impella Position Unknown	Impella Catheter position unknown due to low pulsatility. Assess cardiac function.	Impella Catheter position unknown due to low pulsatility.
	Impella Position Unknown	1. Confirm Impella position with imaging. 2. Follow repositioning guide if needed.	Impella Catheter position unknown detected by algorithm

Table 8.2 Automated Impella® Controller Alarm Messages (continued)

Severity	Alarm Header	Action	Cause
Advisory Alarms	**Placement Signal Lumen Blocked**	Placement and Suction Monitoring are Suspended. Aspirate with syringe, then flush.	Controller detects placement signal pulsatility is low and speed and motor current are high for more than 5 consecutive minutes.
	Purge Cassette Incompatible	Contact Abiomed Service to update Impella Controller.	Incompatible purge cassette RFID version.
	Purge Flow Decreased	The purge flow has decreased by 2.5 mL/hr or more. This is a notification only; no action is required.	Purge flow has decreased by ≥2.5 mL/hr.
	Purge Flow Increased	The purge flow has increased by 2.5 mL/hr or more. This is a notification only; no action is required.	Purge flow has increased by ≥2.5 mL/hr.
	Purge Volume Low	1. Open **PURGE SYSTEM** menu and select Change Purge Fluid. 2. Follow the instructions to change the purge fluid.	There are 30 mL (in addition to 5% of the starting bag volume) or fewer remaining in the purge fluid bag.
	Transfer to Standard Configuration	Follow instructions under Purge System to transfer to Standard Configuration.	Follow instructions or press **MUTE ALARM** to clear the alarm for 30 minutes.

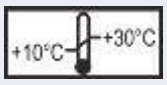
9 GENERAL SYSTEM INFORMATION

TERMINOLOGY, ABBREVIATIONS, AND SYMBOLS

TERMINOLOGY AND ABBREVIATIONS

Catheter serial number	Identification number of the Impella® Catheter; stated on the package label, on the red Impella® plug, and the Automated Impella® Controller display screen
Dextrose and Glucose	The terms “dextrose” and “glucose” are used interchangeably to refer to the solution used as purge fluid for the Impella® System
Hz	Hertz
Motor housing (or pump housing)	Enclosure of the Impella® Catheter motor
Pump	Central delivery unit of the Impella® Catheter, consisting of the motor, motor housing, cannula with inlet and outlet, and pigtail at the tip
Purge pressure	Pressure present in the Impella® Catheter and in the infusion line
Purge system	Impella® purge cassette used for rinsing the Impella® Catheter
Retrograde flow	Reverse flow through the cannula when the Impella® Catheter is at a standstill (e.g., regurgitation)
V	Volt
VA	Volt ampere (Watt)

SYMBOLS

	Caution; consult instructions for use
	Defibrillator-proof type CF equipment
	Keep dry
	Storage temperature (e.g., 10°C to 30°C)
	Declares conformity with directive 93/42/EEC for medical devices, and with Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment
 **2014-10-01**	Date of manufacture (e.g., October 1, 2014)

	Protect from sunlight
LOT	Symbol for lot designation; the manufacturer's lot designation must be stated after the LOT symbol
REF 123456	Abiomed part number (e.g., part number 123456)
SN 123456	Manufacturer's serial number (e.g., serial number 123456)
Non Sterile!	The product is not sterile
 2016-06-01	Use-by date (e.g., use before June 1, 2016)
	Do not reuse
STERILE EO	Sterilized using ethylene oxide
	Electric scrap; must be disposed of separately. Must not be disposed of as domestic waste.
	Protective Earth
	ON / OFF
	Alternating current (AC) only
	Equipotentiality
	Fuse
	Non-ionizing electromagnetic radiation
	USB port
	CAT 5 Port (Ethernet)
	MR Unsafe

AUTOMATED IMPELLA® CONTROLLER MECHANICAL SPECIFICATIONS

Parameter	Specification	
Model Number	0042-0000-US	
Temperature	Operating:	10°C to 40°C (50°F to 104°F)
	Storage:	–15°C to 50°C (5°F to 122°F)
Relative Humidity	Operating:	95%
	Storage:	95%
Atmospheric Pressure	Operating:	8000 ft (750 hPa) to –1000 ft (1050 hPa)
	Storage:	18,000 ft (500 hPa) to –1000 ft (1050 hPa)
Dimensions	Height:	351 mm (13.8 in)
	Width:	443 mm (17.4 in)
	Depth:	236 mm (9.3 in)
Dimensions – Packaged	Height:	508 mm (20.0 in)
	Width:	559 mm (22.0 in)
	Depth:	406 mm (15.0 in)
Weight	Maximum:	11.8 kg (26.1 lbs)
Weight – Packaged	Maximum:	13.6 kg (30 lbs)
Maintenance and repair interval	12 months (Work must be performed by technicians authorized by Abiomed who have completed Abiomed's Service Training Certification Program)	

AUTOMATED IMPELLA® CONTROLLER ELECTRICAL SPECIFICATIONS

AC operation	100-230 V AC (nominal); 47-63 Hz; 1.1 A
Internal battery operation	14.4 V DC (nominal); lithium ion
Characteristic values	
Max. power consumption under load	120 VA
9.7 fuses	2 Amp. 250 V. 5 mm x 20 mm, slow-blow fuses
Running time without AC power with fully charged batteries	At least 60 minutes (charging duration of at least 5 hours)
Electrical system	Installation in accordance with pertinent regulations is required for use in medical facilities (e.g., IEC stipulations).

