Device Troubleshooting: IABP, Impella, TandemHeart, and ECMO

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IABP Inflation & Deflation

- Midpoint of the T wave triggers balloon inflation
- Peak of the R wave triggers balloon deflation

Graph showing time (horizontal axis) and pressure (vertical axis) with annotations for balloon inflation and deflation points.
Wrong inflation or deflation time

- Early deflation: systolic augmentation can be lost
- Late deflation increase afterload
- Early inflation increase afterload
- Late inflation less consequential but decreases systolic augmentation
Impella potential Troubles and Troubleshooting

- Abnormal Position
  - Aortic Position
  - Ventricular
- Suction
- Hypotension
- Hemolysis
Impella Correct Position

Impella 2.5® or Impella CP® Device in the Heart

- 9 Fr Catheter Shaft
- Motor
- Blood Outlet Area (In aorta)
- Blood Inlet Area (In ventricle)
- Cannula 12 Fr - Impella 2.5
- 14 Fr - Impella CP
- Pigtail
- Open Pressure Area

Correct Impella 2.5® or Impella CP® Device Placement

Placement Signal: Aortic

Motor Current: Pulsatile
Impella 5.0 & Impella LD

Impella 5.0° and Impella LD° Devices in the Heart

Correct Impella 5.0° and Impella LD° Device Placement

Placement Signal: Pulsatile

Motor Current: Pulsatile
Left-sided Impella® Device as Seen on Color Doppler Echocardiography

**CORRECT:**
Dense mosaic pattern of turbulence above the aortic valve near the outlet area of the catheter.

**INCORRECT:**
Dense mosaic pattern of turbulence beneath the aortic valve indicating the catheter is too far into the ventricle or entangled in papillary muscle.
Impella CP is too deep

- Placement Signal:

- Motor Current:

- Actions
  1. Reduce Flow Rate to P
  2. Echo guidance to reposition the pump until the inlet area measures 3.5 cm below the aortic valve annulus.
  4. Lock Touhy Valve.
Impella CP is not deep enough

- Placement Signal
- Motor Current

1. Reduce Flow Rate to P
2. Echo guidance to reposition the pump until the inlet area measures 3.5 cm below the aortic valve annulus.
4. Lock Touhy Valve.
If the Impella motor current is not restored by pushing the catheter

- Cancel Echo and move to the cath lab
Impella 5.0 or LD

- Placement Signal:
  - ?
  - ?
  - Motor Current:
    - ?

- Actions
  1. Reduce Flow Rate to $P - 2$.
  2. Using echo guidance, reposition the pump until the inlet area measures 3.5 cm below the aortic valve annulus.
  3. Resume previous $P - level$ setting.
  4. Lock Touhy Valve.
### Impella Suction Alarm

<table>
<thead>
<tr>
<th>Risks</th>
<th>Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less support</td>
<td>Wrong Impella inlet position</td>
</tr>
<tr>
<td>Hemolysis</td>
<td>Low LV filling pressure:</td>
</tr>
<tr>
<td></td>
<td>- Low volume</td>
</tr>
<tr>
<td></td>
<td>- RV Failure</td>
</tr>
</tbody>
</table>
Troubleshooting of suction alarm

- Decrease the flow rate until the alarm stop
- Assess volume status
- Assess RV function
- Rule out tamponade
Interference with Device Operation results in hemolysis

**Inflow obstruction**
- Ventricular structures obstruct inlet area
- Blood subjected to higher shear in cannula
- Higher shear = hemolysis

**Obstruction within cannula**
- Clot or fibers narrow cannula
- Blood subject to higher shear in cannula
- Higher shear = hemolysis

**Outflow obstruction**
- Aortic valve or wall obstruct outlet area
- Force with which blood contacts obstruction = hemolysis
Impella position in the LV determine its function
Hemolysis

- Consider adding volume if hemolysis is accompanied by CVP or PCWP (PAD) < 10mmHg
- May reduce the P-level if hemolysis is present
- Goal is to run at the lowest possible level to achieve the highest amount of flow
### TROUBLESHOOTING: Suction (all devices)

