Support of the RV

What are the Mechanical Circulatory Support (MCS) options for the patient with RV failure

Rakesh C. Arora

Special Session - The Right Ventricle in Critical Care

Tuesday October 27, 2015
Disclosures

• R.C. Arora has received an unrestricted educational grant from Pfizer Canada Inc. for work unrelated to this presentation
Acknowledgements

Rohit Singal (Winnipeg)

David Nagpal (London)

Michael McDonald (Toronto)
• Case Presentation

• Discussion of the issues of acute right heart failure (ARVF)

• Options for mechanical circulatory support (MCS) of the RV
Case Presentation

• 59 male presents (Nov 27) with syncope due to AS
  – Previous STEMI (DES to RCA) 2009
  – DMII, Ex-smoker
  – Restless leg, OSA, Dyslipidemia
  – Atorvastatin 80 OD, Metoprolol 12.5 BID, Ramipril 5 OD, Plavix 75 OD, ECASA 81 OD

• ECHO (January): EF 50% with inferolateral hypokinesis, AVA 0.9

• Angio (Oct): No significant CAD, Stent patent

• DECEMBER 01: Inpatient AVR (23mm Mechanical)
Post-CPB TEE
Case Presentation

• POD #2: Deterioration overnight requiring increasing inotropes with evidence of RV dysfunction
  – PEA arrest at 0715hrs
  – CSU-ALS initiated
The CSU-ALS Protocol

**CARDIAC ARREST**

**assess rhythm**
- ventricular fibrillation or tachycardia
  - DC shock (3 attempts)
- asystole or severe bradycardia
  - pace (if wires available)
- pulseless electrical activity

**start basic life support**
- amiodarone 300mg via central venous line
- consider external pacing
- if paced, turn off pacing to exclude underlying VF

**prepare for emergency resternotomy**
- continue CPR with single DC shock every 2 minutes until resternotomy
- continue CPR until resternotomy
- continue CPR until resternotomy

**airway and ventilation**
- If ventilated turn FiO2 to 100% and switch off PEER
- Change to bag valve with 100% O2, verify ET tube position and cuff inflation
- Listen for breath sounds bilaterally to exclude a pneumothorax or hemothorax
- If tension pneumothorax suspected, immediately place large bore canula in the 2nd/3rd space anterior mid-clavicular line
- **DO NOT GIVE EPINEPHRINE unless a senior doctor advises this.**
- If an IABP is in place change to pressure trigger
- Do not delay basic life support for defibrillation or pacing for more than one minute
Here is what the heart looked like
Case Presentation

• POD #2:
  – TEE: no pericardial effusion, severe biventricular dysfunction
  – Chest opened in the ICU
What’s Good and Bad About Acute Right Ventricular Failure (ARVF)?

- **BAD** - Associated with significant morbidity and mortality

Other Important References:

*Taken from:* Cheung, AW, White, CW, Davis, MK, Freed, DH. The J Heart Lung Transplant 2014;33(8), 1–6.
What’s Good and Bad About Acute Right Ventricular Failure (ARVF)?

**The Good:**
- May exhibit a greater capacity for rapid recovery
- 42% to 75% of patients recover sufficient function

**However:**
- Requires rapid identification of the need and subsequent implementation of support

**Challenge:**
- Has traditionally required adaptation of currently available technology

Treatment Options

• “Traditional Treatment Methods”
  – reversing the underlying cause
  – maintaining adequate preload
  – reducing RV afterload
  – enhancing RV contractility
High risk of death in post cardiotomy shock

 Allegheny University Hospital

Probability of death (%)

No dose  Low dose  Moderate dose  One high dose  Two high dose  Three or more high dose

Low dose: 1–4 μg/min epinephrine, 1–4 μg/kg/min dobutamine or dopamine, or 0.1–0.24 μg/kg/min milrinone
Moderate dose: 5–9 μg/min epinephrine, 5–9 μg/kg/min dobutamine or dopamine, or 0.25–0.49 μg/kg/min milrinone
High dose: ≥10 μg/min epinephrine, ≥10 μg/kg/min dobutamine or dopamine, or ≥0.5 μg/kg/min milrinone
Treatment Options

• “Traditional Treatment Methods”
  – reversing the underlying cause
  – maintaining adequate preload
  – reducing RV afterload
  – enhancing RV contractility
To the Cath Lab!
Interventional/Surgical Options

A. Intra-aortic balloon pump (IABP)
B. Veno-arterial extracorporeal membrane oxygenation (VA-ECMO)
C. Right heart assist device (RVAD) implantation
D. Heart transplantation
IABP

Diastole

Systole
Intraaortic balloon support for myocardial infarction with cardiogenic shock.