NOTE: Circuit diagrams available upon request.

EQUIPMENT DESIGN

The Automated Impella® Controller conforms to the applicable requirements of the following standards:

- IEC 60601-1 (2005/01/01) Ed:3 Medical Electrical Equipment Part 1: General Requirements for Basic Safety and Essential Performance
- CSA C22.2#60601-1 (2008) Ed:3 Medical Electrical Equipment Part 1: General Requirements for Basic Safety and Essential Performance
- CENELEC EN60601-1 (2006) Medical Electrical Equipment Part 1: General Requirements for Basic Safety and Essential Performance. Included when concurrent with IEC 60601
- AAMI ES60601-1 (2005) Medical Electrical Equipment Part 1: General Requirements for Basic Safety and Essential Performance
- UL 60601-1 (2003), +Revision (2006) 1st Edition Medical Electrical Equipment, Part 1: General Requirements for Safety
- CAN/CSA C22.2 No 601.1-M90 (1990; Reaffirmed 2005) + Amendment 2 (2006), Medical Electrical Equipment, Part 1: General Requirements for Safety
- IEC 60601-1 (1998) 2nd Edition Medical Electrical Equipment Part 1: General Requirements for Safety + (Amd. 1-1991) (CENELEC EN 60601-1: 1990) + (Amd. 2-1995) (Corrigendum-1995)
- IEC 60601-1-1 (2000), 2nd Edition Medical Electrical Equipment, Part 1-1: General Requirements for Safety – Collateral Standard: Safety Requirements for Medical Electrical Equipment
- IEC 60601-1-4 (2000), Edition 1.1 Consolidated Edition, Medical Electrical Equipment Part 1-4: General Requirements for Safety – Collateral Standard: Programmable Electrical Medical Systems
- IEC 60601-1-2:2007 Edition 3, Medical Electrical Equipment – Part 1-2: General Requirements for Basic Safety and Essential Performance – Collateral Standard: Electromagnetic Compatibility – Requirements and Tests
- IEC 60601-1-2 (2001), Medical Electrical Equipment, Part 1-2: General Requirements for Safety – Collateral Standard: Electromagnetic Compatibility – Requirements and Tests
- IEC 60601-1-6 (2010) 3rd Edition Medical Electrical Equipment – Part 1-6: General Requirements for Safety – Collateral Standard: Usability
- IEC 60601-1-6 (2004) Medical Electrical Equipment – Part 1-6: General Requirements for Safety – Collateral Standard: Usability
- IEC 60601-1-8 (2006) 2nd Edition Medical Electrical Equipment – Part 1-8: General Requirements for Basic Safety and Essential Performance – General Requirements, Tests and Guidance for Alarm Systems in Medical Electrical Equipment and Medical Electrical Systems
- IEC 60601-1-8 (2003) Medical Electrical Equipment – Part 1-8: General Requirements for Safety – Collateral Standard: General Requirements, Tests and Guidance for Alarm Systems in Medical Electrical Equipment and Medical Electrical Systems

EQUIPMENT CLASSIFICATIONS

Type of protection against electric shock	IEC 60601-1: Class I degree of protection: CF defibrillation-proof and internally powered. Relies not only on basic insulation against shock but also includes additional protection. Accomplished by providing means for connecting the equipment to the protective earth conductor of the fixed wiring of the installation in a way that prevents accessible metal parts from becoming live if basic insulation fails.
Degree of protection against electric shock for Automated Impella® Controller	Class I Equipment
Mode of operation	Continuous
Degree of protection against explosion hazard	Not suitable for use in the presence of a flammable anesthetic mixture with air or with oxygen or nitrous oxide. Also not suitable for use in an oxygen-enriched atmosphere.
Degree of protection against harmful ingress of water	IEC 60529: IPX1 protected against dripping water.

FEDERAL COMMUNICATIONS COMMISSION (FCC) NOTICE

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by Abiomed, Inc. could void the user's authority to operate this device.

ELECTROMAGNETIC COMPATIBILITY

Medical electrical equipment needs special precautions regarding EMC and needs to be installed and put into service according to the electromagnetic compatibility (EMC) information provided in this document.

Portable and mobile RF communications equipment can affect medical electrical equipment.

The equipment or system should not be used adjacent to or stacked with other equipment. If adjacent or stacked use is necessary, the equipment or system should be observed to verify normal operation in the configuration in which it will be used.

