BSH Heart Failure Day for Revalidation and Training 2017

Presentation title: Management of cardiogenic shock

Speaker: Stephen Pettit

Conflicts of interest: None
Management of Cardiogenic Shock

Outline

• Cardiogenic shock
  – Definition, INTERMACS classification

• Medical management of cardiogenic shock
  – Inotropes and vasoactive drugs
  – PA catheters and haemodynamic targets

• Mechanical circulatory support
  – Intra-aortic balloon pumps
  – VA ECMO
  – Temporary ventricular assist devices
Management of Cardiogenic Shock

**Definition**

<table>
<thead>
<tr>
<th>Clinical criteria</th>
<th>Hypotension (systolic BP &lt;90 mmHg for 30 minutes or need for support to maintain systolic BP of &gt;90 mmHg) AND Heart rate of &gt;60 bpm AND End-organ hypo-perfusion: cool extremities, urine output &lt;0.5 ml/kg/hr, serum lactate &gt;2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Haemodynamic criteria</td>
<td>Cardiac index of &lt;1.8 L/min/m² AND Pulmonary-capillary wedge pressure of &gt;20 mmHg</td>
</tr>
</tbody>
</table>
Management of Cardiogenic Shock

*Spiral to death if untreated*
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ICU mortality remains 50% in current era

Puymirat E et al. Eur J Heart Fail 2017;19:192-200
### Management of Cardiogenic Shock

**INTERMACS classification**

<table>
<thead>
<tr>
<th>INTERMACS</th>
<th>Description</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>'Crash and burn'</td>
<td>Need to do something now</td>
</tr>
<tr>
<td>2</td>
<td>'Sliding on inotropes'</td>
<td>Need to do something in the next few days</td>
</tr>
<tr>
<td>3</td>
<td>'Stable on inotropes'</td>
<td>Need to do something in the next few weeks</td>
</tr>
</tbody>
</table>
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*Initial management steps*

- Emergency revascularisation for acute STEMI
- Move appropriate patients to high dependency area
- Invasive pressure and cardiac output monitoring
  - Do they really have cardiogenic shock?
  - How sick is the patient?
  - What is the trajectory?
- Optimise medical therapy
  - Identify and treat any co-existent pathology
  - Try to lower intra-cardiac filling pressures
  - Think about inotrope and vasoactive drugs
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PA catheter may guide management

1. Filling pressures
   - RA: 2-8 mmHg
   - RV: 15-30 mmHg
   - PA: 15-20 mmHg
   - PCWP: 5-15 mmHg

2. Cardiac output
   - CO 4.5 L/min
   - CO 3.1 L/min
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**Basic cardiovascular physiology**

\[
Q = \frac{\Delta P}{R} \\
Q = \text{Flow} \\
P = \text{Pressure drop} \\
R = \text{Resistance}
\]

\[
CO = \frac{\text{MAP} - \text{CVP}}{\text{SVR}}
\]
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Need Cardiac Power to survive in SHOCK

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

\[ 0.6 \times 451 = \text{MAP} \times \text{CO} \]

\[ 270 = \text{MAP} \times \text{CO} \]

Aim for MAP ≈ 70 and CO ≈ 4
Management of Cardiogenic Shock  

**Inotropic and vasoactive drugs**

<table>
<thead>
<tr>
<th>Drug</th>
<th>Mechanism</th>
<th>Effect on Mortality</th>
<th>Key Trials (Ref. #)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digoxin</td>
<td>Na-K pump inhibitor, raises SR calcium</td>
<td>Neutral, Increased mortality if long-term therapy discontinued</td>
<td>DIG (15, 20)</td>
</tr>
<tr>
<td>Dopamine</td>
<td>Dose-dependent D1, α1, and β1-adrenergic receptor agonist</td>
<td>Increased</td>
<td>(48)</td>
</tr>
<tr>
<td>Norepinephrine</td>
<td>β1- and α1-adrenergic receptor agonist</td>
<td>Increased</td>
<td>(48)</td>
</tr>
<tr>
<td>Dobutamine</td>
<td>β1- and β2-adrenergic receptor agonist</td>
<td>Increased</td>
<td>FIRST (47)</td>
</tr>
<tr>
<td>Milrinone</td>
<td>PDE inhibitor, raises SR calcium</td>
<td>Increased</td>
<td>OPTIME-CHF (5)</td>
</tr>
<tr>
<td>Levosimendan</td>
<td>Myofilament calcium sensitizer, PDE-3 inhibitor</td>
<td>Neutral</td>
<td>REVIVE-II (61), SURVIVE (7)</td>
</tr>
<tr>
<td>Omeprazol</td>
<td>Potentiates the effects of myosin on actin to prolong systole</td>
<td>Unknown</td>
<td>ATOMIC AHF (underway), (66, 69)</td>
</tr>
<tr>
<td>Istaroxime</td>
<td>Na-K pump inhibitor, PDE inhibitor</td>
<td>Unknown</td>
<td>HORIZON-HF (75)</td>
</tr>
<tr>
<td>SERCA2a gene therapy</td>
<td>Restoration of SERCA2a to improve calcium release and reuptake from the SR</td>
<td>Unknown</td>
<td>CUPID (70)</td>
</tr>
</tbody>
</table>

Use the smallest dose of the most appropriate medication for the shortest length of time

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Outcomes are worse with inotropes

Kaplan-Meier survival curve for all-cause mortality by intravenous vasoactive medication use.