**Suction**
1. Check filling and volume status.
2. Check Impella position
3. Reduce P-Level.

<table>
<thead>
<tr>
<th>What is it?</th>
<th>What to look for</th>
<th>What to do</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Causes of suction:</strong></td>
<td>- Impella Flow Reduced alarm</td>
<td>1. Drop 1 or 2 P-levels or until Suction breaks.</td>
</tr>
<tr>
<td>- Low Volume</td>
<td>- Suction alarm</td>
<td>2. Assess volume status</td>
</tr>
<tr>
<td>- Incorrect position</td>
<td>- Lower than expected flow rates</td>
<td>3. Evaluate catheter position with imaging; reposition if necessary</td>
</tr>
<tr>
<td>- Inadequate LV filling due to RV failure</td>
<td>- Reduced mean motor current</td>
<td></td>
</tr>
<tr>
<td><strong>Effects of suction:</strong></td>
<td>- Lower patient blood pressure</td>
<td>4. Confirm RV function</td>
</tr>
<tr>
<td>- Lower than expected Impella flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Patient may not fully benefit from Impella support</td>
<td></td>
<td>5. Return flow rate to pre-alarm setting when suction resolved</td>
</tr>
<tr>
<td>- Potential for hemolysis</td>
<td></td>
<td></td>
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</table>
NCSI Algorithm

**CARDIAC POWER OUTPUT (CPO)**
CPO = MAP x CO / 451

**PULMONARY ARTERY PULSATILITY INDEX (PAPI)**
PAPI = sPA - dPA / RA

**IMPELLA**

**PCI**

**Right Heart Cath**

CPO < 0.6

Calculate PAPI

PAPI < 0.9

Possible RV Failure

Consider RV Support

PAPI > 0.9

RV Normal

Consider ↑ LV Support

CPO ≥ 0.6 and PAPI > 0.9

Continue to Titrate ↓ Pressors/Inotropes

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NCSI Algorithm
ECPella Troubleshooting

- 57 y/o EcPella post LMCA acute stent thrombosis
- Previous procedure was complicated by possible perforation
Suction all night long, CVP 8, MBP 60 mmHg
In the Cath Lab
After US and Fluoroscopic Guided Pericardiocentesis

- CVP down to 4
- MBP 75
TROUBLESHOOTING: Purge Pressure High

normal 300-1100

1. Check purge tubing for kinks.
2. Decrease concentration of dextrose in purge solution.

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<th>What to do</th>
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</table>
| 1             | Are there any kinks:  
- In the purge tubing?  
- In the clear sidearm?  
- Anywhere along the catheter? | Straighten the tubing, clear sidearm, or catheter. |
| 2             | Is the purge fluid concentration too high? | Ensure D5W with Heparin is being used. |
| 3             | If unable to resolve high purge pressure, monitor for increases in motor current which can indicate impending pump failure. | May need to replace pump |
# TROUBLESHOOTING: Purge Pressure Low

| Purge Pressure Low | 1. Check purge system tubing for leaks.  
|                    | 2. Increase concentration of dextrose in purge solution.  
|                    | 3. Replace purge cassette. |

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| 1             | Are there any leaks:  
|               | - In the purge cassette connections?  
|               | - In the Y connector?  
|               | - In the luer connections to the catheter? | Tighten any loose connections. Replace purge cassette if leaking. |
| 2             | Is the purge fluid concentration too low? | Increase the purge fluid concentration. |
| 3             | If unable to resolve low purge pressure, monitor for increases in motor current which can indicate impending pump failure. | May need to replace pump |
TandemHeart Troubles and Troubleshooting

- Catheters misposition
  - Left atrial
  - Arterial
- Low flow
TandemHeart Left Atrial Catheter too Deep
Troubleshooting Left Atrial Catheter is too Deep

- Pull the catheter slowly under TEE or fluoroscopic guidance
- If the blood in the catheter became darker push forward
TandemHeart Left Atrial Catheter Pulled back to the right atria

- Decrease rpm to 3500
- Clamp the outflow
- Reposition under fluoroscopic guidance
- Or add an oxygenator and convert to ECMO
## TandemHeart Low Flow Alarm

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<tr>
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<th>Outflow catheter (arterial) issues</th>
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<tbody>
<tr>
<td>Catheter position</td>
<td>Kinks</td>
</tr>
<tr>
<td>Check volume status</td>
<td>Arterial stenosis</td>
</tr>
<tr>
<td>Check RV status</td>
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## ECMO Troubleshooting
### Low Flow

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North South Syndrome
When the head receives deoxygenated blood

**THE HARLEQUIN SYNDROME (north south syndrome)**
- Saturation of upper part of the body is lower than that of lower half.
- This is due to flow competition in the aorta
  - recovering heart vs ECMO pump
High cardiac output from native recovering heart prevents the retrograde flow of ECMO to perfuse upper part.
If pulmonary function is impaired:
- "BLUE HEAD": deoxygenated blood to upper part
- "RED LEGS": hyperoxygenated blood to lower part