Cardiogenic Shock: Pharmacological and Mechanical Therapy

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Case

• A 55 year old with no known medical problems presents with an anterior STEMI 5 days after the start of symptoms.
• Despite prompt revascularization and vasopressor support hypotension persists and
• An IABP is inserted with temporary improvement in hemodynamics.
• An echocardiogram demonstrates a ventricular septal defect and he is taken urgently to the operating room for repair.
• Post operatively hemodynamics deteriorate and he is placed on ECMO.
• Seven days later he is weaned off ECMO and decanulated.
• He is subsequently discharged home from the hospital.

Shock is Inadequate End Organ Perfusion Despite Adequate Fluid Resuscitation

• Criteria for the diagnosis of cardiogenic shock
  • SBP <90 for >30 minutes or vasopressor needed to maintain SBP >90
  • Pulmonary congestion/elevated LV filling pressures
  • Signs of impaired perfusion
    • Mental status
    • Cool extremities
    • Oliguria
    • Elevated lactate

Differential Diagnosis of Cardiogenic Shock in Patients in the CVICU

• Complications of acute myocardial infarction
  • Left-ventricular dysfunction (80% of cardiogenic shock)
  • VSD
  • Ventricular wall rupture
  • Acute valvular heart disease
  • Decompensated chronic HFrEF
  • HFrEF
  • Viral cardiomyopathy
  • Post cardiotomy
  • Arrhythmia
  • Valvular heart disease
  • Right ventricular failure
    • Post operative right ventricular failure
    • Decompensated chronic pulmonary hypertension
Don’t Forget About Non-Cardiogenic Causes of Shock!

- Distributive
  - Sepsis
- Obstructive
  - Pulmonary embolism
- Neurogenic
  - Spinal cord injury
- Hypovolemic
  - Acute blood loss
  - Intravascular volume depletion

Mortality in Cardiogenic Shock Is High

- Secondary to acute MI
  - Ventricular septal rupture 87%
- Right ventricular failure from PAH 30-48%

Factors associated with increased mortality after acute MI:

- Advanced age
- Shock on admission
- Clinical end organ hypoperfusion
- Anoxic brain injury
- Decreasing SBP
- Prior CABG
- Non-inferior AMI
- Creatinine >1.9

Initial Cardiac Dysfunction Leads To A Cascade of Downstream Abnormalities

Approach to Patients With Suspected Cardiogenic Shock

- Optimize volume status
- Use vasopressors to maintain adequate blood pressure to prevent end organ ischemia and dysfunction
- Use Inotropes (inodilators) to optimize cardiac output
- Continually reevaluate response to therapy
- Consider surgical repair of structural heart disease early
- Consider implementation of mechanical support early

Survival Is Improved With Early Revascularization in SHOCK From ACS


It Is Unknown If Culprit PCI Is Superior to Multivessel PCI In Shock

http://www.culprit-shock.eu/the-project/

The Pulmonary Artery Catheter Is Useful Carefully Selected Patients With Cardiogenic Shock

- Escape trial
  - Found not difference in outcomes between therapy guided with PAC or without
  - Excluded Dobutamine or dopamine >3 mcg/kg/min, any milrinone, Cr>3.5


Alpha Agonists: Mechanism of Action

Mechanism of Action: Beta Agonists

Cardiac myocyte

Vascular smooth muscle

Mechanism of PDE- Inhibitor: Milrinone

Catecholaminergic Receptor Activity

Vasopressors In Cardiogenic Shock: What Choice Is Best?

- Shock trial: Increased death with dopamine in cardiogenic shock
- Post hoc subset analysis of 280 patients
- Pressor choice requires careful consideration of individual patient hemodynamics to choose the optimal vasopressor
Mechanisms and Hemodynamic Effects of IABP

- Increased diastolic blood flow to the proximal aorta
- Reduced afterload due to vacuum effect of balloon deflation
- ↓SBP
- ↑DBP
- ↑MAP
- ↓HR
- ↓PCWP
- ↑CO
- ↑Coronary perfusion

Hemodynamic Benefits From IABP Varies By Population Studied

<table>
<thead>
<tr>
<th>Effect of IABP Placement on Hemodynamic Measures</th>
<th>Pre-IABP</th>
<th>Post-IABP</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic blood pressure (mm Hg)</td>
<td>109 ± 28</td>
<td>108 ± 25</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diastolic blood pressure (mm Hg)</td>
<td>65 ± 17</td>
<td>62 ± 17</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Augmented diastolic blood pressure (mm Hg)</td>
<td>—</td>
<td>122 ± 29</td>
<td>—</td>
</tr>
<tr>
<td>Mean arterial pressure (mm Hg)</td>
<td>82 ± 21</td>
<td>87 ± 21</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Heart rate (beats/min)</td>
<td>89 ± 24</td>
<td>90 ± 23</td>
<td>0.59</td>
</tr>
</tbody>
</table>

Data are presented as the mean value ± SD.
IABP = intra-aortic balloon pump.