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Phone for help if transplant/MCS candidate
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There is a mountain to climb

- Get through early post-operative care
- Perform heart transplant or durable LVAD implant
- Allow end-organ recovery
- Achieve reasonable MAP and CO
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Goals of Mechanical Support

- Unload injured ventricles
- Wean toxic levels of vasopressors
- Maintain end-organ perfusion/function
- Allow cytokines to be metabolised
- Allow replenishment of ATP stores
- Allow myocardium to declare potential for recovery
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What MCS options are available?

Peripheral

Central
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Intra-Aortic Balloon Pump

Diastole
- Left subclavian
- Aorta
- Balloon inflated

Systole
- Left subclavian
- Aorta
- "Safe zone"
- Balloon deflated
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IABP increase MAP and decrease afterload

The decrease in aortic pressure means the left ventricle needs to generate less pressure to open the aortic valve. Thus, afterload is reduced.

As the balloon deflates, aortic pressure decreases.
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IABP do not improve outcome in post-MI shock

Figure 1. Time-to-Event Curves for the Primary End Point.
Time-to-event curves are shown through 30 days after randomization for the primary end point of all-cause mortality. Event rates represent Kaplan–Meier estimates.

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Veno-arterial (VA) ECMO

Pro: Percutaneous, easy to deploy, transportable
Cons: Bleeding, thrombosis, LV distension, Harlequin syndrome possible
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**Percutaneous LVAD**

Impella family
- 2.5: Percutaneous, left-sided
- CP: Percutaneous, left sided
- RP: Percutaneous, right sided
- 5.0: Femoral cut-down

Pro: Quick to insert (Impella 2.5, CP, RP), can assess RV function
Cons: Expensive, dislodgment, <3.5L/min, haemolysis, aortic incompetence
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**Tandem Heart**

Pro: Percutaneous or open, works with any cannula, LVAD/RVAD, +/- ECMO

Cons: Expensive, trans-septal puncture needed for percutaneous use
### Management of Cardiogenic Shock

**Comparison of Peripheral MCS devices**

<table>
<thead>
<tr>
<th></th>
<th>IABP</th>
<th>ECMO</th>
<th>TandemHeart</th>
<th>Impella 2.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump mechanism</td>
<td>Pneumatic</td>
<td>Centrifugal</td>
<td>Centrifugal</td>
<td>Axial flow</td>
</tr>
<tr>
<td>Cannula size</td>
<td>7.9 Fr</td>
<td>18–21 Fr inflow; 15–22 Fr outflow</td>
<td>21 Fr inflow; 15–17 Fr outflow</td>
<td>13 Fr</td>
</tr>
<tr>
<td>Insertion technique</td>
<td>Descending aorta via the femoral artery</td>
<td>Inflow cannula into the right atrium via the femoral vein, outflow cannula into the descending aorta via the femoral artery</td>
<td>21 Fr inflow cannula into left atrium via femoral vein and transseptal puncture and 15–17 Fr outflow cannula into the femoral artery</td>
<td>12 Fr catheter placed retrogradely across the aortic valve via the femoral artery</td>
</tr>
<tr>
<td>Haemodynamic support</td>
<td>0.5 – 1.0 L min⁻¹</td>
<td>&gt;4.5 L min⁻¹</td>
<td>4 L min⁻¹</td>
<td>2.5 L min⁻¹</td>
</tr>
<tr>
<td>Implantation time</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Risk of limb ischaemia</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Anticoagulation</td>
<td>+</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
</tr>
<tr>
<td>Haemolysis</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Post-implantation management complexity</td>
<td>+</td>
<td>+++</td>
<td>++++</td>
<td>++</td>
</tr>
<tr>
<td>Optional active cooling in post-cardiopulmonary resuscitation patients</td>
<td>No</td>
<td>Yes</td>
<td>(Yes)</td>
<td>No</td>
</tr>
</tbody>
</table>

Management of Cardiogenic Shock

Summary

• Cardiogenic shock is usually fatal if untreated
  – PA catheter may be useful for diagnosis and guiding treatment
  – Use inotropes or vasoconstrictors with caution
  – Watch end-organ function

• Consider MCS before multi-organ dysfunction occurs
  – IABP reduce PCWP and augment MAP, but don’t give much extra CO
  – Consider peripheral VA ECMO in sickest patients (INTERMACS 1)
  – Percutaneous VADs are physiologically more attractive but expensive

• Start with the end in mind and phone for help early
Any questions?