Right Ventricular Infarction and Shock

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AHEPA University Hospital.
Abnormal RV function is likely to be a common occurrence in the setting of AMI-CS, regardless of the culprit coronary vessel

SHOCK trial, J Cardiac Failure 2017

However, a small subset of patients in shock has significant right ventricular (RV) dysfunction in isolation or in combination with LV dysfunction

SHOCK trial, JACC 2003
Cardiogenic Shock Caused by Right Ventricular Infarction
A Report From the SHOCK Registry

shorter median time between the index MI and the diagnosis of shock (2.9 vs. 6.2 h)

5.3%
mortality is unexpectedly high

Predominant RV Shock (n=49)
Predominant LV Shock (n=884)

Logrank P-value=0.685

TIME FROM HOSPITALIZATION (days)

SURVIVAL (%)

Jacobs AK, J Am Coll Cardiol 2003;41:1273–9
Mortality for patients with RV and LV shock undergoing CABG or PTCA
A Report From the SHOCK Registry

Jacobs AK, J Am Coll Cardiol 2003;41:1273–9
RV Ischemic Injury Pattern by CMR- Reversible Dysfunction

T2w imaging (oedema)

LGE imaging (necrosis /fibrosis)

LGE: Late Gadolinium Enhancement
Complete Reperfusion: normal flow in the right main coronary artery and its major RV branches
EFFECT OF REPERFUSION ON BIVENTRICULAR FUNCTION AND SURVIVAL AFTER RIGHT VENTRICULAR INFARCTION

TERRY R. BOWERS, M.D., WILLIAM W. O’NEILL, M.D., CINDY GRINES, M.D., MARK C. PICA, B.S., ROBERT D. SAFIAN, M.D., AND JAMES A. GOLDSTEIN, M.D.
Occurrence and severity of Cardiogenic Shock due to RV infarction

Extent of RV ischemia

Intact LV septum

RV filling
- concomitant atrial infarction
- loss of atrioventricular synchrony
- intravascular volume depletion
Compromise of Potential Collateral Channels shows a significant positive correlation with RV infarct size.
Occurrence and severity of Cardiogenic Shock due to RV infarction

Extent of RV ischemia

Intact LV septum

RV filling

concomitant atrial infarction

loss of atrioventricular synchrony

intravascular volume depletion
Importance of Left Ventricular Function and Systolic Ventricular Interaction to Right Ventricular Performance During Acute Right Heart Ischemia

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Saint Louis, Missouri
Occurrence and severity of Cardiogenic Shock due to RV infarction

Extent of RV ischemia

Intact LV septum

**RV filling**

- concomitant atrial ischemia
- intravascular volume depletion
- loss of atrioventricular synchrony
Atrial branches

60% RCA

40% CX
Compensatory role of augmented RA contraction in RVI

RA Infarction
MANAGEMENT

Fluids

Inotropes/ vasopressors

Rhythm

Reduction in RV afterload
Relation between right ventricular stroke work index (RVSWI) and mean right atrial pressure (MRAP) in 41 patients with right ventricular infarction.

\[ ([PAP - RAP]) \times SV/BSA \]

Volume Loading ★ vs Dobutamine ■ in RV infarction

Ferrario study: AJC 1994
the mean arterial pressure in RV infarction

Effect on perfusion


Effect on LV-RV interaction

Klima U, JTCS, 2002
Rhythm disorders and reflexes

Atrial pacing
fixed stroke volume > cardiac output strongly depends on the heart rate

A-V sequential pacing


Bezold-Jarisch reflex
inhibitory cardiac sensory reflexes
Escalation of support in RV Infarction

effectiveness not determined
Hemodynamic characteristics of pts with RV and LV shock

<table>
<thead>
<tr>
<th></th>
<th>RV Shock</th>
<th>LV Shock</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right heart catheterization (%)</td>
<td>61.2</td>
<td>64.4</td>
<td>0.649</td>
</tr>
<tr>
<td>Right atrial pressure (mm Hg)</td>
<td>23.0 ± 9.9</td>
<td>14.2 ± 7.4</td>
<td>0.0001</td>
</tr>
<tr>
<td>Systolic pulmonary artery pressure (mm Hg)</td>
<td>35.0 ± 7.3</td>
<td>41.1 ± 12.8</td>
<td>0.045</td>
</tr>
<tr>
<td>Diastolic pulmonary artery pressure (mm Hg)</td>
<td>22.2 ± 6.3</td>
<td>23.9 ± 8.0</td>
<td>0.370</td>
</tr>
<tr>
<td>Pulmonary capillary wedge pressure (mm Hg)</td>
<td>23.1 ± 11.2</td>
<td>23.6 ± 8.6</td>
<td>0.339</td>
</tr>
<tr>
<td>Cardiac output (l/min) n</td>
<td>3.8 ± 1.6</td>
<td>3.9 ± 1.6</td>
<td>0.774</td>
</tr>
<tr>
<td>Cardiac index (l/min/m²)</td>
<td>1.9 ± 0.6</td>
<td>2.1 ± 0.8</td>
<td>0.776</td>
</tr>
<tr>
<td>Right atrial/pulmonary capillary wedge pressure ≥0.8 (%)</td>
<td>70.6</td>
<td>23.6</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

*Measurements obtained on sympathomimetic amines and/or intra-aortic balloon support. LV = left ventricular; RV = right ventricular.

