



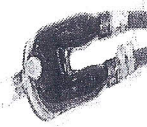
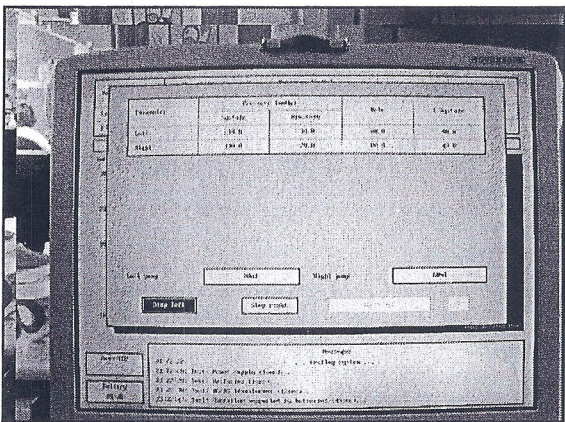
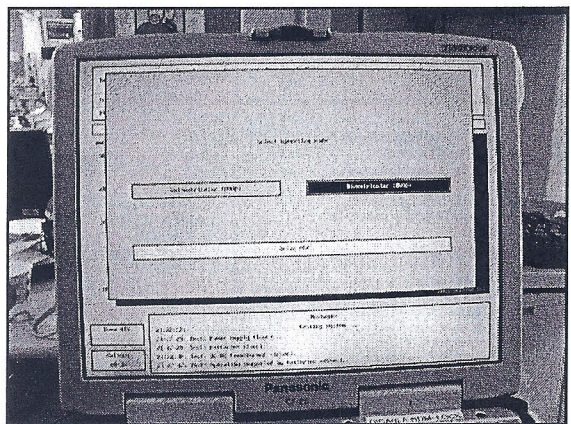
Berlin Heart
Maryalice Gowen RN, BSN
LPCH CVICU-Mechanical Support

Thoratec vs. Berlin Heart

- **Thoratec**
 - FDA approved
 - Equipment available in facility
 - 1 blood pump size (65 ml) because of significant \$ 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

- 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.

Berlin Heart Driver Console Display

Parameter	Operation	Pressure (mmHg)		Rate	% Systole
		Systole	Diastole		
Left	L	100.0	-10.0	90.0	90.0
Right	R	100.0	-10.0	90.0	90.0

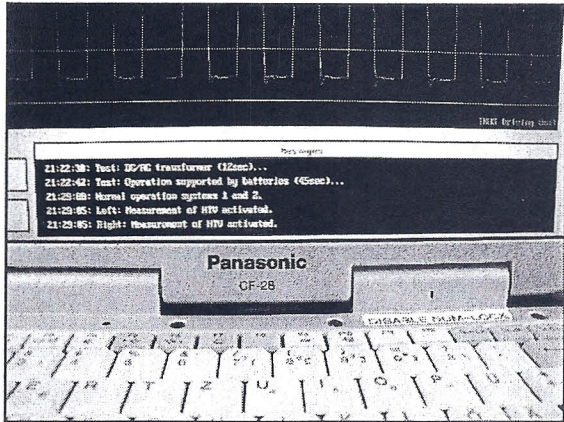
A Parameter table for displaying/c hanging operating parameters and models

B Graphic real time display of the current data

C Message window

```

Messages
11:44:361 ... testing system ...
11:44:362 ... testing system 2 ...
11:44:371 ... testing system ...
11:44:381 ... testing system ...
11:44:382 ... testing system 1 and 2 ...
  
```

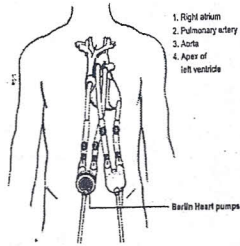


Cannulae Placement

- **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 1st LA cannulation in North America
- Tissue granulation occurs around cannulae

The Berlin Heart VAD Flow....

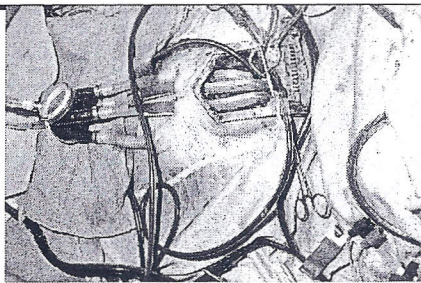
- Deoxygenated blood flows into the right atrium (1)
- Right atrium unable to pump to lungs so blood goes into Berlin Heart and pumped through pulmonary artery to the lungs (2)
- Oxygenated blood from lungs returns to left atrium to the left ventricle (4)
- Blood flows from left ventricle to Berlin heart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



What Happens in the OR

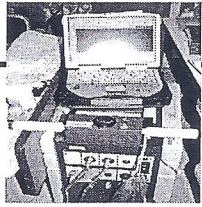
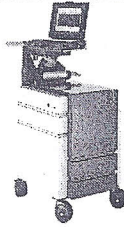
- Pre-implant assessment of right heart function
- LVAD—preferable
- Patient will be assessed in OR after the LVAD placement for right heart fx— usually 1-2 hours
- Patient will be assessed for Bleeding and any corrections will be made in the OR before leaving
- Settings for VAD will be established in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

