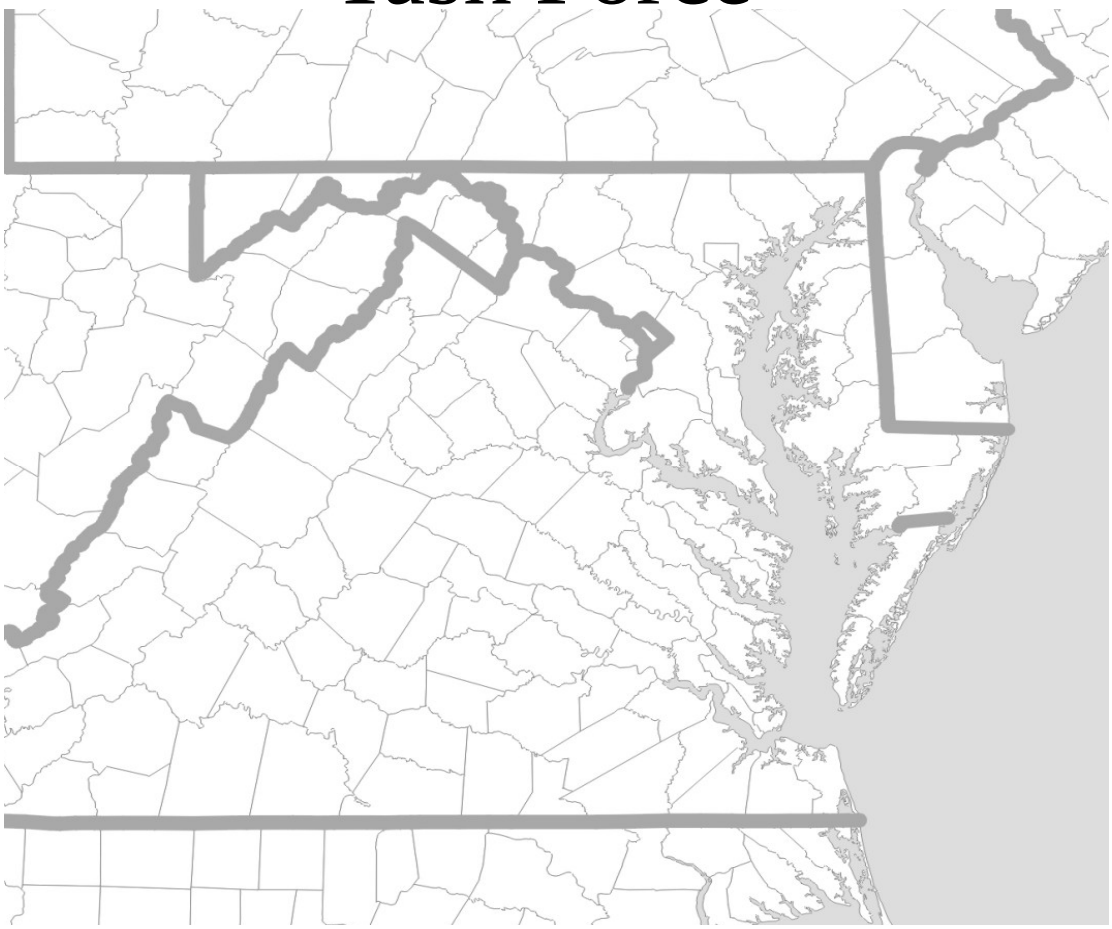
Mid-**A**tlantic **R**egional **P**re-**H**ospital

Mechanical **C**irculatory **S**upport

Task Force



2009 Field Guide

Disclaimer:
This field guide is for reference only and does not supersede any local, state, or federal procedures. Please reference your company's policies for treatment guidelines and/or the manufacturer's user guides. The content enclosed does not represent the views of any one institution.

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March 2009

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HeartWare HVAD™

1. **Can I do external CPR?**
   CPR is discouraged, but there may be instances when it may be warranted.

2. **If not, is there a "hand pump" or external device to use?**
   No.

3. **If the device slows down (low flow state), what alarms will go off?**
   A red alarm will sound.

4. **How can I speed up the rate of the device?**
   IV fluids. There is nothing in the prehospital setting to increase the output

5. **Do I need to heparinize the patient if it slows down?**
   Call the accepting VAD facility for guidance.

6. **Can the patient be defibrillated while connected to the device?**
   Yes

7. **If the patient can be defibrillated, is there anything I have to disconnect before defibrillating?**
   No, defibrillate per protocol.

8. **Does the patient have a pulse with this device?**
   The patient may be pulseless. If the patient's own heart has some function, you may be able to feel a thready pulse.