Jacobs AK, J Am Coll Cardiol 2003;41:1273–9
## Hemodynamic variables for detection of Right Ventricular (RV) Function

<table>
<thead>
<tr>
<th>Variable</th>
<th>RV Dysfunction (RVD)</th>
<th>Severe RVD</th>
<th>Recover Right Trial Criteria for RV Failure (RR-RVF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVP</td>
<td>&gt;10 mmHg</td>
<td>&gt;15 mmHg</td>
<td>&gt;15 mmHg OR</td>
</tr>
<tr>
<td>CVP/PCWP</td>
<td>&gt;0.63</td>
<td>&gt;0.8</td>
<td>&gt;0.63</td>
</tr>
<tr>
<td>PAPi*</td>
<td>&lt;2.0</td>
<td>&lt;1.5</td>
<td><strong>Cardiac index</strong> &lt;2.2 L/min. m2</td>
</tr>
<tr>
<td>RVSWI**</td>
<td>&lt;450 mmHg mL/m²</td>
<td>&lt;300 mmHg mL/m²</td>
<td><strong>Inotrope/pressor</strong> &gt;1</td>
</tr>
</tbody>
</table>

*PASP-PADP)/CVP

**The RV stroke work index (RVSWI) can be approximated by the equation:

\[
[(\text{meanPAP} - \text{meanRAP}) \times \text{SV/BSA}] \times 0.0136 \text{ mmHg mL/m}^2 \text{ gr m/m}^2
\]

The normal values range is between 350–750 mmHg mL/m² or 5 - 10 gr m/m²
Intra-aortic counterpulsation balloon pumps (IABPs) are commonly used to support RV failure but are not optimally suited for this purpose.
Intraortic Balloon Pump support

RA: 34 mmHg

RV
Acute mechanical circulatory support devices for right ventricular (RV) failure

<table>
<thead>
<tr>
<th>Direct RV Bypass</th>
<th>Indirect RV Bypass</th>
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<tbody>
<tr>
<td>Impella RP</td>
<td>VA-ECMO</td>
</tr>
<tr>
<td>Axial Flow</td>
<td>Extracorporeal Centrifugal Flow</td>
</tr>
<tr>
<td>Tandem RVAD</td>
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<tr>
<td>Protek Duo</td>
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</tbody>
</table>
Pt with RV failure and Cardiogenic Shock
Percutaneous acute mechanical circulatory support of the RV with the Impella RP microaxial pump.
Percutaneous biventricular acute mechanical circulatory support
Clinical Studies Evaluating the Utility of Acute Mechanical Circulatory Support Systems for Right Ventricular Failure

<table>
<thead>
<tr>
<th>Device</th>
<th>Patient Population</th>
<th>Outcomes</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impella RP</td>
<td>18 Patients (15 Impella RD, 3 Impella RP)</td>
<td>30-d Survival, 72% 1-y Survival, 50% Hemodynamic effects: increased CI, decreased RA pressure</td>
<td>Cheung et al^{83}</td>
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<tr>
<td></td>
<td>AMI, 39% (n=7)</td>
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<td></td>
<td>PCCS, 22% (n=4)</td>
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<td></td>
<td>Post-OHT, 17% (n=3)</td>
<td></td>
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<tr>
<td></td>
<td>Post-LVAD, 11% (n=2)</td>
<td></td>
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<tr>
<td></td>
<td>Myocarditis, 11% (n=2)</td>
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PCCS, postcardiotomy cardiogenic shock  OHT, orthotopic heart transplantation

CONCLUSIONS

✓ RV-Cardiogenic Shock (CS) in its pure form is not frequent, but is associated with high mortality.

✓ RV-CS can be reversed with complete RCA revascularization but hemodynamic support is needed with judicious use of fluids and inotropes/vasopressors and rhythm management.

✓ Although no percutaneous support device has significantly affected the 6-month mortality in AMI-CS pts, in the case of RVI-CS even late unloading of the RV may decrease mortality considering the RV free wall resistance to necrosis.