Berlin Heart
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LPCH CVICU-Mechanical Support

• With the Berlin Heart you have the ability to visualize both chambers of the VAD.
• This allows you to assess for complete fill and eject of the VAD.
• In addition you are able to assess the VAD for clots/deposits.

Thoratec vs. Berlin Heart

• Thoratec
  • FDA approved
  • Equipment available in facility
  • A blood pump size (65 ml) because of significant size for FDA approval process for smaller blood pumps

• Berlin Heart
  • Labor intensive FDA process for US
  • Equipment not available in facility
  • Variety of blood pump sizes (10 ml - 60 ml)

Berlin Heart Driver Console

Display

Parameter table for displaying changing operating parameters and trends

Graphic real time display of the current data

Message window
The Berlin Heart VAD Flow....

- Deoxygenated blood flows into the right atrium (1)
- Right atrium unable to pump to lungs so blood goes into Berlin Heart and pumped through pulmonary artery to the lungs (2)
- Oxygenated blood from lungs returns to left atrium to the left ventricle (4)
- Blood flows from left ventricle to Berlin Heart then from Berlin into the aorta (3) and out to the body

Cannulae Placement

- RVAD
  - Right ventricle to Pulmonary artery
  - Right Atrium to Pulmonary artery
- LVAD
  - Left ventricle to Aorta
  - Left atrium to Aorta
  - Not common practice
  - LPCH performed LA cannulation in North America
- Tissue granulation occurs around cannulae

What Happens in the OR

- Pre-implant assessment of right heart function
- LVAD—preferable
- Patient will be assessed in OR after the LVAD placement for right heart fix—usually 1-2 hours
- Patient will be assessed for Bleeding and any corrections will be made in the OR before leaving
- Settings for VAD will be established in the OR and once stable on those settings will return to the PICU

Surgical Implantation
Berlin Components

- Ikus - Driver
- Cannulas
- Blood pump
- Drive line

Blood Pump

- Sizes
  - 10 ml
  - 20 ml
  - 30 ml
  - 50 ml
  - 60 ml
  - 80 ml
- Valves
  - Inlet
  - Outlet
  - Diaphragm

Excor 10ml Blood Pump

Selection of Pump Size

For RVAD use combination of 10/10 ml, 20/30 ml, 50/60 ml. Larger pump volume on the left side prevents pulmonary congestion.

Incomplete Filling/Emptying

- Incomplete filling
- Complete filling

Pump Cycles

- 2 Cycles
  - Filling - diastole - vacuum
  - Emptying - systole - drive pressure
- Maximum flow is achieved through complete filling and emptying
Filling Phase

- Assisted by vacuum
- How do I know it's filling?
  - Completely convex

Incomplete Filling

- Hypovolemia
- Bleeding
- RV failure with LVAD support
- Ventricular recovery
- Cardiac tamponade
- Inadequate pharmacologic support
- VAD cannula position change
- Cannula or drive line kinked
- Insufficient vacuum
- Rate set too high, % systole set too high

Ejection/Emptying Phase

- Ejection assisted by Drive Pressure (Set systolic pressure)
- Pressure is usually set approx. 100mmHg greater than peak systolic pressure
- How do I know it's ejecting?
  - Completely concave

Incomplete Ejection

- EXCOR pressure too low
- Set % systole too low
- Systolic pulmonary pressure or systolic blood pressure too high
- Outflow cannula kinked

Complete Filling & Ejection Preven...<br> <br> % Systole

- What is % systole?
  - The amount of time you tell the pump to spend in ejection
  - If the % systole is increased = longer ejection, less time filling
  - If % systole is decreased (too short) = more time filling, less time ejecting

Complete filling and ejection are required to prevent stasis in the VAD and prevent thrombus formation.
Pump Assessment

- Assess every hour (and pm) for:
  - Clot
  - Red/Purple
  - Pinpoint or strand
  - Deposit
  - White
  - Pinpoint strand
  - Complete Filling (Convex)
  - Complete Emptying (Concave)

- Most common area of clot/deposit formation: Valves
Deposit Development

- "pin-point"
- thin layer (almost translucent)
  - Check anticoagulation parameters
  - Check Platelet aggregation regimen
  - Adjust therapy if levels not within range

