High-Risk Conventional Cardiac Surgery: Current Strategy

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Disclosures: Edwards, Medtronic (Speaker)
High-Risk Cardiac Surgery Considerations

• What defines high-risk?
• Strategies for preop optimization
• What if the ventricle still doesn’t work?
High-Risk Cardiac Surgery
What defines high-risk?

• Diminished EF?
  – Other factors are at play
• Predicted mortality > 5%?
  – Wash U. data for reop cardiac surgery, less than one-half had procedures that could be quantified by STS risk score
• Combination of objective / subjective criteria
High-Risk Cardiac Surgery
What defines high-risk?

• Survey of cardiovascular surgeons – What defines high-risk?
  – Low EF: 87%
  – ↑ EuroSCORE: 67%
  – Redo surgery: 50%
  – ↑ Creatinine: 37%
  – LM/unstable angina: 27%
  – ↑ Troponin: 20%
  – ↑ BNP: 7%
High-Risk Cardiac Surgery
Incidence of Low CO Syndrome

- Toronto General – 4,558 Cardiac Surgery
  - 9% developed LCOS
  - Mortality: 17% with vs. 0.9% without LCOS (p<.001)

- Risk Factors for LCOS
  - low EF: OR 5.7 (27% frequency)
  - redo operation: OR 4.4 (25%)
  - emergent/urgent: OR 3.7 (27%)
  - female, DM, age > 70 yo, LM, recent MI, 3-V D.
    - OR < 2.5 for all, frequency < 16%
Low Cardiac Output Syndrome Risk Factors

- Stepwise Logistic Regression Analysis – Predictors of LCOS

<table>
<thead>
<tr>
<th>EF grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&gt;60%</td>
</tr>
<tr>
<td>2</td>
<td>40-59%</td>
</tr>
<tr>
<td>3</td>
<td>21-39%</td>
</tr>
<tr>
<td>4</td>
<td>≤ 20%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Elective</td>
</tr>
<tr>
<td>2</td>
<td>Same Hosp.</td>
</tr>
<tr>
<td>3</td>
<td>Emerg/Urgent</td>
</tr>
</tbody>
</table>

Rao et al. JTCVS 1996;112:38
Low Cardiac Output Syndrome
Risk Factors

- Predictive probability of LCOS
Impact of low EF on Outcomes
Isolated CABG

- STS Database Risk Model – 774,881 pts
  - Impact of EF on mortality and complications

<table>
<thead>
<tr>
<th>EF%</th>
<th>% of pts</th>
<th>Death</th>
<th>CVA</th>
<th>ARF</th>
<th>Vent</th>
<th>Comp</th>
<th>↑LOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25</td>
<td>3%</td>
<td>7.2%</td>
<td>2.2%</td>
<td>8.0%</td>
<td>25%</td>
<td>32%</td>
<td>14%</td>
</tr>
<tr>
<td>25-34</td>
<td>7%</td>
<td>4.6%</td>
<td>2.1%</td>
<td>6.1%</td>
<td>18%</td>
<td>24%</td>
<td>10%</td>
</tr>
<tr>
<td>35-44</td>
<td>14%</td>
<td>3.0%</td>
<td>1.7%</td>
<td>4.7%</td>
<td>12%</td>
<td>18%</td>
<td>7%</td>
</tr>
<tr>
<td>45-54</td>
<td>25%</td>
<td>1.9%</td>
<td>1.3%</td>
<td>3.4%</td>
<td>9%</td>
<td>13%</td>
<td>5%</td>
</tr>
<tr>
<td>≥55</td>
<td>45%</td>
<td>1.5%</td>
<td>1.1%</td>
<td>2.7%</td>
<td>7%</td>
<td>11%</td>
<td>4%</td>
</tr>
</tbody>
</table>

Shahian et al.
ATS 2009;88:S2
Impact of low EF on Outcomes
CABG, valve, combined procedures

• With CABG: For each 10% decrease in EF, there is 19% increase in the odds of operative mortality

• With isolated valve procedures: ↓10% in EF → ↑9% mortality

• With combined procedures:
  – MV repair/CABG: ↓10% in EF → ↑9% mortality
  – AVR / CABG: ↓10% in EF → ↑10% mortality
  – MVR / CABG: ↓10% in EF → ↑23% mortality
Impact of low EF on Outcomes Long-term Survival

- 2,054 CABG: EF: ≤ 0.30 8%, 0.30-0.60 32%, ≥ 0.60 in 60%
  - Op death: with low EF 5.6% vs. 1.3% (OR 5.11)
  - 1-yr survival: with low EF 88% vs. 98% (OR 2.28)
High-Risk Cardiac Surgery Considerations