Routine Use Of An IABP After AMI Does Not Improve Outcomes

- 598 patients with hypotension pulmonary edema and impaired end organ perfusion
- No difference in mortality
- Trend towards benefit in younger patients without prior MI and anterior MI

9.1. Cardiogenic Shock

9.1.1. Treatment of Cardiogenic Shock: Recommendations

Class I

1. Emergency revascularization with either PCI or CABG is recommended in suitable patients with cardiogenic shock due to pump failure after STEMI irrespective of the time delay from MI onset [36,38,39] (Level of Evidence: B)

2. In the absence of contraindications, thrombolytic therapy should be administered to patients with STEMI and cardiogenic shock who are unsuitable candidates for either PCI or CABG [36,38,39] (Level of Evidence: B)

Class Ia

1. The use of intra-aortic balloon pump (IABP) counterpulsation can be useful for patients with cardiogenic shock after STEMI who do not quickly stabilize with pharmacological therapy [36,38,39] (Level of Evidence: B)

Class Ib

1. Alternative LV assist devices for circulatory support may be considered in patients with refractory cardiogenic shock. (Level of Evidence: C)

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Characteristics of Temporary Mechanical Support Devices

<table>
<thead>
<tr>
<th>Device Features</th>
<th>IABP</th>
<th>Impella 2.5</th>
<th>Impella CP</th>
<th>Impella 5</th>
<th>VAD-ECMO</th>
<th>Thoratec HeartMate</th>
<th>CentriMag</th>
<th>Ferrarini</th>
<th>Impella RP</th>
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</thead>
<tbody>
<tr>
<td>Pump mechanism</td>
<td>Percutaneous</td>
<td>Axial flow</td>
<td>Axial flow</td>
<td>Axial flow</td>
<td>Centrifugal</td>
<td>Centrifugal</td>
<td>Axial flow</td>
<td>Axial flow</td>
<td>Axial flow</td>
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<tr>
<td>Canister</td>
<td>85%</td>
<td>115%</td>
<td>115%</td>
<td>115%</td>
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<td>115%</td>
<td>115%</td>
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<tr>
<td>Isolation</td>
<td>Percutaneous</td>
<td>0-48h</td>
<td>0-48h</td>
<td>0-48h</td>
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<td>0-48h</td>
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<tr>
<td>Hemodynamics</td>
<td>200/100</td>
<td>60/40</td>
<td>60/40</td>
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<tr>
<td>Blood volume</td>
<td>1000 mL</td>
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<tr>
<td>Abnormalities</td>
<td>Reduced</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Increased</td>
<td>Neutral</td>
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<tr>
<td>P/F Ratio</td>
<td>Slightly reduced</td>
<td>Slightly reduced</td>
<td>Slightly reduced</td>
<td>Slightly reduced</td>
<td>Reduced</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Slightly increased</td>
<td>Neutral</td>
</tr>
</tbody>
</table>
Impella Registry: Early Implantation of Impella May Improve Outcomes

IMPRESS trial of Impella Compared to IABP In Cardiogenic Shock: No Difference In Mortality

Ouweneel. JACC. 2016.

Meta Analysis Demonstrates Better Hemodynamics, Increased Complications, Similar Outcomes


Meta Analysis Demonstrates Better Hemodynamics, Increased Complications, Similar Outcomes

Few Data To Evaluate ECMO

The Use Of MCS Devices Has Increased Dramatically

Mortality Has Decreased For Recipients of Short Term Mechanical Support

Shift To Earlier Use of Percutaneous Devices for MCS
A Team Approach To Evaluation Of The Candidates For Advanced Mechanical Support Is Recommended

- Heart failure/heart transplant specialist
- Intensivist
- Cardiac surgeon

Pathway to Decision for Use of MCS

Considerations In Choosing Mechanical Support