Deposit in Silicone Cannula

- poor filling
- low rate / flow for prolonged time (weaning)
- mismatch between pump size and cannula

Pump Assessment: Deposit/Clot Formations

- white deposit
  - check anticoagulation/aggregation parameters
  - depending on patient situation
    - pump position (left / right)
    - controlled close monitoring
- red clot usually in combination with white formation
  - Re-evaluate after 24h of COPAXIS Pump

User Interface / Laptop Display

Operations

- Univad connections are made to the RED Outlet – Even with RVAD
- Systolic pressure usually set – 100mmHg > than patient’s systolic blood pressure
- Ejection time is % systole = amount of time heart spends in ejection
Main Power Switch

- The main power switch must NEVER be turned off
- The key should NEVER be touched

Battery

- Console must always be plugged into a red outlet
- Always be aware of outlets during transport
- Battery light LEDs are illuminated with battery operation
- Approximate battery time is ~60 minutes
- Recharge time is 6 hours
- Be certain that green light is illuminated on the connection panel when it is in A/C mode

Battery Emergency

- Plug in IMMEDIATELY if console reads “Battery power discharged” and LEDs flash
- * Never fully discharge the batteries! The system cannot be restarted if the batteries are depleted!

Alarms

- When message occurs:
  - Audible alarm
  - Alarm light illuminates
  - Text message display
    - Time
    - Problem
    - Action

Alarm Example

- Message window indicates alarm type, time and if corrected displays “OK” message.
- For example: “Left pump is filling insufficiently!” - “Left: Driving line/pump OK.”

Common Alarms

- Insufficient filling – Check pump
  - Kinked cannula
  - Kinked or occluded drive line
- Manipulating the laptop will trigger an alarm
  - Can only be silenced through computer access
- Disconnection of drive tube
**Actions**

- Inspect drive tube and all connection sites
- Examine pump diaphragm for proper function
- Check cannulae
- Check patient

**Goal of Device Operation**

- Minimal to no console adjustment

**Hand Pumping**

- Disconnect at connector site
- Connect to hand pump
- Pump rhythmically > 30 BPM (50 – 90 BPM)
- Do not need to pump to full extension—only enough to completely fill and empty diaphragm
- Monitor hemodynamics, neuro status, pump diaphragm

**Backup operation left / right**

If the left-hand (or the right-hand) drive is defective. The respective pump will be powered by the backup drive.

- Normal operation
  - Drive 1: left pump
  - Drive 2: right pump
  - Drive 3: backup
- Failure of one unit
  - Drive 1: failure
  - Drive 2: right pump
  - Drive 3: left pump
  - The message "Backup operation left/right* is shown.
- Failure of two units
  - Drive 1: failure
  - Drive 2: failure
  - Drive 3: left & right pump
  - The message "emergency mode" is shown.
**Travel**
- VAD Off-Unit protocol
- Notify:
  - Charge nurse/Resource
  - VAD Call Person
  - Attending/unit fellow/HP
  - Ascom Phone
- Berlin documentation
- Hand pump
- Red Outlets

**Bleeding Risk Factors**
- Prior surgeries
- Anticoagulation
- Prolonged CPB time
- Prolonged clotting time

**Thromboembolism Risk Factors**
- *Inadequate anticoagulation
- *Incomplete VAD ejection
- *Low VAD flow/stasis in pump
- *High fibrin or platelet count
- Dehydration
- Sepsis
- Cannula or pneumatic hose kinking

**Thromboembolism Management**
- *Anticoagulation (monitor PT, PTT, INR, TEG, platelet mapping, antifactor XA)
- *Anti-platelet medications (Aspirin, Persantine)
- *Verify complete VAD emptying
- *Smooth diaphragm for Berlin Heart
- Early mobilisation
- Treat hypertension
- Treat infections

**Anti-Platelet/Anti-Coagulation Medications**
- Initial post-operative period patient's are generally on Heparin
- Aspirin or Persantine will be added
- Once Coumadin started, patient weaned from Heparin
- Always check for Heparin, Lovenox or Coumadin
- Always check for INR with Coumadin
- Verify Coumadin 1x dose on MAR