- What defines high-risk?
- Strategies for preop optimization
- What if the ventricle still doesn’t work?
High-risk Cardiac Surgery
Preoperative optimization of CHF

• Has the patient been adequately risk-stratified?
  – EuroSCORE / STS calculation (what is too high for your center?)
High-risk Cardiac Surgery
Preoperative optimization of CHF

• Has the patient been adequately risk-stratified?
  – EuroSCORE / STS calculation (what is too high for your center?)
• Assess modifiable parameters of end-organ dysfunction
  – CBC (correct anemia) – with ES-II > 4, Hgb < 11 → ↑risk 3-fold
  – Creatinine (compare to lowest in last 12 months)
  – LFTs / albumin (malnutrition)
High-risk Cardiac Surgery
Preoperative optimization of CHF

- Has the patient been adequately risk-stratified?
  - EuroSCORE / STS calculation (what is too high for your center?)

- Assess modifiable parameters of end-organ dysfunction
  - CBC (correct anemia) – with ES-II > 4, Hgb < 11 → ↑risk 3-fold
  - Creatinine (compare to lowest in last 12 months)
  - LFTs / albumin (malnutrition)

- Is the patient acutely decompensated?
  - Is there time for outpatient therapy? (ACE, ARB, β-blockers)
  - PA catheter (goal-directed therapy)
  - IABP and inotropes
High-risk Cardiac Surgery
Prophylactic IABP

• 5 RCTs – 255 high-risk pts randomized to preop IABP
  – EF < 30-40%
  – Redo Surgery
  – Unstable angina / Tight LM

• Assessed operative mortality, LCOS, and length of time with IABP to identify benefit

• Contraindications: mod-severe AI, peripheral vascular D.
### Prophylactic IABP for High-risk Surgery

no IABP vs. IABP

- Impact of IABP on CI (measures made with IABP on standby)

<table>
<thead>
<tr>
<th>Cardiac Index</th>
<th>Group 1</th>
<th>( p ) Value</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before IABP</td>
<td>1.82 ± 0.16 (30)</td>
<td>&lt; 0.0001</td>
<td>1.52 ± 0.22 (30)</td>
</tr>
<tr>
<td></td>
<td>( p &lt; 0.0001 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before cardiopulmonary bypass</td>
<td>2.69 ± 0.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weaning</td>
<td>1.99 ± 0.54 (30)</td>
<td>&lt; 0.0001</td>
<td>3.20 ± 0.70 (30)</td>
</tr>
<tr>
<td>+30 minutes</td>
<td>2.58 ± 0.86 (30)</td>
<td>&lt; 0.0001</td>
<td>3.52 ± 0.71 (30)</td>
</tr>
<tr>
<td>+12 hours</td>
<td>2.67 ± 0.76 (27)</td>
<td>0.0046</td>
<td>3.45 ± 0.65 (30)</td>
</tr>
<tr>
<td>+24 hours</td>
<td>2.80 ± 0.64 (27)</td>
<td>0.0020</td>
<td>3.36 ± 0.58 (29)</td>
</tr>
<tr>
<td>+48 hours</td>
<td>2.67 ± 0.52 (24)</td>
<td>0.0008</td>
<td>3.38 ± 0.56 (29)</td>
</tr>
<tr>
<td>+72 hours</td>
<td>2.75 ± 0.39 (24)</td>
<td>&lt; 0.0001</td>
<td>3.37 ± 0.53 (29)</td>
</tr>
<tr>
<td>+96 hours</td>
<td>2.82 ± 0.92 (21)</td>
<td>0.0521</td>
<td>3.23 ± 0.73 (13)</td>
</tr>
</tbody>
</table>

\*Group 1 did not receive preoperative IABP treatment, and group 2 received preoperative counterpulsations. All measurements except values before CPB in group 2 patients were performed without ongoing IABP. Values are mean ± standard deviation. The number of observations is given in parentheses.

Christenson et al.
ATS 1999;68:934
Prophylactic IABP for High-risk Surgery
Impact of duration of preop IABP