Use of cables, other than those sold by Abiomed, may result in increased emissions or decreased immunity of the Automated Impella® Controller.

The Automated Impella® Controller uses RFID (radio frequency identification) to identify and communicate with the purge cassette. Other equipment may interfere with the Automated Impella® Controller even if that other equipment complies with CISPR emission requirements.

During transport, the Automated Impella® Controller may be exposed to stronger electromagnetic disturbance than during in-hospital use. Strong electromagnetic disturbance may cause the Automated Impella® Controller to display soft button menu selections that were not selected by the user. Operators should be aware that, under these conditions, the operating parameters are not affected. No user intervention is required. Monitor Impella® Catheter flow and patient hemodynamics to confirm normal operation. The condition will resolve itself once the Automated Impella® Controller is no longer exposed to the disturbance.

NOTE: The EMC tables and other guidelines that are included in this manual provide information to the customer or user that is essential in determining the suitability of the equipment or system for the electromagnetic environment of use, and in managing the electromagnetic environment of use to permit the equipment or system to perform to its intended use without disturbing other equipment and systems or non-medical electrical equipment.

TRANSPORT BETWEEN HOSPITALS

During transport, the Automated Impella® Controller may be exposed to stronger electromagnetic disturbance than during in-hospital use. Strong electromagnetic disturbance may cause the Automated Impella® Controller to display soft button menu selections that were not selected by the user. Operators should be aware that, under these conditions, the operating parameters are not affected. No user intervention is required. Monitor Impella® Catheter flow and patient hemodynamics to confirm normal operation. The condition will resolve itself once the Automated Impella® Controller is no longer exposed to the disturbance.

GUIDELINES FOR PATIENT TRANSPORT

Following HRPCI, intra-hospital transport with the Impella 2.5 System in place may be required if a patient is unable to be weaned and requires additional resources and specialized teams located at another hospital. The patient may be transferred to such a location using the Automated Impella® Controller for hospital-to-hospital transport via ambulance, helicopter, or fixed-wing aircraft.

Maintaining optimal patient hemodynamic status and correct Impella® Catheter position are two key factors in managing patients supported with the Impella® System during transport. Steps should be taken to eliminate or minimize any aspect of the transport that might adversely affect these factors.

The Automated Impella® Controller is designed to operate for 60 minutes on battery power. Transport teams should take this into consideration when planning the transport. If the total transport time is expected to include more than 60 minutes during which the system will be disconnected from AC power, arrangements should be made to use a vehicle with a built-in DC to AC power inverter.

IMPORTANT TRANSPORT CONSIDERATIONS

1. Planning is critical to success. Abiomed representatives can help with planning for transport. They can be contacted 24 hours a day at 1-800-422-8666.
2. The Automated Impella® Controller should be fully charged prior to transport. Keep the Automated Impella® Controller connected to AC power (or an AC inverter) whenever possible.
3. Do not stress the connector cable from the controller to the Impella® Catheter. Such tension could move the catheter out of correct position and compromise patient circulatory support.
4. Carefully monitor purge pressures during changes in altitude.
5. The Automated Impella® Controller should be positioned to allow easy access to the display screen and soft buttons to view alarms and make any necessary changes.
6. Maintain ACTs between 160 and 180 or at the level recommended by the physician responsible for the patient.

FAA ADVISORY

The Automated Impella® Controller has been subjected to, and passed, the EMC/EMI tests as specified in IEC 60601-1-2 (General requirements for safety—Collateral standard: Electromagnetic compatibility—Requirements and tests). The Automated Impella® Controller does not, however, meet the requirements for conducted emissions of RTCA/DO-160G section 21.4 and has not been tested for radiated emissions per RTCA/DO-160G section 21.5. Abiomed recommends that air transport carriers follow the guidance FAA Advisory Circular AC No: 91-21.1B. Section 8-a of FAA Advisory Circular AC No: 91-21.1B states:

> "Equipment tested and found to exceed the section 21, Category M, emission levels are required to be evaluated in the operator's M-PED selected model aircraft for electromagnetic interference (EMI) and radio frequency interference (RFI). All navigation, communication, engine, and light control systems will be operating in the selected aircraft during the evaluation."

TABLE 201
Guidance and Manufacturer's Declaration – Emissions, All Equipment and Systems

The Automated Impella® Controller is intended for use in the electromagnetic environment specified below. The customer or user of the Automated Impella® Controller should ensure that it is used in such an environment.

Emissions Test	Compliance	Electromagnetic Enforcement – Guidance
RF Emissions CI SP R 11	Group 1 Class A	The Automated Impella® Controller uses RF energy only for its internal function. Therefore, its RF emissions are very low and are not likely to cause any interference in nearby electronic equipment.
Harmonics IEC 61000-3-2	Class A	The Automated Impella® Controller is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network that supplies buildings used for domestic purposes.
Flicker IEC 61000-3-3	Complies	

TABLE 202
Guidance and Manufacturer's Declaration – Immunity

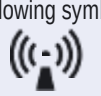
The Automated Impella® Controller is intended for use in the electromagnetic environment specified below. The customer or user of the Automated Impella® Controller should ensure that it is used in such an environment.

