Mechanical Circulatory Support and Mobility
Physiology to Clinical Decisions

Academy of Acute Care Physical Therapy
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Evan Haezebrouck, PT, DPT
Kyle J. Ridgeway, PT, DPT
University of Colorado Hospital

Learning Objectives

1. Understand background knowledge on physiology and mechanical circulatory support including: ventricular assist devices, extracorporeal membrane oxygenation, and percutaneous (Centrimag, Tandem Heart, Impella, intra-aortic balloon pump).

2. Identify potential physiologic measures to assist in initiating, monitoring, and progressing vs. regressing activity.

3. Understand a practical approach for rehabilitating and mobilizing this population.

4. State considerations for exercise and activity dosage and intensity.
Heart Failure

Inability of the heart to supply the body’s tissues with an adequate amount of blood under conditions of normal cardiac filling pressure. (McMurray 2012)

1. Heart Failure with Preserved Ejection Fraction (HFpEF)
   - Left ventricular volume: normal
   - Ejection fraction: normal
   - LV End Diastolic Pressure: increased

2. Heart Failure with Reduced Ejection Fraction (HFrEF)
   - Ejection Fraction < 40%

General Considerations

- Ejection Fraction in HFrEF
- Peripheral muscular sequelae of HF
- Peripheral mechanisms of exercise training in HF
- Presence of frailty as sequelae (physiologic and decreased activity)
- Readmission risk
- Previous level of function & baseline NYHA Functional Class
- Restrictive vs. dilated cardiomyopathy
- Co-morbidities
- Psychological sequelae

Acute Considerations

- Fluid Status & Diuresis: Daily weight, positive vs. negative fluid daily fluid balance, diuretic dose trend, weight gain from “dry weight”
- Orthostasis & Vitals Response to Position & Activity
- Symptoms: Shortness of Breath, Fatigue, Muscle Fatigue, Dizziness/Light Headedness
- Medication Profile & Trend
- Inotropes (see cardiogenic shock)
- Acute (vs. baseline) ejection fraction

Frailty and Heart Failure

Biologic syndrome reflecting a state of impaired physiologic and homeostatic reserve and heightened vulnerability to stressors, resulting from the accumulation of multiple morbidities, aging, and disability (Joyce 2016)
New York Heart Association Classes: Functional/Symptoms & Objective Assessments

<table>
<thead>
<tr>
<th>Class</th>
<th>Patient Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>No limitation of physical activity. Ordinary physical activity does not cause undue fatigue, palpitation, dyspnea (shortness of breath).</td>
</tr>
<tr>
<td>II</td>
<td>Slight limitation of physical activity. Comfortable at rest. Ordinary physical activity results in fatigue, palpitation, dyspnea (shortness of breath).</td>
</tr>
<tr>
<td>III</td>
<td>Marked limitation of physical activity. Comfortable at rest. Less than ordinary activity causes fatigue, palpitation, or dyspnea.</td>
</tr>
<tr>
<td>IV</td>
<td>Unable to carry on any physical activity without discomfort. Symptoms of heart failure at rest. If any physical activity is undertaken, discomfort increases.</td>
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<thead>
<tr>
<th>Class</th>
<th>Objective Assessment</th>
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<tbody>
<tr>
<td>A</td>
<td>No objective evidence of cardiovascular disease. No symptoms and no limitation in ordinary physical activity.</td>
</tr>
<tr>
<td>C</td>
<td>Objective evidence of moderately severe cardiovascular disease. Marked limitation in activity due to symptoms, even during less-than-ordinary activity. Comfortable only at rest.</td>
</tr>
<tr>
<td>D</td>
<td>Objective evidence of severe cardiovascular disease. Severe limitations. Experiences symptoms even while at rest.</td>
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Cardiogenic Shock

“Low cardiac output despite adequate or elevated filling pressure.” (Lim 2016)
“Failure of global oxygen delivery to meet oxygen consumption, resulting in tissue hypoperfusion.” (Lim 2016)
“Physiological state of end-organ hypoperfusion characterized by reduced cardiac output in the presence of adequate intravascular volume.” (Hasdai 2002)

**Clinical Definition**

- SBP < 90mmHg after adequate fluid challenge for 30 min (Harjola 2015) or drop in MAP > 30 mmHg for at least 30 min (Li 2016)
- Need for vasopressors to maintain SBP > 90 mmHg (Harjola 2015)
- Signs of hypoperfusion (Harjola 2015)
  - Altered mental status
  - Cold periphery
  - Oliguria
  - Elevated blood lactate
- Congestive heart failure (Puymirat 2016, Li 2016)
Acute Considerations

- Current Vitals, Lab, Medications, and their Trends
- Need for Inotropes and Vasopressors
- Trend of improvement (or not) and stability of hemodynamics (or not)
- Hemodynamic stability with nursing care (HOB elevation, turning, stimulation)

Acute Respiratory Distress Syndrome (ARDS)

ARDS Berlin definition.

The Berlin definition of acute respiratory distress syndrome

<table>
<thead>
<tr>
<th>Timing</th>
<th>Within 1 week of a known clinical insult or new or worsening respiratory symptoms</th>
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<tbody>
<tr>
<td>Chest Imaging</td>
<td>Bilateral opacities — not fully explained by effusions, lobar/bronchial collapse, or nodules</td>
</tr>
<tr>
<td>Origin of edema</td>
<td>Respiratory failure not fully explained by cardiac failure or fluid overload.</td>
</tr>
<tr>
<td>Oxygenation</td>
<td>Need objective assessment (e.g., echocardiography) to exclude hydrostatic edema if no risk factor present</td>
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<table>
<thead>
<tr>
<th>Oxgenation category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>PaO2/FiO2 &lt; 300 mmHg with PEEP or CPAP ≤ 5 cmH2O</td>
</tr>
<tr>
<td>Moderate</td>
<td>100 mmHg &lt; PaO2/FiO2 ≤ 200 mmHg with PEEP ≥ 5 cmH2O</td>
</tr>
<tr>
<td>Severe</td>
<td>PaO2/FiO2 ≥ 200 mmHg with PEEP ≥ 5 cmH2O</td>
</tr>
</tbody>
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Technical specifications for the Berlin definition:

1. PaO2/FiO2: 100% Fio2
2. CPAP: Continuous positive airway pressure
3. PaO2: Partial pressure of oxygen
4. FiO2: Fraction of inspired oxygen

Abbreviations: CPAP, continuous positive airway pressure; Fio2, fraction of inspired oxygen; PaO2, partial pressure of arterial oxygen; PEEP, positive end-expiratory pressure; aChest radiograph or computed tomography scan; bIf altitude is higher than 1,000 m, the correction factor should be calculated as follows: [PaO2/FiO2] x (760/altitude + 760)]; cThis may be delivered noninvasively in the mild acute respiratory distress syndrome group.

General Considerations

- Severe ARDS: High mortality rate
- Poor long term physical, functional, cognitive, psychological outcomes
- High risk for disability and weakness

Acute Considerations

- Mechanical Ventilation Parameters: Current & Trend
  - FiO2
  - PEEP
  - “Lung protective ventilation” strategy, which may involve higher PEEP
- Neuromuscular blockade
  - More widely utilized & studied, especially acute (within first 48 hours)
  - Or when plateau pressures are high
- Sedation Medications: Dosages and Trends
- PF Ratio (PaO2/FiO2)
  - 200-300: Mild ARDS
  - 100-200: Moderate ARDS
  - <100: Severe ARDS
- Hemodynamic stability (including SpO2 and FiO2 needs) with nursing care (HOB elevation, turning, stimulation)

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Pair wake up/sedation vacation with mobility and PT assessment
COLLABORATE: RT, RN, MD

Mechanical Circulatory Support

“For patients with either chronic or acute HF who cannot be stabilized with medical therapy, MCS systems can be used to unload the failing ventricle and maintain sufficient end-organ perfusion.” (Ponikowski 2016)
“The primary goals of temporary MCS are to decrease preload, decrease afterload, and augment cardiac output. The end goal is to provide adequate organ perfusion and oxygen delivery.” (Gilotra 2014)

Medical Goals (Rihal 2015, Briceno 2015):
1. Improve and stabilize organ perfusion
2. Improve cardiac output
   ○ Reduce cardiac filling pressure and improve congestion/pulmonary edema
   ○ Decrease LV volume, wall stress
3. Supplement coronary perfusion
4. Reduce myocardial oxygen demand

INTERMACS 1: Critical cardiogenic shock; life-threatening hypotension despite increasing inotropic and vasopressor support with organ hypoperfusion
INTERMACS 2: Progressive decline; deteriorating presentation despite dependence on inotropic support
INTERMACS 3: Stable, but dependent on inotropic support with inability to wean as evidenced by hypotension and/or organ dysfunction. May have temporary MCS.
INTERMACS 4: Experiencing HF symptoms at rest, worsening with basic ADLs
INTERMACS 5: Exertion intolerant; stable at rest, however activity is limited
INTERMACS 6: Exertion limited; comfort at rest, able to leave home, however any continuous, meaningful activity elicits symptoms
INTERMACS 7: Advanced NYHA Class III

Common Clinical Scenarios
1. Severe Cardiogenic Shock
2. End Stage Heart Failure
3. Severe ARDS failing max mechanical ventilation
4. Bridge to heart or lung transplant

Ventricular Assist Device

An electromechanical device for assisting cardiovascular circulation, used to either partially or completely replace the function of a failing heart.