9. **What are acceptable vital sign parameters?**
   MAP>80. Use a Non-Invasive BP or Doppler to obtain a BP

10. **Can this patient be externally paced?**
    Yes

FAQs

- May not be able to obtain cuff pressure (continuous flow pump)
- Pump connected to electric line exiting patient's abdominal area and is attached to computer which runs the pump.
- Pump does not affect EKG
- All ACLS drugs may be given.
- No hand pump is available.
- A set of batteries last approximately 3 hours
- Any emergency mode of transportation is ok. These patients are permitted to fly.
- Be sure to bring ALL of the patient's equipment with them.

Adapted from Sweet, L. and Wolfe, Jr., A. Mechanical Circulatory Devices in Transport in ASTNA: Patient Transport Principles and Practice, 4th ed., Mosby, 2010 in press.

Emergency Operation

Controller

Battery

ALARM ADAPTER

- Used to silence the internal NO POWER ALARM
- Should only be used on a Controller
- Do **NOT** connect to a pump
- Must be inserted into the blue connector of the original Controller connector before both power sources are disconnected or the alarm will sound for up to 2 hours.

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HeartWare HVAD™ Emergency Operation

Driveline Connection

To Connect to Controller:

- Align the two red marks and push together. An audible click will be heard confirming proper connection. *(Figure A)*
- The Driveline Cover must completely cover the Controller's silver driveline connector to protect against static discharge. *(Figure B)*
- *NOTE: an audible click should be heard when connecting the Driveline or Driveline extension to the controller. Failure to use the Driveline Cover may cause an Electrical Fault Alarm.*

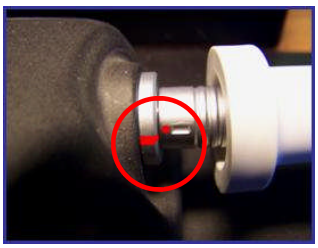


Figure A

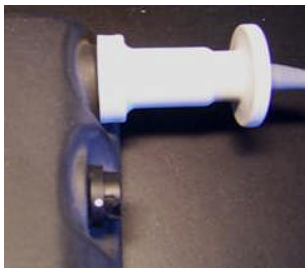


Figure B

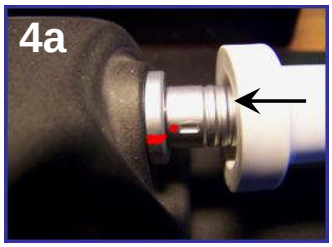
Connecting Power to Controller

To Connect:

- Grasp the distal part of connector leaving proximal part of connector free to rotate.
- Line up the solid white arrow on the connector with the white dot on the Controller and push straight in until you hear a "click." To remove battery, turn connector 1/4" turn to left to release the locking mechanism and pull straight out.
- Push the cable firmly onto the Controller until it locks into place.
- Confirm the Power Cables are properly locked on the Controller by gently pulling the cable near the Controller power connector. A "VAD Stopped" alarm will activate if the pump Driveline is not connected to the new Controller within 10 seconds. This alarm will resolve once the pump Driveline is Connected.

Steps to exchange the Controller

- **Step 1:** Access back-up controller and power sources.
- **Step 2:** Remove white driveline cover.
- **Step 3:** Connect back-up power to back-up controller.
- **Step 4:** Disconnect driveline from original controller and connect to back-up controller. Cover silver connection with white driveline cover. The pump should restart. Verify the pump is working (rpm, flow, watts). If not, call for medical assistance immediately.
- **Step 5:** Insert the red alarm adapter into the blue Connector on the original Controller.
- **Step 6:** Disconnect both power sources from original Controller. (Original Controller will turn off and all alarms silenced).



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HeartWare HVAD™ Troubleshooting

ALARM TYPE	ALARM DISPLAY (Line 1)	ACTION (Line 2)
High - Critical (FLASHING RED)	VAD STOPPED	CONNECT DRIVELINE
	VAD STOPPED	CHANGE CONTROLLER
	CRITICAL BATTERY 1	REPLACE BATTERY 1
	CRITICAL BATTERY 2	REPLACE BATTERY 2
	CONTROLLER FAILED	CHANGE CONTROLLER
MEDIUM (FLASHING YELLOW)	CONTROLLER FAULT	CALL ACCEPTING VAD HOSPITAL
	CONTROLLER FAULT	CALL: ALARMS OFF
	HIGH WATTS	CALL ACCEPTING VAD HOSPITAL
	ELECTRICAL FAULT	CALL ACCEPTING VAD HOSPITAL
	LOW FLOW	CALL ACCEPTING VAD HOSPITAL
	SUCTION	CALL ACCEPTING VAD HOSPITAL
LOW (SOLID YELLOW)	LOW BATTERY 1	REPLACE BATTERY 1
	LOW BATTERY 2	REPLACE BATTERY 2
	POWER DISCONNECT	RECONNECT POWER 1
	POWER DISCONNECT	RECONNECT POWER 2

