Implementing Acute MCS
Putting it All Together

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Tufts Medical Center
The Cardiovascular Center

The Acute MCS Working Group

ACC/SCAI Interventional Cardiology Overview and Board Preparatory Course
Relevant Disclosures

Research Funding: Abiomed, Maquet, Cardiac Assist, Abbott, Boston Scientific
Speaker/Consulting Honoraria: Abiomed, Maquet, Cardiac Assist, Abbott
We don’t provide hemodynamic support effectively or early enough in the Shock Spectrum

**Circulatory Support**
- Systemic Perfusion
  - Mean Arterial Pressure
- Lactate
- Creatinine

**Ventricular Support**
- LV/RV Unloading
  - LV-ESP & EDP
- Aortic Pulse Pressure
- Vent Tachycardia
- BNP

**Coronary Perfusion**
- MAP - LVEDP
- ST-Changes
- Troponin/CK-Mb

**Renal & Hepatic Unloading**
- RA-PA Hemodynamics
- Creatinine, LFTs, Coagulopathy

**Hemodynamic Problem**
- Recovery
- Time in Cardiogenic Shock
- Death

**Bridge to Recovery**
- Detroit Cardiogenic Shock Initiative

**Hemo-Metabolic Problem**
- It’s Too Late for AMCS
- Impress Trial

Kapur and Esposito Curr Cardio Risk 2016 & F1000 2017
Mortality vs Number of Vasopressors/inotropes Pre-Device Implant Among the Total Cohort

One-way ANOVA p=0.02

One-way ANOVA p=0.08

Early and Effective Device Support is Critical for Survival

Esposito and Kapur et al. TCT 2016
It’s Hard to Ignore these Data
IABP Therapy in Acute-MI + Cardiogenic Shock

Examine your own practice and evaluate the clinical efficacy of IABP therapy for CGS

Thiele H et al. NEJM 2012
Thiele H et al Lancet 2013
60+% of Cardiogenic Shock Patients Fail an IABP First before Receiving an Impella or VA-ECMO

63%

64%

It’s Hard to Ignore those Data...But We Do Stepwise Escalation of Support Delays Treatment

Esposito and Kapur et al. Under Review 2017
We don’t use hemodynamic data to guide Acute MCS decision-making.

Cardiac Power Output (CPO) is defined as:

\[
CPO = \frac{MAP \times CO}{451}
\]

<table>
<thead>
<tr>
<th>Therapy</th>
<th>CPO (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical Therapy</td>
<td>0.28</td>
</tr>
<tr>
<td>+ Impella LVAD</td>
<td>0.68</td>
</tr>
<tr>
<td>+ TandemHeart RVAD</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Fincke et al JACC 2004
Early Use of a PA Catheter Improves Outcomes in Acute HF and CG-Shock

Impact of pulmonary artery catheter on outcome in patients with acute heart failure syndromes with hypotension or receiving inotropes: From the ATTEND Registry☆,☆☆,☆☆☆

A Kaplan-Meier Estimates for Time to All-cause Death

- Control
- PAC

Logrank test: $P = 0.003$

Follow-up (days)

Control group 502 501 493 486 476 468 458 454 444 437 429
PAC group 502 502 502 499 495 487 479 475 470 464 464

<table>
<thead>
<tr>
<th>Hemodynamic Formulas to Assess RV Function</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cardiac Filling Pressures</strong></td>
</tr>
<tr>
<td>RA / PCWP</td>
</tr>
<tr>
<td>&gt;0.63 (RVF after LVAD) [14]</td>
</tr>
<tr>
<td>&gt;0.86 (RVF in Acute MI) [31]</td>
</tr>
<tr>
<td><strong>PA Pulsatality Index</strong></td>
</tr>
<tr>
<td>(PASP-PADP) / RA</td>
</tr>
<tr>
<td>&lt;1.85 (RVF after LVAD) [42]</td>
</tr>
<tr>
<td>&lt;1.0 (RVF in Acute MI) [41]</td>
</tr>
<tr>
<td><strong>Pulmonary Vascular Resistance</strong></td>
</tr>
<tr>
<td>mPA-PCWP / CO</td>
</tr>
<tr>
<td>&gt;3.6 (RVF after LVAD) [16]</td>
</tr>
<tr>
<td><strong>Trans-pulmonary Gradient</strong></td>
</tr>
<tr>
<td>mPA-PCWP</td>
</tr>
<tr>
<td>Undetermined [36]</td>
</tr>
<tr>
<td><strong>Diastolic Pulmonary Gradient</strong></td>
</tr>
<tr>
<td>PAD - PCWP</td>
</tr>
<tr>
<td>Undetermined [36, 37]</td>
</tr>
<tr>
<td><strong>RV Stroke Work</strong></td>
</tr>
<tr>
<td>(mPAP-RA) x SV x 0.0136</td>
</tr>
<tr>
<td>&lt;15 (RVF after LVAD) [16]</td>
</tr>
<tr>
<td>&lt;10 (RVF after Acute MI) [40]</td>
</tr>
<tr>
<td><strong>RV Stroke Work Index</strong></td>
</tr>
<tr>
<td>(mPA-RA) / SV Index</td>
</tr>
<tr>
<td>&lt;0.3-0.6 (RVF after LVAD) [14,42]</td>
</tr>
<tr>
<td><strong>Pulmonary Artery Compliance</strong></td>
</tr>
<tr>
<td>SV / (PASP-PADP)</td>
</tr>
<tr>
<td>&lt;2.5 (RVF in Chronic Heart Failure) [39]</td>
</tr>
<tr>
<td><strong>Pulmonary Artery Elastance</strong></td>
</tr>
<tr>
<td>PASP / SV</td>
</tr>
<tr>
<td>Undetermined [38]</td>
</tr>
</tbody>
</table>

