Cardiogenic Shock Definition
- Persistent hypotension with systolic blood pressure (SBP) < 90 mmHg
- Mean arterial pressure (MAP) < 60 mmHg or 30 mmHg lower than baseline
- Significantly elevated filling pressures
- Cardiac Index (CI) < 1.8 L/min without support or < 2 L/min with support
- Left ventricular end-diastolic pressure > 20 mmHg
- Right ventricular (RV) end-diastolic pressure > 15 mmHg

Management Options
- Vasopressors
- Inotropes
- IABP
- Left ventricular assist devices (LVADs)
  - Impella
  - Centrimag
  - Tandem Heart
  - Heartware
  - Heartmate II/III
- Right ventricular assist devices (RVADs)
  - Impella
  - Tandem Heart
  - Centrimag
- Extracorporeal membrane oxygenation (ECMO)
  - VA-ECMO
  - VV-ECMO

Indications for Mechanical Circulatory Support
- For patients with chronic or acute HF who cannot be stabilized with medical therapy
- MCS systems are used to unload failing ventricle and maintain sufficient end-organ perfusion
- Acute/short term management – extracorporeal, non-durable life support systems
- Chronic, refractory HF management – left ventricular assist device (LVAD)

MECHANICAL CIRCULATORY SUPPORT DEVICES

Intra-Aortic Balloon Pump (IABP)
- Reduces afterload and myocardial oxygen demand
- Lower risk, less invasive, easy to implant
- Useful as first-line MCS option for temporary support
- Cannot partially or completely replace cardiopulmonary function

Impella Technology
- Augment cardiac out and off load the ventricle
- Continuous purge flow creates hydraulic “pressure barrier” at the sleeve bearing preventing the infiltration of blood into the pump motor. Purge Pressure > Blood Pressure
- Heparin purge solution recommendation by manufacture [500 mL (default)]
  - Heparin 50 units/mL in 5% dextrose in water (alternative solution available), ACT goal 160 – 180
  - Systemic heparin in addition to purge solution is recommended

Tandem Heart
- FDA approved for up to 14 days for end organ perfusion
- Transseptal cannulation of left atrium to decompress and rest the left ventricle
- Maximum left ventricular unloading up to 80 – 90%
- Capable of delivering blood flow up to 5.0 L/min
- Anticoagulation with unfractionated heparin

Centrimag
- Extracorporeal circulatory support
- FDA approved for use up to 6 hours
- Approved for use as an RVAD up to 30 days
- Capable of delivering high flows up to 9.9 LPM
Extracorporeal Life Support (ECLS/ECMO)

- Indications: Acute severe heart or lung failure
- Membrane lung and blood flow capable of oxygen delivery and CO2 removal
- Blood flow support 3 L/m2/min
- Anticoagulation
  - Unfractionated heparin (ACT or PTT) for ECMO, maintain ACT or PTT ~1.5 x normal
  - Percutaneous devices (Tandem Heart, CentriMag), anticoagulation with heparin with target ACT 1.5x normal

Left Ventricular Assist Device (Heartmate II, III, Heartware)

- Restores blood flow, Relieves symptoms, Improves exercise performance, Enables participation in cardiac rehabilitation
- Increase survival -- increase time for device-specific complications (e.g., aortic regurgitation, line infection, thrombosis)
- Use as a bridge to transplantation, does not fully restore functional capacity
- Criteria: Anticipated survival ≤ 2 years due to HF, HF Class IV/ Stage D w/symptoms despite optimal medical therapy, Refractory angina, Chronic IV inotropic therapy, Refractory ventricular arrhythmias

Complications

- Bleeding, Pump Thrombosis, Stroke, Hemolysis, Renal dysfunction, Infection, Right Heart Failure, Device Malfunctions, Respiratory Failure

**Pump thrombosis management:**

<table>
<thead>
<tr>
<th>Medical Management</th>
<th>Surgical Management</th>
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<tr>
<td>• Intensify anticoagulation</td>
<td>• Line exchange</td>
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<tr>
<td>• Addition of antiplatelet agent (clopidogrel, dipyridamole)</td>
<td>• Device Replacement</td>
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<td>• Thrombolytic treatment</td>
<td>• Transplantation</td>
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<td>• Glycoprotein IIb/ Illa receptor antagonist</td>
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**Pump thrombosis prevention:**

- Adequate anticoagulation (heparin/enoxaparin, warfarin (INR goal 2 - 3 (HM II and HeartWare)
- Antiplatelet therapy with aspirin is core therapy for all patients on LVADs (Heartmate II – aspirin 81 mg, Heartware – aspirin 325 mg)
- Blood pressure control, Maintain MAP ≤ 80 mmHg
- Treatment of infection

References: