Current Concepts in Management of RV Failure

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NZ A ASM  ICCVA
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NO CONFLICT OF INTEREST
59 years old male scheduled for CABG x 4

• PMH positive for:
  • HTN
  • IDDM
  • Atrial fibrillation
  • ESRD on HD
  • Steroid dependence

• Meds:
  • Amlodipine, Fosinopril, Lasix, Coumadin, Metoprolol, Prednisone, Hydralazine and Vardenafil.
• PE: A.fib, Lungs clear

• Labs within normal limits

• Cath: 3 vessel CAD

• Echo: EF 60%, borderline PAH
Intraoperative Course

Pre CPB

Immediately post CPB
CPB Wean

- Epinephrine and phenylephrine infusions
- Acid-base status corrected
- Bronchoscopy
- Milrinone and norepinephrine started
- Vasopressin and methylene blue given
- IABP inserted
do you think you could write the next chapter of the twilight saga?

Show us what you’ve got!
CPB LAST TAKE

- RVAD considered
- Pulmonary edema
- “ECMO” requested ….BUT
- “We do not do this at Yale”
Pulmonary embolism

Migration

Embolus

Post Bypass

FR 26Hz
14cm
2D
56%
C 50
P Off
Gen
CF
80%
4.9MHz
WF High
Med

87 bpm
Incidence:

- 5% patients have cardiogenic shock post CPB
- 80% respond to medical treatment ± IABP
- Mortality rate 80% for non-responders if not mechanically supported.
Who is at risk???

**Patient factors:**
- Old age.
- Female
- Low ejection fraction < 35%
- H/O CHF
- Cardiomegaly.
- CVA
- DM
- Renal insufficiency

**Surgery factors:**
- ??Length of CPB
- ??Length of aortic cross clamp time.
Pathogenesis of RV Failure

AO = Aorta
PA = Pulmonary Artery
LA = Left Atrium
RA = Right Atrium
LV = Left Ventricle
RV = Right Ventricle

Oxygen-rich Blood
Oxygen-poor Blood

Pulmonary Veins from Lungs
Superior Vena Cava
Atrial Septum
Tricuspid Valve
Inferior Vena Cava

Mitral Valve
Aortic Valve
Ventricular Septum

to Lungs
Pulmonary Veins from Lungs
Goals of treatment in RV failure:

1. Optimization of RV preload

2. Maintenance of aortic root pressure

3. Optimization of RV systolic function

4. Reduction of RV afterload by reducing PVR
1. Volume Mgt in RV Failure
2. Maintenance of aortic root pressure:

coronary perfusion pressure = Diastolic BP – LVEDP

RV coronary perfusion pressure = Diastolic BP – RVEDP

MAP – mean RV pressure
Which vasopressor to use??

Hirsch, Chest. 1991 Sep;100(3):796-801
3. Optimization of RV systolic function: Inotropic support:

- Epinephrine
- Milrinone
- Dobutamine
Calcium Sensitizers

- **Levosimendanin:**
  - Stabilizes troponin C without increasing calcium.
  - It has a peripheral and pulmonary V.D. effects.
  - It also preserves coronary perfusion.
<table>
<thead>
<tr>
<th>Study</th>
<th>Type of study</th>
<th>Inclusion</th>
<th>Number of patients</th>
<th>Dose</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lilleberg et.al.,</td>
<td>1998 RCT</td>
<td>Adults with normal EF for elective CABG</td>
<td>23</td>
<td>Placebo or 8 -µg/kg or 24 µg/kg</td>
<td>Significant increase in CO and coronary blood flow. Decrease in SVR,PVR. No change in myocardial oxygen consumption.</td>
</tr>
<tr>
<td>Nijhawan et.al.,</td>
<td>1999 RCT</td>
<td>Adults with normal EF for elective CABG</td>
<td>18</td>
<td>Placebo or 18 or 36 µg/kg loading followed by 0.2 or 0.3 µg/kg/min infusion</td>
<td>Significant increase in CO and decrease in SVR.</td>
</tr>
<tr>
<td>Sandell et.al.,</td>
<td>2002 RCT</td>
<td>Adults with normal EF for elective CABG</td>
<td>18</td>
<td>Placebo or 18 or 36 µg/kg loading followed by 0.2 or 0.3 µg/kg/min infusion</td>
<td>Significant increase in CO. Decrease in SVR,MAP and MPAP</td>
</tr>
<tr>
<td>Rajek et.al.,</td>
<td>2003 case series</td>
<td>Adults with EF 19 ± 5% for elective CPB cardiac surgery</td>
<td>8</td>
<td>0.6 µg/kg loading followed by 0.2 µg/kg/min infusion</td>
<td>Significant increase in CO that persisted to POD 1. Decrease inotrope requirement and ICU stay.</td>
</tr>
</tbody>
</table>
Nevertheless, it was concluded that the use of levosimendan in high-risk cardiac patients is as effective as the use of IABP, in terms of maintaining stable hemodynamics during and after operations under CPB. The lower level of troponin I at 6 h postoperatively suggests cardioprotective properties of levosimendan, but this requires further investigation. Our preliminary data may facilitate the design of a comprehensive safety/efficacy randomized controlled clinical trial.
4. Reduction of RV Afterload
A. Non-pharmacologic Approach

- Correction of hypoxia, hypercarbia and acidosis.
- Ventilatory strategies to limit $P_{plat}$. 

John West. Essential physiology 10$^{th}$ edition
B. Pharmacologic Approach

Diagram showing the Endothelin pathway, Nitric oxide pathway, and Prostacyclin pathway.
Deoxygenated blood from pulmonary artery

Alveolus

capillary
2. Pharmacological measures to reduce PVR

- Oral
- IV
- Inhalational
Intravenous Route

PVR
- Ventilated Lung = Happy life
- Non-Ventilated = Shunt >>> Hypoxia

SVR
- RV perfusion pressure = RV Ischemia

NO Donors: NTG, SNP
PDE3I: Milrinone
PGE: Epoprostenol
?? Adenosine
Oral Route

- **Prostacyclin derivatives:**
  - Beraprost

- **Endothelin-receptor antagonist:** Bosentan

- **Phosphodiesterase 5 Inhibitors:**
  Oral: Sildenafil and Vardenafil.
Oral Sildenafil Reduces Pulmonary Hypertension After Cardiac Surgery

Aaron L. Trachte, MD, Emilio B. Lobato, MD, Felipe Urdaneta, MD, Phillip J. Hess, MD, Charles T. Klodell, MD, Tomas D. Martin, MD, Edward D. Staples, MD, and Thomas M. Beaver, MD

Departments of Surgery, Division of Thoracic and Cardiovascular Surgery, and Anesthesiology, University of Florida College of Medicine, and Department of Anesthesiology, Malcolm B. Randall Veterans Affairs Medical Center, Gainesville, Florida

Inhalational Route

Nitric Oxide: Gold standard

- Expensive
- Short half-life
- Rebound hypertension
- Risk of methemoglobinemia
- Needs a special delivery system
What else can we nebulize??

**Prostacyclin (PGI₂):**
Epoprostenol, Flolan & iloprost

**Nitric Oxide Donors:**
NTG and SNP

**Phosphodiesterase Inhibitors: “PDEI”**
PDE3I Milrinone
PDE5I Sildenafil
But, are they as effective as NO??
IF
A=B
AND
B=C
THEN
A=C
Nitric Oxide Vs Inhaled Prostacyclin

Prostacyclin as effective as NO

A = B
Inhaled Prostacyclin Vs Inhaled NTG

Prostacyclin is as effective as NTG

\[ B = C \]
Inhaled Milrinone Vs Inhaled NTG

Milrinone is an effective method to reduce PVR

\[ A = C \]
“If a lion chases you to the bank of a river filled with crocodiles, you will leap into the water, convinced you have a chance to swim to the other side.”

Christiaan Barnard, M.D.
Conclusion:

RV failure is a serious and often times fatal complication

Current Therapy

- Optimize Volume status
- Support systemic arterial BP
- Inotropic support: potential role for new inotrops
- Reduce PVR
- Mechanical support should be considered early
Thank you