Right atrial (RA); Pulmonary artery (PA); PA systolic pressure (PASP); PA diastolic pressure (PADP); mean PA pressure (mPAP); Pulmonary capillary wedge pressure (PCWP); Right ventricular failure (RVF); Left ventricular assist device (LVAD); Myocardial infarction (MI); Stroke volume (SV)
Re-Defining Cardiogenic Shock in the Era of AMCS

The Tufts Cardiogenic Shock Algorithm

AMI and Cardiogenic Shock Refractory to 1 inotrope/vasopressor

Echocardiogram

Pericardial Disease Tamponade

PA Catheter

No Pericardial Disease No Tamponade

Cardiac Index > 2.2
Consider non-cardiac origin
or intra-cardiac shunt

Cardiac Index < 2.2

+ Severe Aortic Insufficiency

TH-LVAD

RA<15 PCWP<18
Hypovolemia

Volume Resuscitation

RA<15 PCWP≥18
LV-Dominant

RA≥15 PCWP<18
RV-Dominant

RA≥15 PCWP≥18
BiV-Dominant

+ Hypoxemia or
+ Persistent VT/VF

TH-LVAD

VA-ECMO + LV Vent

PAPi > 1.0

Acute LV AMCS (Impella CP)
(Impepla 5.0)
(TH-LVAD)

Inotropes Vasodilators Diuresis

PAPi < 1.0

Acute RV AMCS (Impella RP)
(TH-RVAD)

PAPi > 1.0

Acute LV AMCS
(Impella CP)
(Impepla 5.0)
(TH-LVAD)

PAPi < 1.0

Acute BiV AMCS
(BiPella)
(VA-ECMO + LV Vent)
(TH-BiVAD)

Kapur & Esposito. Curr Cardiol. 2017
We must centralize and tailor expertise for cardiogenic shock management

Acute MI Cardiogenic Shock
50-60%

Advanced HF Cardiogenic Shock
20-30%

Modified from Goodlin. JACC 2009;54:386
Who do you want on *your* Shock Team?

**Acute MI Cardiogenic Shock**
1. Interventional Cardiologist
2. Cardiac Surgeon
3. Critical Care / Intensivist (MD)
4. Advanced HF Specialist
5. Critical Care Nursing Team
6. Perfusion Team
7. Respiratory Specialists
8. Physical and Occupational Therapy
9. Palliative Care

**Advanced HF Cardiogenic Shock**
1. Advanced HF Specialist
2. Interventional Cardiologist
3. Cardiac Surgeon
4. Critical Care / Intensivist (MD)
5. Critical Care Nursing Team
6. Palliative Care
7. Perfusion Team
8. Respiratory Specialists
9. Physical and Occupational Therapy
Durable MCS Devices are Not Commonly Used for Acute Circulatory Support

Higher Mortality with INTERMACS 1 and 2 Patients > 65 years of Age

Rare use of Durable MCS as a Bridge to Recovery or Rescue Therapy Option

Adapted from Kirklin et al JHLT 2014
# AMCS Device Options for Advanced HF & Shock

## Left Ventricle

<table>
<thead>
<tr>
<th>Pulsatile</th>
<th>Continuous Flow Pumps</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Axial-Flow</td>
</tr>
<tr>
<td></td>
<td>Centrifugal Flow</td>
</tr>
</tbody>
</table>

## Right Ventricle

- **Primary Objectives**
  - Outpatient Discharge
  - Inpatient Stabilization

- **Clinical Scenarios**
  - Stable, but sick
  - Sick and unstable

- **Technical Implant Features**
  - Cardiotomy
  - Vascular Puncture

- **Post-procedural Management**
  - Surgical
  - Medical

- **Outcomes/Metrics of Success**
  - OHTx or DT-VAD
  - Recovery, Durable MCS, OHTx

- **Withdrawal of Care**
  - Failure
  - Success in select cases

## Acute MCS Devices are Not VADs

<table>
<thead>
<tr>
<th>Primary Objectives</th>
<th>Durable MCS</th>
<th>Acute MCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outpatient Discharge</td>
<td>Inpatient Stabilization</td>
<td></td>
</tr>
<tr>
<td>Stable, but sick</td>
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<tr>
<td>Cardiotomy</td>
<td>Vascular Puncture</td>
<td></td>
</tr>
<tr>
<td>Surgical</td>
<td>Medical</td>
<td></td>
</tr>
<tr>
<td>OHTx or DT-VAD</td>
<td>Recovery, Durable MCS, OHTx</td>
<td></td>
</tr>
<tr>
<td>Failure</td>
<td>Success in select cases</td>
<td></td>
</tr>
</tbody>
</table>

## Device Options

- Impella RP
- VA-ECMO
- Tandem pRVAD
- Protek Oxy-RVAD
The Role of the Cardiac Intensivist

1. Optimize hemodynamic status
2. Pulmonary stabilization
3. Renal stabilization
4. Sepsis/infectious issues (prevention and management)
5. Nutrition, mobilization, prophylaxis against DVT/ulcers
6. Optimize metabolic parameters (i.e., lactate)
7. Assist with Acute MCS, VA-ECMO, and VV-ECMO management
Cardiac Intensivists Improve Clinical Outcomes for Patients with Cardiogenic Shock

Association Between Presence of a Cardiac Intensivist and Mortality in an Adult Cardiac Care Unit

![Graph showing mortality rates for cardiovascular death, noncardiovascular death, and sepsis with and without a cardiac intensivist.]

### TABLE 2 Treatment Characteristics

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Low-Intensity (n = 616)</th>
<th>High-Intensity (n = 1,815)</th>
<th>p Value</th>
<th>Standardized Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inotropes or vasopressors</td>
<td>203 (33.0)</td>
<td>506 (27.9)</td>
<td>0.02</td>
<td>-9.5</td>
</tr>
<tr>
<td>Dopamine</td>
<td>117 (19.0)</td>
<td>170 (9.3)</td>
<td>&lt;0.001</td>
<td>-21.5</td>
</tr>
<tr>
<td>Norepinephrine</td>
<td>125 (20.3)</td>
<td>321 (17.7)</td>
<td>0.15</td>
<td>-5.7</td>
</tr>
<tr>
<td>Dobutamine</td>
<td>99 (16.1)</td>
<td>248 (13.7)</td>
<td>0.14</td>
<td>-2.2</td>
</tr>
<tr>
<td>Vasopressin</td>
<td>25 (4.1)</td>
<td>51 (2.8)</td>
<td>0.12</td>
<td>-3.3</td>
</tr>
<tr>
<td>Epinephrine</td>
<td>12 (2.0)</td>
<td>104 (5.7)</td>
<td>&lt;0.001</td>
<td>8.2</td>
</tr>
<tr>
<td>Milrinone</td>
<td>4 (0.7)</td>
<td>29 (1.6)</td>
<td>0.08</td>
<td>2.4</td>
</tr>
<tr>
<td>Intra-aortic balloon pump</td>
<td>52 (8.4)</td>
<td>53 (2.9)</td>
<td>&lt;0.001</td>
<td>-21.6</td>
</tr>
<tr>
<td>Extracorporeal membrane oxygenation</td>
<td>33 (5.4)</td>
<td>102 (5.6)</td>
<td>0.81</td>
<td>0.6</td>
</tr>
<tr>
<td>Mechanical ventilation</td>
<td>115 (18.7)</td>
<td>289 (15.9)</td>
<td>0.11</td>
<td>-5.3</td>
</tr>
<tr>
<td>Continuous renal replacement therapy</td>
<td>69 (11.2)</td>
<td>136 (7.5)</td>
<td>0.004</td>
<td>-9.5</td>
</tr>
</tbody>
</table>
If you manage CG-Shock in 2017 you should be an Acute MCS Specialist

Hemodynamic Problem

Recovery

Time in Cardiogenic Shock

Death

Hemo-Metabolic Problem

AMI Shock

ED Cath Lab CCU/ICU

SHOCK TEAM AMCS TEAM

Diagnosis Drugs Delay

YES/NO AMCS

AMCS

Interventional Cardiology

Cardiac Surgery

Critical Care Team

Advanced Heart Failure

AMCS Specialist
A Hub and Spoke Vision for Primary Unloading In AMI & Cardiogenic Shock

EMS-STEMI Activation

Cath Lab Arrival
Hemodynamically Stable?

Primary Reperfusion
PA Catheter
Support then Reperfuse

Stable, then Reperfuse
Unstable, then Support and Reperfuse

Primary Unload Lab

Advanced Acute MCS Center

If Unstable after Revasc → Transfer to Adv AMCS Center
Clinical Success with Acute MCS:
Less about the tools, More about *how and when* you use them

Kapur and Davila
Eur H J 2017
Thank you

nkapur@tuftsmedicalcenter.org

To Learn More about Acute MCS & Hemodynamics

The Acute MCS Working Group

TEACH

TRAINING & EDUCATION IN ADVANCED CARDIOVASCULAR HEMODYNAMICS

CHIP: Hemodynamic Support and Complex PCI

Tufts Medical Center

The CardioVascular Center

Interventional Heart Failure

August 24-25, 2017: Barcelona, Spain

Device Therapies for Heart Failure
December 15-16 2017
Berlin, Germany