- Prophylactic IABP for 1-2 hrs vs. 12 hrs vs. 24 hrs

<table>
<thead>
<tr>
<th>Cardiac Index</th>
<th>Group 2 T2</th>
<th>Group 2 T12</th>
<th>Group 2 T24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before IABP</td>
<td>1.53 ± 0.27 (10)</td>
<td>1.50 ± 0.21 (10)</td>
<td>1.53 ± 0.20 (10)</td>
</tr>
<tr>
<td></td>
<td>( p &lt; 0.001 )</td>
<td>( p &lt; 0.001 )</td>
<td>( p &lt; 0.001 )</td>
</tr>
<tr>
<td>Before cardiopulmonary bypass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+30 minutes</td>
<td>2.65 ± 0.75 (10)</td>
<td>2.70 ± 0.645 (10)</td>
<td>2.72 ± 0.63 (10)</td>
</tr>
<tr>
<td></td>
<td>3.49 ± 0.75 (10)</td>
<td>3.40 ± 0.81 (10)</td>
<td>3.59 ± 0.63 (10)</td>
</tr>
<tr>
<td>+12 hours</td>
<td>3.37 ± 0.51 (10)</td>
<td>3.57 ± 0.56 (10)</td>
<td>3.42 ± 0.89 (10)</td>
</tr>
<tr>
<td>+24 hours</td>
<td>3.52 ± 0.52 (10)</td>
<td>3.42 ± 0.50 (10)</td>
<td>3.11 ± 0.48 (9)</td>
</tr>
<tr>
<td>+48 hours</td>
<td>3.48 ± 0.76 (10)</td>
<td>3.43 ± 0.43 (20)</td>
<td>3.20 ± 0.40 (9)</td>
</tr>
<tr>
<td>+ 72 hours</td>
<td>3.56 ± 0.79 (10)</td>
<td>3.35 ± 0.29 (10)</td>
<td>3.18 ± 0.37 (9)</td>
</tr>
<tr>
<td>+96 hours</td>
<td>3.19 ± 0.77 (5)</td>
<td>3.28 ± 0.30 (6)</td>
<td>3.29 ± 0.42 (2)</td>
</tr>
</tbody>
</table>
Prophylactic IABP for High-risk CABG Impact on ITA and SVG flow

- 84 pts: mean flow (Qm), maximal flow, pulsatility index

<table>
<thead>
<tr>
<th></th>
<th>In-Situ LITA</th>
<th>A-C Bypass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IABP On</td>
<td>IABP Off</td>
</tr>
<tr>
<td>Qm (mL/min)</td>
<td>50 ± 32</td>
<td>42 ± 29</td>
</tr>
<tr>
<td>Max (mL/min)</td>
<td>112 ± 68</td>
<td>82 ± 51</td>
</tr>
<tr>
<td>Pulsatility index</td>
<td>3.0 ± 0.8</td>
<td>2.3 ± 0.9</td>
</tr>
<tr>
<td>DFI (%)</td>
<td>72 ± 7</td>
<td>67 ± 8</td>
</tr>
</tbody>
</table>

Takami et al. ATS 2008;86:823
Prophylactic IABP for High-risk CABG
Impact in OPCAB

• Since 2000, aggressive strategy for OPCAB with ↓ EF
  – ↓ mortality by 67% and ↑ completeness of revascularization
High-risk Cardiac Surgery
Prophylactic IABP

- Metaanalysis of 5 RCTs, 255 high-risk patients
  - ↓mortality: OR 0.18 (p<0.001), ↓LCOS: OR 0.14 (p<0.001)

Impact of preop IABP

Cochrane Database 2011;CD004472
High-risk Cardiac Surgery
Prophylactic IABP

• preop IABP ↓ short-term mortality by 74% (p<0.001)
  – ↓ postop MI by 64%, ↓ LCOS by 84%

Wang et al.
ATS 2016;101:2007
High-risk Cardiac Surgery Scoring system to predict IABP

- Blackpool IABP score > 10
  - predicts 50% who need IABP with 96.5% specificity

<table>
<thead>
<tr>
<th>The Blackpool IABP rule: optimal score</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>One intravenous inotrope</td>
<td>2</td>
</tr>
<tr>
<td>LMS &gt; 50%</td>
<td>2</td>
</tr>
<tr>
<td>Mod impairment of EF (30–50%)</td>
<td>3</td>
</tr>
<tr>
<td>Cardiac catheter on this admission</td>
<td>3</td>
</tr>
<tr>
<td>Cardiogenic shock</td>
<td>5</td>
</tr>
<tr>
<td>Emergency priority</td>
<td>6</td>
</tr>
<tr>
<td>Salvage priority</td>
<td>9</td>
</tr>
<tr>
<td>Poor EF (&lt;30%)</td>
<td>8</td>
</tr>
<tr>
<td>Two or more inotropes</td>
<td>9</td>
</tr>
<tr>
<td>Previous cardiac surgery</td>
<td>3</td>
</tr>
</tbody>
</table>

Dunning et al. Int CVTS 2003;2:639
Prophylactic IABP for High-risk Cardiac Surgery Impact on renal function

• Metaanalysis of 17 studies (7 RCT), 2,539 high-risk patients
  – preop IABP ↓AKI by 46% overall, 72% vs. postop IABP

Wang et al. ATS 2016;101:2007
Prophylactic IABP for High-risk Cardiac Surgery
Impact on renal function