Need to maintain good coronary perfusion pressure for the RV.
Review of Technology and RV Support Device Selection

I'M USING ALL OF MY DEVICES SIMULTANEOUSLY TO SHOP FOR MORE DEVICES.
Continuous flow devices

- Impella
- Levitronix
- Rotaflow/Biomedicus
- Tandem Heart

- axial or centrifugal flow
- potential for contacting surfaces to deteriorate
Short-term mechanical circulatory support for recovery from acute right ventricular failure: Clinical outcomes

Anson W. Cheung, MD, MS, Christopher W. White, MD, Margot K. Davis, MD, and Darren H. Freed, MD, PhD

Figure 1  Impella Recover Right Direct (Abiomed, Danvers, MA) device.

Figure 2  Impella Right Peripheral (Abiomed, Danvers, MA) device.

Now no longer available in Canada
Impella
Temporary MCS options to consider: Axial Flow Cannulae

Pros
- Implanted percutaneously
- Transportable
- Easy to manage
- Unloads RV effectively?

Cons
- Limited duration of support (< 1 week)
- Trauma to AV, hemolysis major potential complications
- Efficacy debatable
Centrifugal Flow-ventricular support device (CF-VSD)
Centrifugal Flow-right ventricular support device (CF-RVSD)

• Cannula for both venous drainage and reinfusion
Mechanical Circulatory Support for Right Ventricular Failure

Navin K. Kapur, MD,* Vikram Paruchuri, MD,* Anand Jagannathan, MS,* Daniel Steinberg, MD,† Anjan K. Chakrabarti, MD,‡ Duane Pinto, MD,‡ Nima Aghili, MD,§ Samer Najjar, MD,§ John Finley, MD,∥ Nicole M. Orr, MD,¶ Michael Tempelhof, MD,# James O. Mudd, MD,** Michael S. Kieran, MD,* Duc Thinh Pham, MD,* David DeNofrio, MD*

Boston, Massachusetts; Charleston, South Carolina; Washington, DC; Philadelphia, Pennsylvania; Roslyn, New York; Chicago, Illinois; and Portland, Oregon

• In-hospital mortality was 57%
• Best for:
  – Post - LVAD implantation
  – Chronic left heart failure
  – AMI
• No so good for:
  – Increased age
  – Biventricular failure,
  – Major bleeding

Centrifugal Flow-right ventricular support device (CF-RVSD)

- a single cannula for both venous drainage and reinfusion

- Can also be used for ECMO support
Temporary MCS options to consider: CF-RVSD

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Implanted percutaneously</td>
<td>• Limited duration of support</td>
</tr>
<tr>
<td>• Transportable</td>
<td>• Trauma to AV, hemolysis major potential</td>
</tr>
<tr>
<td>• Easy to manage</td>
<td>complications</td>
</tr>
<tr>
<td>• Unloads RV effectively</td>
<td>• Limited Canadian Experience</td>
</tr>
<tr>
<td>• Able to add oxygenator</td>
<td>• Still high mortality</td>
</tr>
</tbody>
</table>
ECMO Cannulation and Configurations

Central

or

Peripheral
Case Presentation - On ECMO

• ECMO DAY #6
  – Neuro function grossly (RASS -3)
  – On CRRT
  – ECMO weaned over 48 hours to 2L
    • normal lactate and venous O2
  – RV function looking improved on last ECHO
  – Ongoing “vasoplegia”
Case Presentation – ECMO Again

• ECMO DAY #6
  – Decannulated – inferior akinesia, RV mild to moderately down
  – Gradual deterioration – re-explored and peripherally cannulated
Temporary MCS options to consider: ECLS/ECMO

**Pros**
- Implanted percutaneously
- Transportable
- Biventricular support
- *Provides oxygenation as needed*
- Good results in centers with high volumes and adequate resources

**Cons**
- Limited duration of support (~2 weeks)
- Ability to ambulate/mobilize in VA configuration is challenging
- Bleeding, limb ischemia complications
- Resource intensive
Case Presentation – Ongoing Saga

• ECMO Day #11
  – Ongoing vasoplegia (NE 0.4, Vaso 2.4), VA ECMO 5LPM
  – LV moderately to severely decreased, RV severely decreased

• Discussion with transplant centres
So Should We Transplant?
Degree of HF/shock at implant can predict outcomes with LVAD support

Significant difference in survival according to INTERMACS level

Kirklin, J Heart Lung Transplant, 2010
Alba, J Heart Lung Transplant, 2009
## INTERMACS - Simplified