Immunity Test	IEC 60601 Test Level	Compliance Level	Electromagnetic Environment – Guidance
Electrostatic Discharge (ESD) IEC 61000-4-2	±6 kV contact ±8 kV air	±8 kV contact ±15 kV air	Floors should be wood, concrete, or ceramic tile. If floors are synthetic, the relative humidity should be at least 30%.
Electrical Fast Transient/burst IEC 61000-4-4 Surge IEC 61000-4-5	±2 kV Mains ±1 kV for input/ output lines ±1 kV Differential ±2 kV Common	±2 kV Mains ±1 kV for input/ output lines ±1 kV Differential ±2 kV Common	Mains power quality should be that of a typical commercial or hospital environment. Mains power quality should be that of a typical commercial or hospital environment.
Voltage dips, short interruptions and voltage variations on power supply input lines IEC 61000-4-11	> 95% dip for 0.5 cycle 60% dip for 5 cycles 30% dip for 25 cycles > 95% dip for 5 seconds	> 95% dip for 0.5 cycle 60% dip for 5 cycles 30% dip for 25 cycles > 95% dip for 5 seconds	Mains power quality should be that of a typical commercial or hospital environment. If the user of the Automated Impella® Controller requires continued operation during power mains interruptions, it is recommended that the Automated Impella® Controller be powered from an uninterruptible power supply or battery.
Power Frequency 50/60 Hz Magnetic Field IEC 61000-4-8	3 A/m	3 A/m	Power frequency magnetic fields should be that of a typical location in a typical commercial or hospital environment.

TABLE 203

Guidance and Manufacturer's Declaration – Emissions, Equipment and Systems that are Life-Supporting

The Automated Impella® Controller is intended for use in the electromagnetic environment specified below. The customer or user of the Automated Impella® Controller should ensure that it is used in such an environment.

Immunity Test	IEC 60601 Test Level	Compliance Level	Electromagnetic Environment – Guidance
			Portable and mobile RF communications equipment should be separated from the Automated Impella® Controller by no less than the recommended separation distances calculated/listed below:
Conducted RF IEC 61000-4-6	10 Vrms 150 kHz to 80 MHz	10 Vrms	$d = 0.35\sqrt{P}$
Radiated RF IEC 61000-4-3	10 V/m 80 MHz to 2.5 GHz	20 V/m	$d = 0.6\sqrt{P}$ 80 to 800 MHz $d = 1.2\sqrt{P}$ 800 MHz to 2.5 GHz Where P is the maximum power rating in watts and d is the recommended separation distance in meters. Field strengths from fixed transmitters, as determined by an electromagnetic site survey[(a)], should be less than the compliance level in each frequency range.[(b)] Interference may occur in the vicinity of equipment marked with the following symbol: 

NOTE 1: At 80 MHz and 800 MHz, the higher frequency range applies.

NOTE 2: These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects, and people.

(a) Field strengths from fixed transmitters, such as base stations for radio (cellular/cordless) telephones and land mobile radios, amateur radio, AM and FM radio broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the Impella® Controller is used exceeds the applicable RF compliance level above, the Impella® Controller should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as re-orienting or relocating the Impella® Controller.

(b) Over the frequency range 150 kHz to 80 MHz, field strengths should be less than 10 V/m

TABLE 205

Recommended Separation Distances Between Portable and Mobile RF Communications Equipment and the Automated Impella® Controller, Equipment and Systems that are Life-Supporting

The Automated Impella® Controller is intended for use in the electromagnetic environment in which radiated disturbances are controlled. The customer or user of the Automated Impella® Controller can help prevent electromagnetic interference by maintaining a minimum distance between portable and mobile RF communications equipment and the Automated Impella® Controller as recommended below, according to the maximum output power of the communications equipment.

Rated Maximum Output	Recommended Separation Distances for the Automated Impella® Controller (m)		
Output Power of Transmitter (Watts)	150 KHz to 80 MHz $d = 0.35\sqrt{P}$	80 to 800 MHz $d = 0.6\sqrt{P}$	800 MHz to 2.5 GHz $d = 1.2\sqrt{P}$
0.01	0.04	0.06	0.12
0.1	0.11	0.19	0.38
1	0.35	0.6	1.2
10	1.11	1.9	3.8
100	3.5	6.0	12

For transmitters rated at a maximum output power not listed above, the recommended separation distance (d) in meters (m) can be determined using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

NOTE 1: At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

NOTE 2: These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects, and people.