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VentrAssist® LVAD

1. **Can I do external CPR?**
   Yes
2. **If not, is there a "hand pump" or external device to use?**
   No.
3. **If the device slows down (low flow state), what alarms will go off?**
   Low flow alarm may occur
4. **How can I speed up the rate of the device?**
   Give volume
5. **Do I need to heparinize the patient if it slows down?**
   No.
6. **Can the patient be defibrillated while connected to the device?**
   Nothing needs to be disconnected. Patient should be placed on battery power BEFORE defibrillation
7. **If the patient can be defibrillated, is there anything I have to disconnect before defibrillating?**
   No. If the defibrillation is unsuccessful, disconnect pump and continue to defibrillate.
8. **Does the patient have a pulse with this device?**
   No.
9. **What are acceptable vital sign parameters?**
   MAP 70 - 90 mm Hg with a narrow pulse pressure
10. **Can this patient be externally paced?**
    Yes.

AC power adaptor

Backpack

Batteries

Adapted from Sweet, L. and Wolfe, Jr., A. Mechanical Circulatory Devices in Transport in ASTNA: Patient Transport Principles and Practice, 4th ed., Mosby, 2010 in press.

Controller

All alarms will be displayed on the LCD screen located on the top of this controller.

The controller may need to be changed if the following alarms occur and the patient is unconscious:

- Back-up control active
- *No pump* alarm
- Blank/scrambled controller screen

***Change controller immediately if any of these alarms occur and patient is compromised.**

Steps to changing a controller

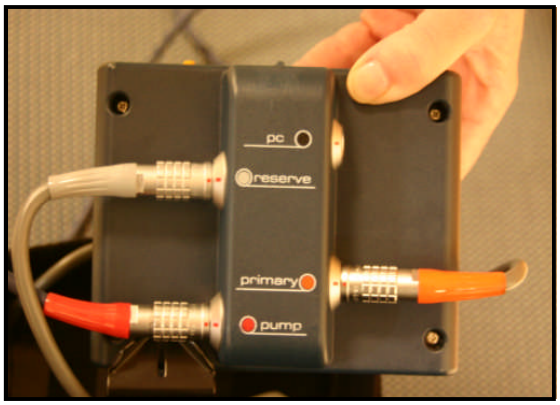
1. Locate the back-up/spare controller.
2. Unclip the primary controller connected to the patient from the bracket in the backpack.
3. Remove the controller to access the connections on the back of the controller.
4. Place the new controller near the controller that needs to be replaced.
5. Change leads from the old controller to the new controller by pulling the leads directly out (DO NOT TWIST) and place into the back of the new controller in the following order:
   --Reserve power supply lead (GRAY)
   --Pump lead (RED)
   --Primary power supply lead (ORANGE)

**When changing the leads, be sure to line up red dots to the red lines before inserting into place.*

6. Replace new controller back into bracket of the backpack.

Swap connections in this order:

GREY → RED → ORANGE



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VentrAssist® ALGORITHM

Patient NOT responsive to pain
AND
Capillary refill > 3 seconds = inadequate perfusion

Patient may **NOT** have palpable pulse or measureable blood pressure even when the pump is providing adequate circulation.
Pulse oximetry may **NOT** be reliable.

Is pump operating?

1. Check controller screen for alarms
2. Ausculate left upper abdominal quadrant: continuous whirring sound

NO

Controller Alarming
"No pump"
"Pump Stopped"

Disconnect Pump
Remove red pump lead from controller socket
Commence CPR

YES

ECG
Treat rhythms as per standard procedure

- Asystole or non-cardiovertable rhythm
- VT, VF OR cardiovertable rhythm
- Stable Rhythm

1. Ensure controller is on battery power only
2. **DEFBRILLATE** using AP placement

VT, VF or cardiovertable rhythm

1. Disconnect pump
2. Continue defibrillation

Stable Rhythm

1. Give fluid load (up to 1L Lactated Ringers/ Hartmann's solution)
2. Treat for Cardiogenic shock as per standard procedure

TRANSPORT URGENTLY TO ER (*see note below)

*If feasible, transport the patient to their implant hospital. If not, transport to the nearest hospital and contact the implant hospital for further advice.

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Thoratec PVAD™ w/TLC II Driver

1. **Can I do external CPR?**
   No
2. **If not, is there a "hand pump" or external device to use?**
   Yes, find the blue bulbs
3. **If the device slows down (low flow state), what alarms will go off?**
   Loss of fill alarm will occur
4. **How can I speed up the rate of the device?**
   IV fluids.
5. **Do I need to heparinize the patient if it slows down?**
   Only if it stops
6. **Can the patient be defibrillated while connected to the device?**
   Yes
7. **If the patient can be defibrillated, is there anything I have to disconnect before defibrillating?**
   No.
8. **Does the patient have a pulse with this device?**
   Yes.
9. **What are acceptable vital sign parameters?**
   Normal blood pressure parameters.
10. **Can this patient be externally paced?**
    Because both sides of the heart are supported, there is little need to pace regardless of the rhythm seen on ECG.

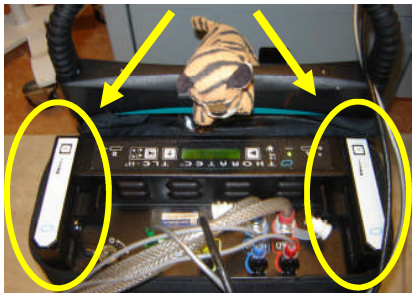
    BUT it can be done if clinically indicated

Adapted from Sweet, L. and Wolfe, Jr., A. Mechanical Circulatory Devices in Transport in ASTNA: Patient Transport Principles and Practice, 4th ed., Mosby, 2010 in press.

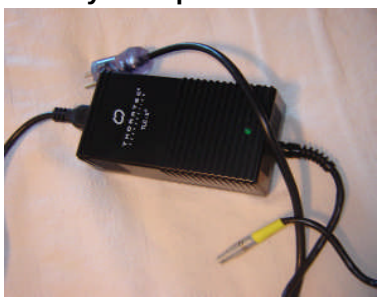
- These patients have biventricular support through 2 pumps: right and left.
- EKG will **NOT** correlate with the patient's pulse.
- Patient may be in any arrhythmia, but because they have biventricular support—**DO NOT TREAT** arrhythmias. Only RVAD or LVAD patients should be treated for arrhythmias.
- Bring all extra batteries & electrical adaptor along during transport. This system is electrically driven.
- The pumps are driven by a compressor called the TLC II driver. The pneumatic hoses and cables plug into the top of the TLC II driver.
- If the Driver loses power, malfunctions, or stops, use the hand pump(s). ***(hand pump instructions on back of this page)***
- Continue hand pumping and then, as soon as possible, replace the TLC II Driver with the backup Driver.
- Backup Driver accompanies the patient at all times. ***(Driver replacement instructions on back of this page)***
- **WARNING:** If the pump has stopped and blood is stagnant in the device for more than a few minutes (depending on the coagulation status of the patient), there is a risk of stroke or thromboembolism. If, or when, the device is restarted or hand pumping is initiated, contact the implanting center for anticoagulation direction.

Battery Charger

Batteries loaded into battery slots on TLC-II Driver



AC Power adapter –plug into yellow port on driver



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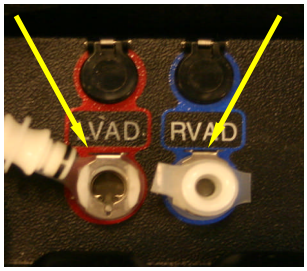
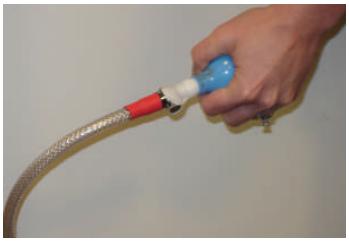
Hand Pumping Instructions

Step 1: Obtain hand pump(s) from carrying case. Note: One (1) hand pump is needed for each VAD



Step 2: Depress metal clip(s) to disconnect the pneumatic lead(s) from the TLC II Driver.

Step 3: Connect the hand pump(s) to the pneumatic lead(s).



Step 4: Squeeze hand pump(s) once per second. Use your foot if necessary.
Note: For 2 VADs (BiVADs), squeeze each hand pump at the same rate. Never hand pump the right VAD (RVAD) faster than the left VAD (LVAD), as this may cause pulmonary edema.

Switching to Backup TLC-II Driver

Step 1: Insert a fully-charged battery (stored in carrying case) into each battery slot of backup TLC-II driver.

Step 2: Turn on key switch

Step 3: Depress metal clip(s) to remove white occluder from pneumatic port(s):

- (LVAD port is **RED**
- RVAD port is **BLUE**).
- **Note:** for BiVADS, switch LVAD first. Do **NOT** remove occluder caps from both ports at the same time (or from unused port during single VAD support), or system will depressurize.