Surgical Implantation



Berlin Components

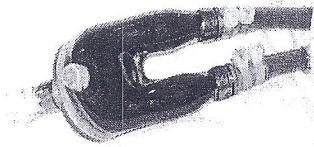
- Ikus - Driver
- Cannulae
- Blood pump
- Drive line



Blood Pump

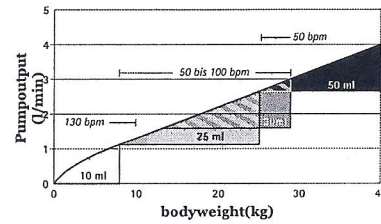
- Sizes
 - 10 ml
 - 25 ml
 - 30 ml
 - 50 ml
 - 60 ml
 - 80 ml
- Valves
 - Inlet
 - Outlet
- Diaphragm

Excior 10ml Blood Pump



Selection of Pump Size

For BVAD use combination of 10/10 ml, 25/30ml, 50/60ml.
Larger pump volume on the left side prevents pulmonary congestion



Pump Cycles

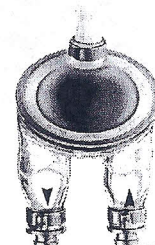
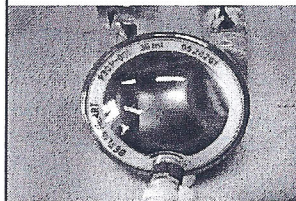
- 2 Cycles
 - Filling– diastole-- vacuum
 - Emptying– systole– drive pressure
- Maximum flow is achieved through complete filling and emptying



Incomplete Filling/Emptying

(Berlin Heart, 2007)

- Incomplete filling
- Complete filling



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

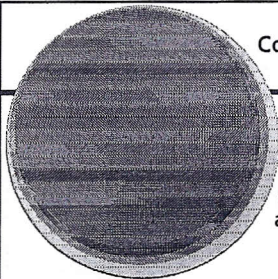


Incomplete Ejection

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

Complete Filling & Ejection Prevents...

CLOTS



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

% 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



Pump Assessment

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

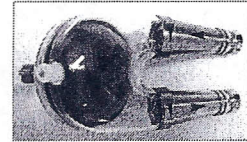
● Most common area of clot/deposit formation:
Valves

Common Areas of Deposit Collection

Between inflow / outflow section



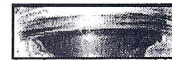
Junction of Ti- Con./ cannula



Outflow section

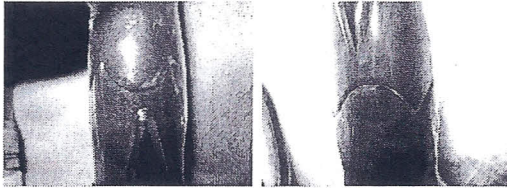


Membrane housing



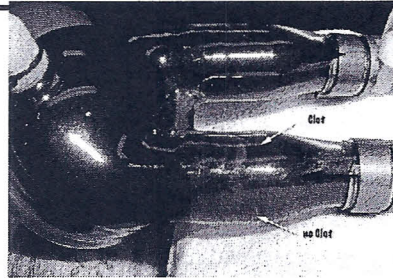
Valves

(Berlin Heart, 2007)



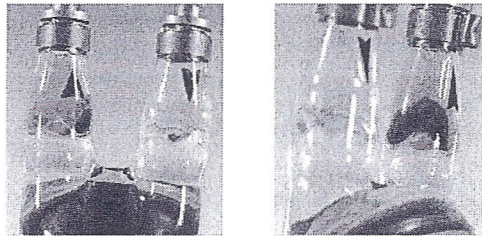
Pump Assessment: Clot

(Berlin Heart, 2007)



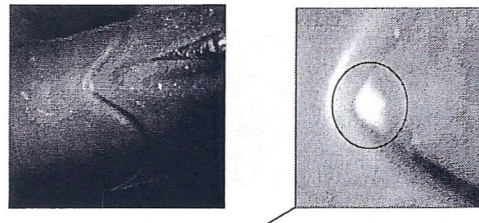
Pump Assessment: Clot

(Berlin Heart, 2007)



Pump Assessment: Deposit

(Berlin Heart, 2007)



Deposit Development

"pin-point"

thin layer (almost translucent)

- Check anticoagulation parameters
- Check Platelet aggregation regimen
- Adjust therapy if levels not within range

→ Good chance deposits will resolve

Pump Assessment: Deposit/Clot Formations

white deposit

Solid white clot

- 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 or Change Pump

Deposit in Silicone Cannula

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

→ Deposit in cannulae may not be completely removable

Console Control Panel

(Berlin 2)

Connection sockets for Blood pumps

Mains Power Indicator

Mains Power Switch (network breaker) NEVER TURN THIS OFF!!!
Battery will lose power and may not recharge!!!
Mains Power Connection 230V/115V

Left pump

Right pump

Battery fuse

External alarm

Designation

Main switch On

External alarm connector

Ground connector

Main control switch (Key Switch)

User Interface / Laptop Display

A Parameter table for displaying/ changing operating parameters and models

Parameter	Designation	Pressure (mmHg)	Rate	X. Function
Normal	Normal	120-0	10-0	40-0
Left	L	120-0	10-0	40-0
Right	R	120-0	10-0	40-0

B Graphic real time display of the current data

C Message window

Pump-Output 2.8 l/min

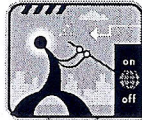
Battery 23.04V

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 Ikus 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.*"

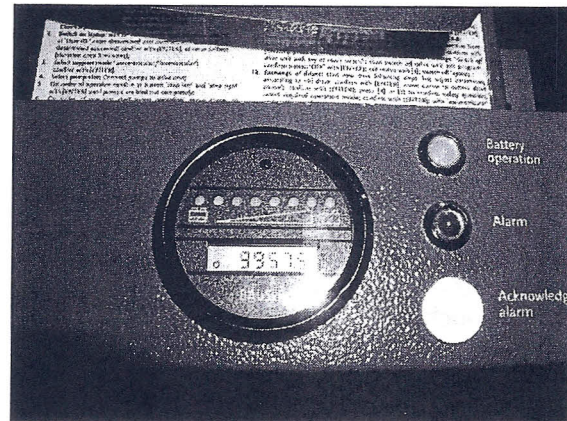
Common Alarms

- 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

LOOK



Goal of Device Operation

- Minimal to no console adjustment



Pump Failure!

NOW WHAT?



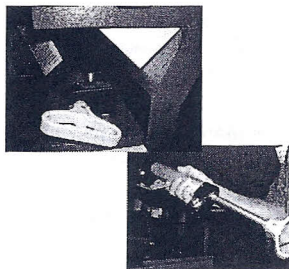
HAND PUMP!!



- HAND PUMP MUST ALWAYS BE ON CONSOLE

Hand Pumping

- Disconnect at connector site
- Connect to hand pump
- Pump rhythmically > 30 BPM (60 – 90 BPM)
- Do not need to pump to full extension—only enough to completely fill and empty diaphragm
 - Monitor hemodynamics, neuro status, pump diaphragm



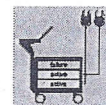
Backup operation left / right

Berlin Heart Version 1.0

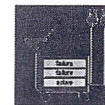
If the left-hand (or the right-hand) drive is defective. The respective pump will be powered by the backup drive.



Normal operation
Drive 1: left pump
Drive 2: right pump
Drive 3: backup



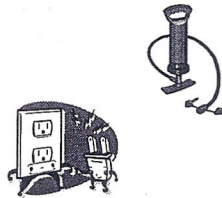
Failure of one unit
Drive 1: failure
Drive 2: right pump
Drive 3: left pump
The message „Backup operation left/right“ is shown.



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/NP
 - Ascum 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 mobilization
- 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

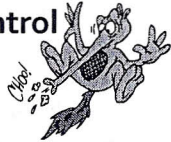
Arrhythmias



- ▶ 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

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

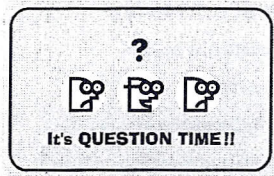
Altered CNS Status

- 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

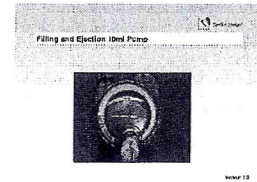
- Maybe manifestations of embolus to abdominal arterial supply causing ischemia pain
- Maybe abdominal clot
- Actions to be Taken:
 - Rapid response to preserve bowel integrity. Call to MD/NP may need CT angio
 - Evaluate pump for change in thrombi

Troubleshooting



Troubleshooting: Filling

- Inadequate VAD filling



Causes:

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



Troubleshooting: Emptying

- Inadequate VAD emptying



Incomplete Ejection

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

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:
 p = small punctual deposit
 P = large punctual deposit
 a = small area of deposit
 A = large area of deposit
 f = small strand
 F = large strand
 t = small thrombus
 T = large thrombus

Datum:	Zeit	Name	Linke Pumpe	ml: 80 ml											
date	time	sign	left pump	No.: 8815											
01.01.01	8:00	z.B.		<table border="1"> <tr> <td>1</td> <td>2</td> <td>3</td> <td>4</td> <td>5</td> <td>6</td> <td>7</td> <td>8</td> <td>9</td> <td>10</td> <td>11</td> </tr> </table>	1	2	3	4	5	6	7	8	9	10	11
1	2	3	4	5	6	7	8	9	10	11					