<table>
<thead>
<tr>
<th>PROFILE-LEVEL</th>
<th>Official Shorthand</th>
<th>General time frame until support need</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEVEL 1</td>
<td>“Crash and burn”</td>
<td>Hours</td>
</tr>
<tr>
<td>LEVEL 2</td>
<td>“Sliding fast”</td>
<td>Days to week</td>
</tr>
<tr>
<td>LEVEL 3</td>
<td>“Stable but Dependent”</td>
<td>Weeks</td>
</tr>
<tr>
<td>LEVEL 4</td>
<td>“Frequent flyer”</td>
<td>Weeks to few months, if baseline restored</td>
</tr>
<tr>
<td>LEVEL 5</td>
<td>“Housebound”</td>
<td>Weeks to months</td>
</tr>
<tr>
<td>LEVEL 6</td>
<td>“Walking wounded”</td>
<td>Months, if nutrition and activity maintained</td>
</tr>
<tr>
<td>LEVEL 7</td>
<td>Advanced Class III</td>
<td></td>
</tr>
</tbody>
</table>

Interagency Registry for Mechanically Assisted Circulatory Support
Why not implant long term VAD support in cardiogenic shock?

• Without intervention, most patients will not survive, but caution is warranted:
  • Unclear neurologic status
  • Respiratory failure
  • Acute renal and liver dysfunction
  • Antithrombotic burden (antiplatelets, IIb/IIIa inhibitors)
  • Uncertain potential for cardiac recovery
  • Unknown psycho-social status
CentriMag Characteristics

- No wearable parts, friction, or heat generation in the blood path.
- Minimizes areas of blood stagnation and turbulence in the pump.
- Large mechanical gaps in the pump (>0.6mm) allows the shear forces to be low
  - Greatly reducing hemolysis.
Case Presentation

• ECMO Day #15
  – Conversion of ECMO to Centrimag
  – Attempt at ECMO wean in isolation and with RVAD

• Resultant hypotension and AF and ongoing biventricular dysfunction
  – Customized Configuration
    • RA to PA, RSPV to Ao
Case Presentation- Hemodynamics

- BiVAD Day #31 – off vasopressors with improving pulse pressure
- Bradycardic wide complex rhythm (? Agonal) for weeks normalized
Case # 1 – BiVAD Wean

• ECHO BiVAD Day #58
  – With arterial line and CVP monitoring
    • Flows gradually down to 1L on RVAD/LVAD
    • After 5 minutes; reasonable biventricular function
  – MAP decrease from 80 to 70 mmHg
  – CVP stable at 9
  – Venous sat 55% with normal lactate

• BiVAD EXPLANT ON DAY #61
Following BiVAD Decannulation
Acute MCS Algorithm

Acute MCS Implemented

Neuro and Multi Organ Recovery?

YES

Cardiac Recovery?

NO

Long Term VAD Candidate?

YES

Wean and Decannulate

NO

Palliation

NO

Palliation
YEAH IF YOU COULD JUST WRAP IT UP

THAT'D BE GREAT
“Traditional” Treatment Modalities Available in Cardiogenic Shock

• Medical Management
  – Inotropic/vasopressor support

• Intra-aortic Balloon Pump

• LVAD, CPB and revascularization if indicated

NONE of these may sufficient for the failing RV
Lessons Learned

• Early identification

• Tailor therapy based on institutional capabilities

• Don’t forget the “basics”
  – ABCDEs
MCS is Team Sport

• Inter-disciplinary support
  – Surgery
  – Anesthesia
  – Critical Care
  – Cardiology
    • Interventional
    • HF
    • Echo
  – Nursing
  – Pharmacy
  – RT, PT, OT, SW
Don’t Forget the ICU Basics
Mobilization

- First Dangle ~ BiVAD Day #16
- First Stand ~ Day #26
- March in Place ~ Day #34
- Bed Biking ~ Day #45
- First Walk ~ Day #54
Lessons Learned

• Can’t win them all
  – Mortality remains high however
• New technology
• Need to develop
  – patient and device monitoring, and weaning protocols
MCS - ECMO Working Group

• Inaugural Meeting
  – Oct. 25, 2015
• **Goals:**
• To advance the care of critically-ill cardiovascular patients using multidisciplinary expertise in a cooperative model.

• [www.cancaresociety.com](http://www.cancaresociety.com)
• [info@cancaresociety.com](mailto:info@cancaresociety.com)
Thank you

WHO'S AWESOME?

You're awesome.