Step 4: Disconnect pneumatic lead(s) from primary Driver (or hand pump) and connect to backup Driver.

Step 5: Disconnect electric leads(s) from primary Driver and connect to backup Driver.

Step 6: Place Driver in AUTO mode, if necessary. Note: Backup Drivers are preprogrammed with a patient's unique settings.

Step 7: Verify full signal(s) is/are ejecting completely.

Step 8: Remove key and place in carrying case pocket.

Step 9: Connect to external power, if available by using the AC power adapter cord.

All modes of emergency transport are acceptable for VAD patients. Aviation electronics will NOT interfere with VAD operation (and vice versa).

Air Transport Consideration: In rotor wing and fixed wing aircraft flying at heights lower than 10,000 feet-when using the hand pump for external CPR, you must re-purge the bulb every 2000 feet in ascent and 1000 feet in descent. This will assure you have consistent cardiac output.

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Jarvik 2000 FlowMaker®

1. Can I do external CPR?
Yes.

2. If not, is there a "hand pump" or external device to use?
No.

3. If the device slows down (low flow state), what alarms will go off?
The Underspeed indicator light. If the pump is stopped you will hear a steady alarm and the pump stopped symbol will light up red. This symbol is shaped like a stop sign with a bell in it.. See next page for symbols and locations. Change to a fully charged battery or change from the reserve battery to the L-ion battery.

4. How can I speed up the rate of the device?
Jarvik has an indicator dial usually at a speed set at 3.

5. Do I need to heparinize the patient if it slows down?
No.

6. Can the patient be defibrillated while connected to the device?
Yes

7. If the patient can be defibrillated, is there anything I have to disconnect before defibrillating?
No.

8. Does the patient have a pulse with this device?
Yes. Palpable pulse depends on ventricular contractility, preload and afterload.

9. What are acceptable vital sign parameters?
Jarvik suggests MAP 65 -75 mm Hg

10. Can this patient be externally paced?
Yes

Adapted from Sweet, L. and Wolfe, Jr., A. Mechanical Circulatory Devices in Transport in ASTNA: Patient Transport Principles and Practice, 4th ed., Mosby, 2010 in press.

- **All ACLS medications can be administered.**
- **The Li-Ion battery can provide up to 10 hours of power when fully charged.**
- **When switching to the reserve battery be sure to follow the color coding of the cables**

Controller attached to the portable Li-ion battery.

Reserve Battery Pack

Jarvik 2000 FlowMaker® system

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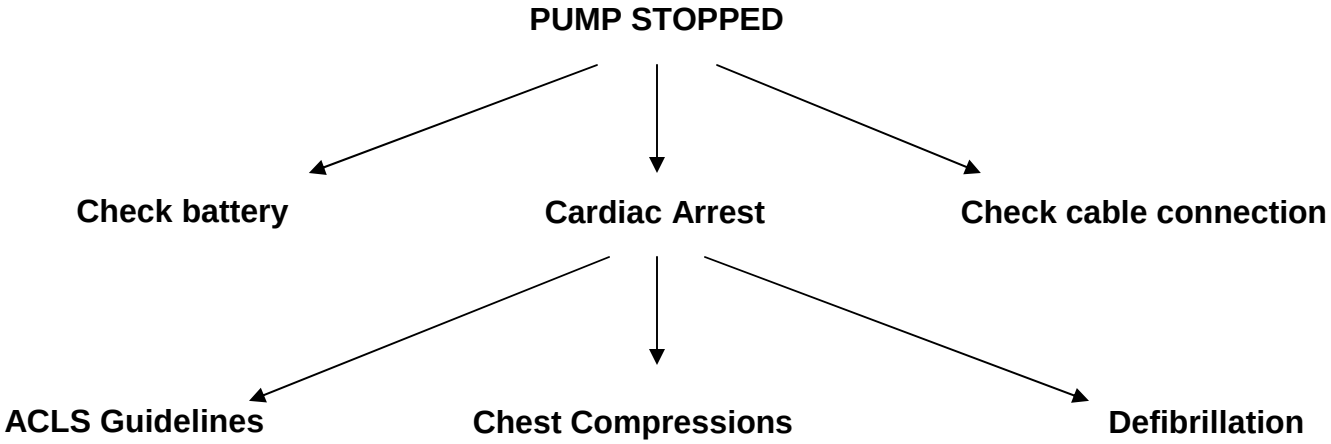
Jarvik 2000 FlowMaker®
Emergency Response Algorithm



If a patient does present with V-tach / V-fib, they are often conscious, but very weak and upon assessment have the classic low output signs.