RFID Transmitter / Receiver Specifications

Frequency	13.56 MHz
Receiver bandwidth	14 kHz
Effective radiated power	30 nW
Modulation	ASK

SLAVE MONITOR CONNECTION

The Automated Impella® Controller, which is equipped with a VGA output connector, can be connected to a remote monitor to display the information from the controller to another screen at a resolution of 800 x 600 pixels. The connection between the controller and the monitor can be made using a cable up to 20 feet in length, or other MDDS device.

ALARM DELAY INFORMATION

For some Automated Impella® Controller alarms, there is a short delay between the triggered event and the audible annunciation and visual display of the alarm.

Impella Defective	8 second delay
Impella Position Wrong	11±5 second delay
Controller Error	12±3 second delay
Emergency Shutdown Imminent	15±1 second delay
Battery Failure	28±8 second delay
Controller Failure	38±8 second delay
Battery Comm. Failure	40±10 second delay
Purge System Blocked	75±45 second delay

PATIENT ENVIRONMENT

The Automated Impella® Controller and the components of the Impella® System are approved for use within the patient environment defined in IEC 60601-1: 3rd edition and in the figure below.

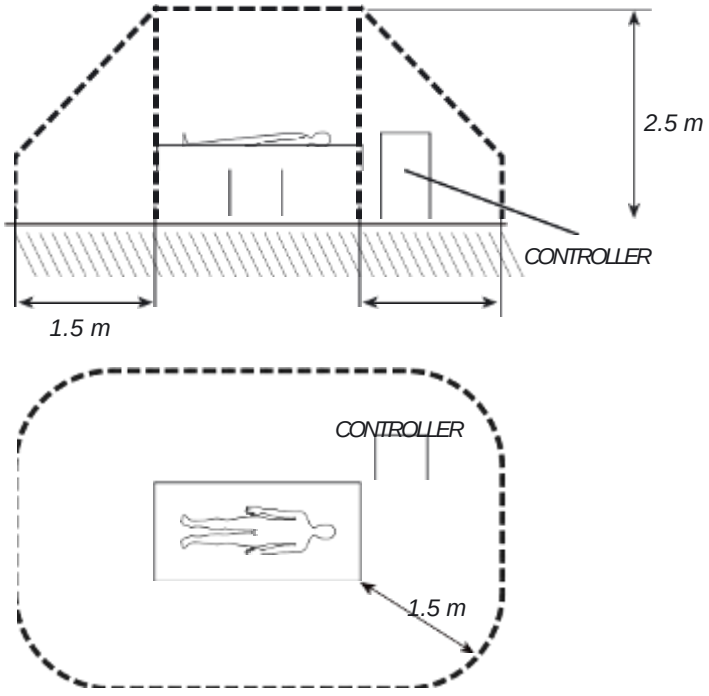


Figure 9.1 Automated Impella® Controller Patient Environment

WHITE CONNECTOR CABLE

Length	2.5 m
Service life	Single use only

IMPELLA® CATHETER PARAMETERS

Speed range	0 to 51,000 rpm
Power consumption	19.8 W
Voltage	Max. 20 V DC
Flow-Maximum	2.5 L/min
Purging the Impella® Catheter	
Recommended purge fluid	20% dextrose solution with heparin concentration of 50 IU per mL
Dextrose concentration	5% to 40%
Purge pressure	300 to 1100 mmHg
Infusion rate	2 to 30 mL/h
Catheter dimensions	
Length of invasive portion (without catheter)	130 ± 3 mm
Diameter	Max. 4.2 mm (nom. 4.0 mm)
Classification per IEC 60601-1	Protection class I, degree of protection: CF defibrillation-proof (Automated Impella® Controller and Impella® Catheter)
Latex content	Not made with natural rubber latex
Maximum duration of use	The duration of use for the Impella 2.5 Catheter is compatible with completion of PCI procedures (< 6 hours).

Latex

The Automated Impella® Controller and Impella® Catheter, including all accessories, are not made with natural rubber latex.