**Arrhythmia**
- SOB
- Hypotension
- Decrease VAD filling
- Decreased VAD output
- May cause thrombus formation in native ventricle
- Patient can maintain flow in BiVAD
- Cardioversion will not harm VAD or Console
Infection Control

- Prolonged hospitalization
- Mobilize as soon as possible
- Encourage eating
- Good hand washing
- Strict adherence to dressing change protocol
- Observe any changes in cannulation/incision sites
- Invasive lines
- Blood cultures/WBC

Bedside Management

- Adequate pre-load necessary for acceptable VAD output
- Wean pharmacological support
- Early extubation and rehabilitation
- Early removal of IV lines
- Transfer from ICU

Hemodynamic Monitoring

- Record VAD settings/VAD Output
- Perfusion
- Blood Pressure
- O2 Saturations
- Lab Values
- Observe complete pump filling
- Observe complete pump emptying
- Listen for audible VAD clicking
- Check for cannula kinks

Bedside Management

- Adequate pre-load necessary for acceptable VAD output
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- Early removal of IV lines
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Signs of Cardiac Tamponade

- Atrial and pulmonary pressures increase
- VAD does not fill (Stroke volume decreases)
- VAD output (CO) decreases
- BP decreases
- O2 Saturation decreases
- Tachycardia/Arrhythmias
- Widening mediastinum
- Cyanosis

RV Failure

- Increased RA pressure
- Decrease or unchanged LA pressure
- LVAD does not fill
- VAD output decreases
- Decreased SVO2
- Atrial Arrhythmias

RV Failure Management

- Pharmacological management
- Pulmonary vasodilators
  - Nitric Oxide
  - RVAD
### BiVAD Support

- Indications for BiVAD
- Signs of right heart failure
- Intractable arrhythmias
- RV/Septal infarction
- Elevated PVR
- Secondary organ involvement
- Prolonged cardiogenic shock "sicker patients"

### Hypertension

- TREAT!! WHAT IS THE CAUSE
- Narcotic / Sedation as needed
- Nipride to keep WNL
- May need to add Hydralazine
- May need after-load reduction: Milrinone

### Hypotension

- TREAT!!
- Volume- NS/5% Albumin/PRBC
- Poor Function ?
- Dopamine
- Epinephrine

### Nursing Orders and Interventions

- Assess hemodynamic status for signs and symptoms of potential problems
- Observe for signs and symptoms of organ dysfunction LOC, perfusion, urine output, liver function.
- Administer 5% albumin, NS to maintain desired filling pressures per MD volume replacement orders

### Altered CNS Status

- May be subtle findings such as irritability or maybe overt localizing findings such as hemiparesis
- May or may not be preceded by visible embolization
- Action to be Taken:
  - Requires RAPID clinical response, as treatment for stroke should be initiated within 3 hours of event for best outcomes
  - Initiate call to the on-call VAD MD/NP. Will need an CT scan

### Abdominal Pain

- Maybe manifestations of embolus to abdominal arterial supply causing ischemia pain
- Maybe abdominal clot
- Actions to be Taken:
  - Rapid response to preserve bowel integrity. Call to MD/NP may need CT angio
  - Evaluate pump for change in thrombi
Troubleshooting

Causes:
- Hypovolemia
- Bleeding
- RVAD failure
- Cardiac tamponade
- Inadequate pharmacological support
- Cannula position
- Insufficient vacuum

Incomplete Ejection
- Drive pressure too low
- Set % systole too low
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Nutritional Support
- Poor appetite common after implantation – high calorie diet
- Nausea
- Supplemental enteric feeds
- Small frequent meals
- Family participation
Rehabilitation

• Rehabilitation is crucial in both the pre- and post-op periods
• PT/OT involvement
• OOB as soon as able
• Coercion/Deals

Description of the EXCOR® Pump Record

For a short description of the results we recommend following code:

I = small amount
A = large amount
P = large portion
F = small portion
T = large threshold

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Vg</th>
<th>L/min Pump</th>
<th>Ref. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/01/01</td>
<td>12:30</td>
<td>z.b.</td>
<td>10</td>
<td>215</td>
</tr>
</tbody>
</table>