Jarvik 2000 FlowMaker Controller
Indicators and Troubleshooting

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HeartMate II®

1. Can I do external CPR?
Only if absolutely necessary

2. If not, is there a "hand pump" or external device to use?
No.

3. If the device slows down (low flow state), what alarms will go off?
A red heart alarm light indicator and steady audio alarm will sound if less than 2.5 lpm.

4. How can I speed up the rate of the device?
Check for hypovolemia or right heart failure and treat

5. Do I need to heparinize the patient if it slows down?
Usually no, but you will need to check with implanting center

6. Can the patient be defibrillated while connected to the device?
Yes

7. If the patient can be defibrillated, is there anything I have to disconnect before defibrillating?
No.

8. Does the patient have a pulse with this device?
May have weak pulse or lack of palpable pulse.

9. What are acceptable vital sign parameters?
MAP 70-90 mm Hg with a narrow pulse pressure

10. Can this patient be externally paced?
Yes.

Adapted from Sweet, L. and Wolfe, Jr., A. Mechanical Circulatory Devices in Transport in ASTNA: Patient Transport Principles and Practice, 4th ed., Mosby, 2010 in press.

FAQs

- May not be able to obtain cuff pressure (axial flow pump)
- Pump connected to electric line exiting patient's abdominal area and is attached to computer which runs the pump.
- Pump does not affect EKG
- All ACLS drugs may be given.
- No hand pump is available.
- A set of batteries last approximately 3 hours
- Any emergency mode of transportation is ok. These patients are permitted to fly.
- Be sure to bring ALL of the patient's equipment with them.

TROUBLE SHOOTING: HeartMate II®

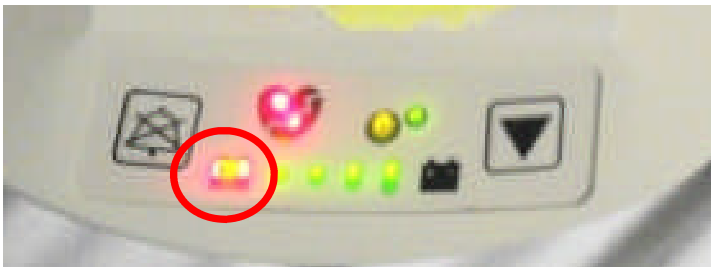
When the Pump Has Stopped

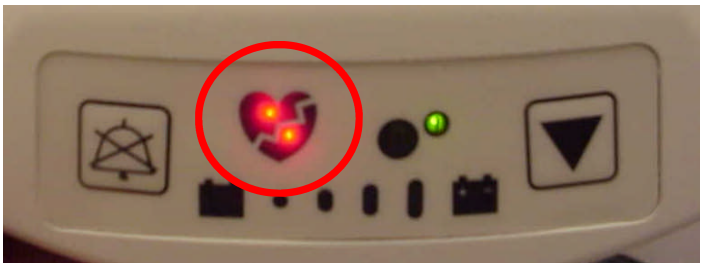
- Check the connections between the controller and the pump and the power source
- Fix any loose connection (s) to restart the pump.
- If the pump does not restart and the patient is connected to batteries replace the current batteries with a new, fully-charged pair *(see changing batteries section no next page)*
- If pump does not restart, change controllers *(see changing controllers section on next page)*

Alarms: Emergency Procedures

Yellow or Red Battery Alarm: Need to Change Batteries.
See changing batteries section on next page.

Red Heart Flashing Alarm: This may indicate a Low Flow Hazard. Check patient--the flow may be too low. If patient is hypovolemic, give volume. If patient is in right heart failure--treat per protocol. If the pump has stopped check connections, batteries and controllers as instructed in the section above.





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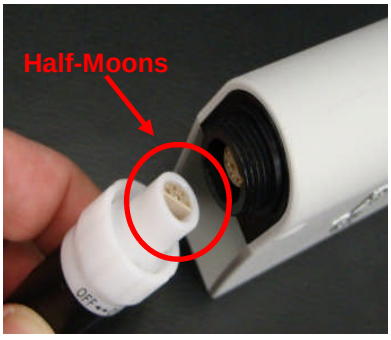
TROUBLE SHOOTING: HeartMate II®