IMPELLA® 2.5 CATHETER DIMENSIONS

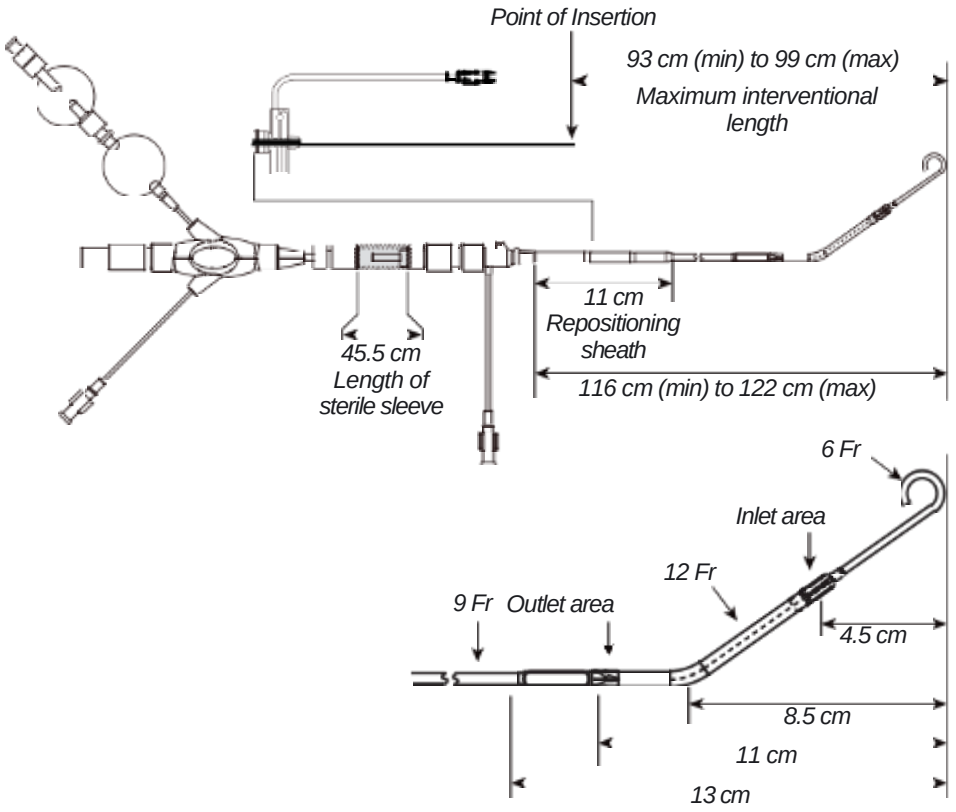


Figure 9.2 Impella® 2.5 Catheter Dimensions

CLEANING

- Clean the Automated Impella® Controller keypad and display with either 70% isopropyl alcohol or soap and water. (NOTE: Be aware that soft buttons may be activated when you spray or wipe the display.)
- Clean the Automated Impella® Controller housing with mild detergent.
- Do NOT clean with or expose any part of the clear sidearm of the Impella® Catheter (e.g., infusion filter, pressure reservoir) to alcohol. Alcohol has been shown to cause cracks and leaks in these components. Carefully read labels on common skin preps and lotions to avoid using any alcohol-containing products in the area of the infusion filter or pressure reservoir.
- Do NOT allow any fluids to enter the connector sockets.
- Clean the connector cable with 70% isopropyl alcohol.

Alcohol Warning

Do NOT clean the Impella® Catheter infusion filter or pressure reservoir with alcohol and AVOID exposing these components to products containing alcohol.

STORING THE AUTOMATED IMPELLA® CONTROLLER

The Li-Ion batteries must be charged for 5 hours prior to system operation in order to meet the runtime requirement of 1 hour. Failure to do so will yield a shorter runtime. After being unplugged, the Automated Impella® Controller will operate for at least 60 minutes after the batteries have been fully charged.

- Place the Automated Impella® Controller on a horizontal surface to prevent falling.
- Connect the AC power cord to an AC outlet.
- The battery may be destroyed if the Automated Impella® Controller is stored with a depleted battery.

Storing the Controller

To keep the Automated Impella® Controller battery charged, the controller should be plugged into an AC outlet. When plugged into an AC outlet, the controller battery will charge whether the controller is on or off.

RETURNING AN IMPELLA® CATHETER TO ABIOMED (UNITED STATES)

To return an Impella® Catheter to Abiomed, contact your local Clinical Consultant for an Abiomed-approved return kit.* The kit includes instructions for returning the Impella® Catheter to Abiomed.

** Only available in the United States.*

APPENDICES

APPENDIX A: IMPELLA® SYSTEM LIMITED SERVICE WARRANTY (UNITED STATES)

Abiomed®, Inc. warrants that, at the time of installation, all Impella® Systems (the "Goods") sold will be free from defects in material and workmanship and remain free from defects under normal use and service for a period of one (1) year from the date of shipment. Extended warranty and service may, at Abiomed's option, be offered for an additional charge, in which event separate or additional terms and conditions may apply. This warranty provides coverage for the Automated Impella® Controller.

This warranty does not cover routine preventative maintenance or replacement parts that are consumed per the controller's periodic maintenance schedule outlined in the Operator's and Service Manuals.

The express warranty set forth on this page is the only warranty given by Abiomed with respect to any goods furnished hereunder. Abiomed makes no other warranty, express, implied or arising by custom or trade usage, and specifically makes no warranty of merchantability or of fitness for any particular purpose. Said express warranty shall not be enlarged or otherwise affected by Abiomed's rendering of technical or other advice or service in connection with the Goods.