- preop IABP ↓ need for renal replacement tx by 82% (p<.03)

Wang et al.
ATS 2016;101:2007
Prophylactic IABP for High-Risk Surgery
Potential mechanisms

- ↑ myocardial perfusion during diastole
- ↓ myocardial oxygen consumption
  - ↓ LV afterload
  - ↓ LV wall tension
- ↑ cardiac output (0.5-1.0 L/min)
- ↓ systemic vasoconstriction
High-risk Cardiac Surgery
Prophylactic Inotropes

• Levosimendan (inodilator)
  – $\text{Ca}^{2+}$-sensitizer with inotropic and vasodilatory effects
• Multicenter, RCT 252 pts – CABG with LV EF < 25%
• Levosimendan vs. Placebo for 24 hrs preop
  – hypotension
  – SVT / VT
  – mental status changes
  – Intubation

Levin et al.
Exp Clin Cardiol 2012;17:125
High-risk Cardiac Surgery
Prophylactic Levosimendan

Exp Clin Cardiol 2012;17:125
High-risk Cardiac Surgery
Prophylactic Inotropes

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Levosimendan in Patients with Left Ventricular Dysfunction Undergoing Cardiac Surgery


• 882 pts: EF < 35%, Levo vs. placebo
  – LCOS; 18% Levo vs. 26% placebo (p=0.007)
  – No difference in 30-day outcomes
  – 90 day mortality: 4.7% Levo vs. 7.1% placebo (p=0.12)
High-risk Cardiac Surgery
Prophylactic Inotropes

- Bayesian-network metaanalysis – 46 trials, 2,647 pts
  - Dobutamine, Milrinone (PDE-3 inhibitor), Levosimendan

Greco et al.  
Br J Anaesth 2015;114:746
High-risk Cardiac Surgery
Prophylactic Inotropes

- Probability to be the best / worst agent to improve survival

Greco et al.
Br J Anaesth 2015;114:746
High-Risk Surgery
Preoperative Assessment

• Assessment tools to quantify the “eyeball test”
• Cause & Effect: Comorbidites → Frailty → Disability

Frailty = 3 of 5: wt loss (10 lbs/yr), self-reported exhaustion, grip strength, walking speed, ↓physical activity
• 5-meter gait speed (≥6 sec): most predictive (OR 2.63 M&M)

Circ CV Qual Outcomes 2012;5:222
High-Risk Surgery
Impact of Frailty

- 208 pts AVR – Royal Brompton Hospital, London
- 6-minute walk test preop: 50% < 300 meters

(de Arenaza et al. Heart 2010;96:113)
High-Risk Surgery
Impact of Frailty

- Impact of 6-minute walk test stratified by preop Euroscore
  - low-mod risk (ES ≤ 6) 70%, high risk (ES > 6) 30%
  - Death/MI/stroke: 6% in low-mod risk, 16% in high risk
High-Risk Cardiac Surgery
Low-EF (<20-25%)

- Dobutamine Stress Echo to assess contractile reserve:
  - Vmax > 4 m/s
  - ↑ LV EF or wall motion
  - ↑ LV SV by 20%

If no contractile reserve, options include:
1. Aggressive CHF Tx with reevaluation of CR in 8-12 wks
2. Appropriate CHF Tx as bridge to hospice
3. If AS, BAV as bridge to decision
4. High-risk Surgery?

- High-risk operative approach: IABP, routine Dobutamine (slow wean), efficient surgical strategy
High-Risk Cardiac Surgery
Considerations

- What defines high-risk?
- Strategies for preop optimization for CABG
- **What if the ventricle still doesn’t work?**
High-Risk Cardiac Surgery
Post-operative cardiogenic shock

• Impella
• Tandem Heart
• ECMO
• VAD (right / left)
• Transplant
### High-Risk Cardiac Surgery
**ECMO at Washington University in Saint Louis**

<table>
<thead>
<tr>
<th></th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>86</td>
<td>86</td>
<td>102</td>
</tr>
<tr>
<td>Male %</td>
<td>63</td>
<td>64</td>
<td>66</td>
</tr>
<tr>
<td>Survival %</td>
<td>46.5</td>
<td>43</td>
<td>40</td>
</tr>
<tr>
<td>ICU stay (d)</td>
<td>22±29</td>
<td>20±37</td>
<td>20±37</td>
</tr>
<tr>
<td>Total Hospital stay(d)</td>
<td>42±56</td>
<td>33±46</td>
<td>30±32</td>
</tr>
<tr>
<td>ECMO to LVAD(n)</td>
<td>17</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Transfer on ECMO(n)</td>
<td>4</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>
High-Risk Cardiac Surgery Considerations

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