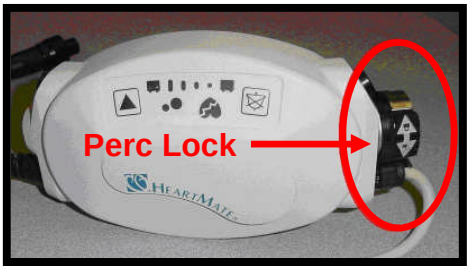
Changing Batteries

- **Warning:** At least one power lead must be connected to a power source **AT ALL TIMES**. Do not remove both batteries at the same time or the pump will stop.
- Obtain two charged batteries from patient's accessory bag. Charged batteries should be marked with a white fuzzy tab on the end of the battery.
- Remove only **one** battery from the clip by pressing the black tab on the battery clip to unlock battery.
- Controller will start beeping and flashing green signals.
- Replace with new battery by lining up arrows on battery and clip.
- Slide a new, fully-charged battery into the empty battery clip by aligning the black arrows. The battery will click into the clip. Gently tug at battery to assure connection. If battery is properly secured, the beeping and green flashing will stop.
- Repeat previous steps with the second battery and battery clip

Changing Controllers

- Place the replacement Controller within easy reach, along with the batteries/battery clips. The spare Controller is usually found in the patient's travel case.
- Make sure patient is sitting or lying down since the pump will momentarily stop during this procedure.
- Attach the battery clip to the spare controller by lining up the half moons and gently pushing together and attach the battery to the spare controller by aligning the black arrows. ALARMS WILL SOUND-THIS IS OK.
- Depress the silence alarm button (upside-down bell with circle) until the alarm is silenced on the new, replacement Controller
- Rotate the perc lock on the replacement controller in the direction of the "unlocked" icon until the perc lock clicks into the fully-unlocked position. Repeat this same step for the original Controller until the perc lock clicks into the unlocked position.
- Disconnect the perc lead/driveline from the original controller by pressing the metal release tab on the connector socket. The pump will stop and an alarm will sound. Note: The alarm will continue until power is removed from the original Controller. **Getting the replacement Controller connected and the pump restarted is the first priority.**
- Connect the replacement Controller by aligning the black lines on the driveline and replacement Controller and gently pushing the driveline into the replacement Controller. The pump should restart, if not complete the following steps:
    1. Firmly press the Silence Alarm or Test Select Button to restart the pump
    2. Check the power source to assure that power is going to the controller
    3. Assure the perc lead is fully inserted into the socket by gently tugging on the metal end. **DO NOT** pull the lead.
- After the pump restarts, rotate the perc lock on the new controller in the direction of the "locked" icon until the perc lock clicks into the fully-locked position. If unable to engage perc lock to the locked position, gently push the driveline into the controller to assure a proper connection. Retry to engage perc lock.
- Disconnect power from the original Controller. The original Controller will stop alarming once power is removed.





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HeartMate® XVE

1. Can I do external CPR?
No.

2. If not, is there a "hand pump" or external device to use?
Yes. Pump at a rate of 60 - 90 beats per minute.

3. If the device slows down (low flow state), what alarms will go off?
A red heart alarm light indicator and steady audio alarm will sound if less than 2.5 lpm. Check for hypovolemia or right heart failure and treat if red heart alarm persist after treatment consider performing a controller exchange.

4. How can I speed up the rate of the device?
Give volume

5. Do I need to heparinize the patient if it slows down?
Please check with the accepting hospital.

6. Can the patient be defibrillated while connected to the device?
No.

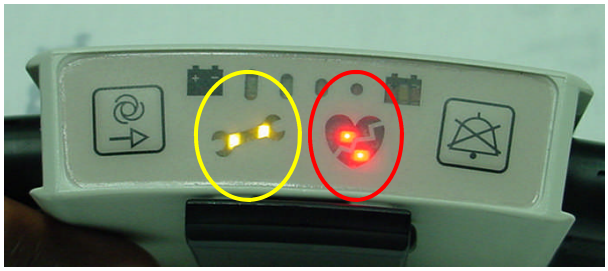
7. If the patient can be defibrillated, is there anything I have to disconnect before defibrillating?
Yes, disconnect from power/batteries first, initiate hand pumping, disconnect controller from driveline, defibrillate the patient, remove hand pump, reattach driveline to patient, and then reattach the power source.

8. Does the patient have a pulse with this device?
Yes, the device produces a Pulsatile flow. Heart rate is independent of pump rate.

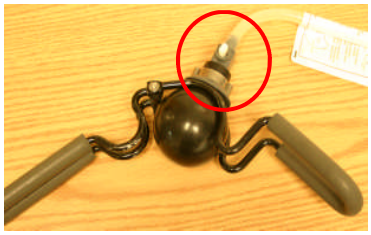
9. What are acceptable vital sign parameters?
The BP will vary. 110/80 - 140/80. If greater, call the accepting hospital.

10. Can this patient be externally paced?
Yes, keep MA less than 40.

Adapted from Sweet, L. and Wolfe, Jr., A. Mechanical Circulatory Devices in Transport in ASTNA: Patient Transport Principles and Practice, 4th ed., Mosby, 2010 in press.