Abiomed shall not be liable for incidental or consequential losses, damages or expenses, directly or indirectly arising from the sale, handling or use of the Goods, or from any other cause relating thereto, and Abiomed's sole responsibility under this warranty will be, at its option, to 1) repair or replace the Goods or any components of the Goods found to be defective in workmanship or material during the foregoing warranty period, or 2) to refund the purchase price paid. All replaced components and Goods will become the property of Abiomed. This warranty shall not apply if the Goods have been: (a) repaired or altered in any way by other than Abiomed or Abiomed authorized service personnel; (b) subjected to physical or electrical abuse or misuse; or (c) operated in a manner inconsistent with Abiomed's instructions for use of the Goods. If Abiomed determines that a claim was not caused by Abiomed or Abiomed's authorized service personnel, then Buyer shall pay Abiomed for all related costs incurred by Abiomed. This warranty is not transferable without the express written consent of Abiomed.

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Abiomed has no obligation to provide a loaner system during service or maintenance of the Goods. However, at Abiomed's sole discretion, Abiomed may provide such loaner systems.

This warranty applies to the Automated Impella® Controller and not to any disposable or other component of the Impella® System. Specific items excluded from this warranty include, but are not limited to, pumps, external tubing, and accessories.

This warranty may not be amended without the express written consent of an authorized officer of Abiomed.

APPENDIX B: ABIOMED-APPROVED GUIDEWIRES AND INTRODUCERS

ABIOMED-APPROVED GUIDEWIRES

Use only Abiomed-tested and supplied guidewires with the Impella® Catheter. Guidewires are specifically designed with unique characteristics to optimize performance of the Impella® System. Guidewires and catheters should always be used in accordance with Abiomed's instructions.

Table B.1 lists the alternative guidewires that have been tested and approved for use with the Impella® System.

Table B.1 Alternative Guidewires

Guidewire	Catalog number
Boston Scientific Platinum Plus™ ST 0.018 in	46-605, model ST/0.018/260
Boston Scientific V-18 Control Wire™ ST 0.018 in	46-854, model V18/18/300

ALTERNATIVE QUALIFIED INTRODUCER SHEATHS

Abiomed has developed and qualified an introducer kit for use with the Impella® Catheter. This kit was specifically designed for use with the Impella® Catheter and takes into account several technical parameters, such as:

- Size of the sheath (internal diameter and length)
- Blood leakage through the hemostatic valve
- Force required to pass the device through the hemostatic valve
- The ability to replace the introducer with a longer-term sheath

Testing and qualification, based on the above criteria, has been completed.

Table B.2 describes alternative introducer sheaths that have been tested and approved for use with the Impella® System. Use this information to evaluate the performance of these alternative introducer sheaths relative to each other and to the Abiomed-provided introducer.

Table B.2 Alternative Introducer Sheaths

Manufacture	Model	Fr	Length	Catalog Number
Cook Incorporated	Check-Flo® Introducer	14	13 cm	RCF-14.0 -38-J
Cook Incorporated	Check-Flo Performer® Introducer	14	30 cm	RCFW-14.0-38-30-J

Note: Use of the Cook introducer may require higher than expected insertion and removal forces.

APPENDIX C: AUTOMATED IMPELLA® CONTROLLER MENU STRUCTURE

OVERVIEW

The soft buttons on the Automated Impella® Controller provide access to the controller menu structure. The menu structure has 5 main elements:

- **MUTE ALARM**
- **FLOW CONTROL**
- **DISPLAY**
- **PURGE SYSTEM**
- **MENU**

This Appendix provides an overview of the Automated Impella® Controller menu structure. Many of the functions accessed through this menu structure are also discussed elsewhere in this manual.

MUTE ALARM

The **MUTE ALARM** soft button mutes (silences) active alarms. It does not open another menu.

When you press **MUTE ALARM**, a bell icon with an X through it replaces the words "MUTE ALARM" in the upper right of the display screen. If no alarms are active, no bell icon is displayed. When you press **MUTE ALARM** it acknowledges all active alarms and silences the audible alarm indicator for 2 minutes (for red or yellow alarms) or 5 minutes (for white alarms). (Refer to section 7 of this manual for more information about Automated Impella® Controller alarms.)

FLOW CONTROL

The **FLOW CONTROL** soft button opens the **FLOW CONTROL** menus. Before the Impella® Catheter is started, the menu options include **OFF** and **Start Pump**. Once the controller is running, the menu options include **BOOST**, **AUTO**, and P-levels between P-0 and P-8 as shown in Figure 5.23 in this manual. The procedure for setting P-level is described in “Positioning and Starting the Impella® Catheter” in section 5.

DISPLAY

The **DISPLAY** soft button opens a menu that includes the following options for viewing waveforms and navigating to other screen displays:

- **Y-axis Scale** –opens a menu from which you can select a waveform and change its appearance by adjusting the scale of the y-axis.

  Once the waveform is selected, turn the selector knob clockwise to increase the y-axis scale and counterclockwise to decrease the y-axis scale.

  Select **OK** to accept the new y-axis scale.

  Select **Restore Default** to return to the default y-axis scale.

  Select **Center Signal** to center the waveform.

  Select **Cancel** to exit the tool.

- **Time Scale** –allows you to apply different time scales to the currently displayed waveforms.
- **Center Motor Current** – automatically centers the motor current waveform and adjusts the range accordingly.
- **Infusion** – opens the Infusion History screen. The Infusion History screen, which is discussed in section 4 of this manual, shows the volume and amount of heparin and dextrose delivered. The top entry in the table shows the volume and amount of heparin and dextrose infused from the top of the hour through the current time.
- **Purge** – displays the purge system waveforms and pressure and flow values.
- **Placement** – opens the placement signal / motor current placement screen (described in section 4 under “Placement Screen”).
- **Home** – opens the home screen (described in section 4 under “Home Screen”).

PURGE SYSTEM

The **PURGE SYSTEM** soft button opens a menu that includes the following purge system procedure options:

- **Change Purge Fluid –** starts the procedure to change the purge fluid
- **Change Purge Cassette –** starts the procedure to replace the purge cassette
- **Change Purge System –** starts the procedure to change both the purge fluid and purge cassette
- **De-air Purge System –** starts the de-air procedure
- **Transfer to Standard Configuration –** starts the procedure for transferring from the set-up configuration of the Impella® System to the standard configuration.

These procedures are described in section 5 of this manual.

MENU

The **MENU** soft button opens a menu of options related to controller settings, alarm history, repositioning, and starting a procedure. The menu includes the following options:

- **Settings / Service**
  Service
    System Information. Opens the System Information table. This provides information about the software version, IP addresses, current type of Impella Catheter, and current catheter runtime.

    Set Date/Time. Displays the menu for changing the date and time

    Service Timers. Displays the Service Timers menu. Console operating time and purge motor operating time are displayed in hours.

  Screen Brightness. Opens the Screen Brightness selection box. The brightness of the screen display can be set from 50% to 100%.

  Language. Opens the Language selection box. Use the selector knob to select German, English, French, Italian, Spanish, or Dutch. The system will immediately change the language on the controller for all displayed text. This language will be used after system restart unless another language is selected.

  Log Export. Displays the Log Export menu for exporting all logs to a USB stick.

  Disable (Enable) Placement Monitoring.

  Disable (Enable) Reverse Flow Control.

  Disable (Enable) Audio – Impella Sensor Failure. Allows you to enable or disable audio for the Impella Sensor Failure alarm. This selection is available only if an Impella Sensor Failure alarm is active or the audio has been disabled for this alarm.

  Disable (Enable) Audio – Purge Flow Low/System Blocked. Allows you to enable or disable audio for the Purge Flow Low or Purge System Blocked alarms. This selection is only available if one of these two alarms is active or the audio has been disabled for one of these alarms.

- **Alarm History** – opens the Alarm History table. This provides a visual display of the chronology of stored alarm messages. The most recently occurring alarm message is displayed at the top of the list. For each message, the date and time it occurred and the alarm message heading is displayed. You can use the selector knob to select individual alarm messages and an explanation for the selected alarm message will be displayed in the failure description box.
- **Start Data Snapshot** – starts the timed data recording function to save real-time operating data for later analysis. Timed Data Recording is described under “Timed Data Recording” in section 6 of this manual.
- **Start Repositioning Guide** – opens the repositioning guide, which provides information about the current position of the Impella® Catheter and the actions required to reposition the catheter. The repositioning guide is described under “Repositioning Guide” in section 6 of this manual.
- **Case Start** – begins the case procedure. Case Start is described in section 5 of this manual under “Case Start.”

APPENDIX D: AXILLARY INSERTION TECHNIQUE

The Impella Catheter can be inserted surgically through the axillary artery if factors such as scarring or tortuous or diseased vessels preclude femoral insertion. This appendix provides an overview of the surgical technique for axillary insertion of the Impella Catheter.

SUPPLIES NEEDED

In addition to the supplies used for femoral artery insertion of the Impella Catheter, you will also need the following for axillary insertion:

- 8 or 10 mm x 20 cm vascular graft
- 6 or 8 Fr sheath

OVERVIEW OF SURGICAL TECHNIQUE FOR AXILLARY INSERTION

1. Expose the axillary artery and wrap vessel loops distal and proximal to the point of incision.
2. Make an incision between the loops and attach an 8 or 10 mm vascular graft.
3. Attach a standard 6 or 8 Fr sheath to the end of the graft to control bleeding.
4. Insert the diagnostic catheter over a diagnostic guidewire into the left ventricle.
5. Remove the diagnostic guidewire and exchange it for the supplied 0.018 inch placement guidewire.
6. Remove the 6 or 8 Fr sheath.
7. Backload the Impella Catheter over the guidewire and insert the catheter into the vessel, advancing it along the placement guidewire into the left ventricle.
8. Remove the guidewire.
9. Cut the graft and advance the repositioning sheath into the remaining end of the graft.
10. After completion of the procedure and removal of the Impella device, cut the graft short and close the remaining graft using secure non-absorbable suture technique.
11. Close the incision site.

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