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Current generation VADs have an inlet cannula at the apex of the left ventricle, an axial flow or centrifugal pump, and outflow graft to the ascending aorta. The implanted pump is connected to an external controller and power source via a percutaneous driveline.

**Indications**
- Destination Therapy (DT)
- Bridge to Transplant (BTT)
- Bridge to Recovery (BTR)
- Bridge to Decision (BTD)

**Acute Considerations**
- Often no peripheral pulses secondary to continuous flow of pump
- MAP (via doppler) before & after activity, when symptomatic
- Suction events
- Fluid status

**Pre and Post Implant Assessment**
- Independence
  - FIM based
  - AM-PAC
  - FSS-ICU
- 6MWT (or 12MWT)
- 10mWT
- Gait Speed
- 5xSTS, 30” STS
- LE PFIT if non-ambulatory
- Grip strength
- MRC sum score
- Inspiratory capacity and effort per IS (IMT if available)
- UE PFIT
- Vital signs and symptom responses

**Extracorporeal Membrane Oxygenation (ECMO)**

Modification of cardiopulmonary bypass circuit that allows for cardiac and/or pulmonary support via external gas exchange and a pump to assist in forward flow.

The ECMO circuit is comprised of an outflow/drainage cannula, centrifugal pump, membrane oxygenator, heat exchanger, and inflow/infusion cannula. There are various potential outflow/inflow cannulation sites.

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**Acute Considerations**
- Cannulation location
- WHY on ECMO
  - Cardiogenic shock
  - Bridge to transplant: heart
  - Bridge to VAD
  - ARDS
  - Bridge to transplant: lung
  - Bridge to decision
  - Bridge to recovery
- V-A vs V-V
- ECMO parameters (flow, sweep, FiO2)
- Mechanical ventilation parameters (if applicable)
- Medications: Dosages & Trends
- “Chatter” of lines

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**Treatment Considerations**

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**Individualized, Response Dependent**

- **Physiology**
  - Labs
  - Medications
  - Medication Effects
  - Diagnoses
  - Vitals: Rest-Peak-Recovery

- **Patient Performance**
  - Function & Level of Assist
  - Strength
  - Speed
  - Power
  - Balance
  - Previous Level of Function

- **Patient Report**
  - Symptoms
  - Better-Worse-Same
  - Mild-Moderate-Severe
  - Dizziness, Light Headed
  - Shortness of Breath
  - Fatigue
  - Pain

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**Information Integration & Assessment**

- Moment to Moment Decision Making

- Within Session

- Between Sessions

- Regression
  - Pause
  - Progression

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**What can we do today?**

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● If no mobility, what can be done?
  ○ Tilt table
  ○ Cycle
  ○ NMES
  ○ Bed level exercises
  ○ Single limb exercises
● If can’t ambulate, but can mobilize?
  ○ Standing
  ○ Device assisted standing
  ○ Marching
  ○ Seated/in chair resisted and endurance activities
● Logistics a barrier?
  ○ Edge of bed standing activities
  ○ Marching
  ○ Repeated sit to stands
● Learn anatomy and physiology of device
● Learn the pathologies & their physiology
● What physiologic parameters should and can be measured?
  ○ i.e. > VAD: No cuff BP. Doppler MAP instead
● Monitor device related metrics
● Medication dosages and trends
● Vitals: Rest, Position Change, Activity, Peak, Recovery
● Oxygen Demand/Ventilatory Support: Rest, Position Change, Activity, Peak, Recovery
● Symptoms: Rest, Position Change, Activity, Peak, Recovery
  ○ Fatigue
  ○ Exertion
  ○ Shortness of breath
  ○ Dizziness/Light Headedness
  ○ Pain

References & Resources
3. New York Heart Association Classes of Heart Failure. [http://www.heart.org/HEARTORG/Conditions/HeartFailure/AboutHeartFailure/Classes-of-Heart-Failure_UCM_306328_Article.jsp#WG0T31MrKUk](http://www.heart.org/HEARTORG/Conditions/HeartFailure/AboutHeartFailure/Classes-of-Heart-Failure_UCM_306328_Article.jsp#WG0T31MrKUk)

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