Heartmate XVE Controller showing yellow wrench & Red Heart indicator lights



Hand pump & white purge valve

Hand Pumping Procedure

Push in white purge valve

Press the black ball while holding down the white purge valve.

Release purge valve.

Count to 10, push white purge valve & black bulb should re-inflate.

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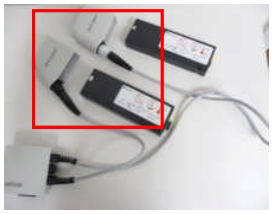
March 2009

HeartMate® XVE

Steps to exchange Controller

Step 1: Place new System Controller within easy reach. Have **Hand Pump** nearby.

Step 2: Disconnect Power source (Batteries, PBU, or EPP) from System Controller. *The System Controller will alarm and the pump will stop.*



Step 3: Disconnect the Driveline (coming from the patient) from the System Controller by pushing down on the black release button and gently pulling the Driveline connector out of the XVE System Controller socket.

Step 4: Connect the Driveline to the new, replacement XVE System Controller by lining up the small black arrows on the Driveline connector and System Controller socket *FIGURE A*. Gently push the connector into the socket until it snaps into place *FIGURE B* *The new System Controller will alarm if the System Controller Battery Module is NOT in place. This is normal and should stop after the System Controller Battery Module is inserted.*

Step 5: Connect the new System Controller to power source (Batteries, PBU, or EPP). *Your pump will restart and alarm will stop.*

Step 6: If the pump does not restart, disconnect System Controller from power source and call for medical assistance; then immediately begin hand pumping.

Air Transport Consideration: In rotor wing and fixed wing aircraft flying at heights lower than 10,000 feet-when using the hand pump for external CPR, you must re-purge the bulb every 2000 feet in ascent and 1000 feet in descent. This will assure you have consistent cardiac output.

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Troubleshooting: HeartMate® XVE

Half Yellow Wrench
Once-per-second beep

Yellow Wrench
Once-per-second beep

Flashing Yellow Battery
No audio tone

Yellow Battery
Once-per-second beep

- Controller inoperable
- Controller malfunction — Rate control fault
- Current limit advisory
- Power cable or battery is disconnected
- XVE system controller battery module voltage low
- Low voltage advisory **(Less than 15 minutes of battery power remain)**

1. Check all XVE system controller connections.
2. Change vent filter, and check vent port for foreign matter.
3. Replace XVE system controller.
4. Replace the power base unit (PBU) cable.
5. Replace PBU.
6. If the Yellow Wrench persists and the XVE LVAD remains operational, seek additional help.

Reconnect cable/ battery: or reinsert battery into battery clips

1. Replace XVE system controller battery module.
2. Perform XVE system controller self-test to clear alarm.

Change to alternate power source

If the XVE system controller is connected to the pecutaneous tube and all power is removed, the XVE system controller will elicit a continuous audio tone signalling the loss of power. This condition is not accompanied by a visual alarm.

Red Heart
Continuous Audio Tone

Red Battery
Continuous Audio Tone

Flashing Yellow Battery, Red Heart, & Yellow Wrench
Continuous Audio Tone

- NO OP or LOW BEAT RATE (Less than 35 BPM)
- LOW STROKE VOLUME* (Less than 25 ML)
- LOW FLOW* (Less than 1.5 LPM)

1. Check connections between XVE system controller and XVE LVAD percutaneous tube, and between XVE system controller and batteries or power base unit (PBU).
2. Remove vent filter, and check vent port for foreign matter.
3. If condition persists, disconnect power and initiate hand pumping.
4. Seek additional help.

LOW VOLTAGE **(Less than 5 minutes of battery power remain)**

1. XVE LVAD will automatically go to PowerSaver mode (50 BPM).
2. Immediately replace batteries or connect to power base unit (PBU) cable.
3. If AC or battery power is unavailable, use emergency power pack (EPP).
4. If AC power, battery power and EPP are unavailable, disconnect power and initiate emergency hand pumping.

XVE system controller disconnected from patient

1. Check XVE system controller cable connection to XVE LVAD percutaneous tube.
2. Insure that both batteries are properly inserted into the battery clips; XVE system controller power cables are properly connected to the power base unit (PBU) Cable.
3. Ensure that PBU Cable is connected to back of PBU.
4. If condition persists, disconnect power and initiate hand pumping.
5. Seek additional help.

***Note**: DO NOT hand pump if there is blood in the vent port. Conditions that affect pump filling, such as hypertension, hypovolemia, or mechanical defects, may limit the restoration of normal pump flows until the conditions are resolved. Hand pumping may be ineffective under these conditions.

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