Treatment strategies for the high-risk patient undergoing cardiac surgery – the role of percutaneous assist devices:

Treatment strategies for post cardiotomy heart failure

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Incidence

Postcardiotomy Mechanical Support: Risk Factors and Outcomes

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Postcardiotomy support in the form of intraaortic balloon pump (IABP) counterpulsation is reported to occur in 4%, and more advanced support is necessary in 0.2% to 1.2% [1].

Patients at increased risk for mechanical support were identified preoperatively, and patients in the postcardiotomy support group were isolated in 19,985 patients, of whom, 97 required ECMO.

Results. Younger age, number of reoperations, emergency operation, higher creatinine, greater left ventricular dysfunction, and history of myocardial infarction were significant predictors. Overall survival was 35%, but significantly better (72%) in the subgroup converted to an extracorporeal support system and then bridged to a stable system.

[Graph showing probability of requiring ECMO (%) vs. age (years).]
Guidelines

No Guidelines
Treatment options

• No augmented treatment
• Maximal medical therapy

►Not the best option
Treatment options

• No augmented treatment
• Maximal medical therapy
• Limited therapy
• Immediate VAD placement
• Stepwise increase of mechanical support
Best strategy

- Stepwise enhancement of mechanical support
  - to increase flexibility
  - to optimize resources
  - to save money
IABP

- Simple MCS device
- Left (@ right) support
- Surgeon @ physician
- Limited effectiveness (partial support)
IABP indication

- Assumed sufficient support
- for predominant LV failure
- without severe peripheral occlusive vascular disease

- Not: severe global heart failure
IABP results

The Intraaortic Balloon Pump for Postcardiotomy Heart Failure

Experience with 169 Intraaortic Balloon Pumps

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Cardiovascular Surgery Unit, Hôpital de la Tour, Meyrin-Geneva & Clinique de Genolier, Genolier, Switzerland

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Duration of IABP support.</th>
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</thead>
<tbody>
<tr>
<td>IABP duration</td>
<td>Survivors</td>
</tr>
<tr>
<td>&lt; 12 hours</td>
<td>1</td>
</tr>
<tr>
<td>12 – 24 hours</td>
<td>20</td>
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<td>25 – 48 hours</td>
<td>29</td>
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<tr>
<td>49 – 72 hours</td>
<td>16</td>
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<tr>
<td>&gt; 72 hours</td>
<td>22</td>
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<tr>
<th>Complications.</th>
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<tbody>
<tr>
<td>IABP support (n = 169)</td>
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<td>-----------------</td>
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<tr>
<td>Mortality</td>
</tr>
<tr>
<td>Myocardial infarction †</td>
</tr>
<tr>
<td>Low cardiac output ††</td>
</tr>
<tr>
<td>Neurol. compl. §</td>
</tr>
<tr>
<td>Gl compl. §§</td>
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<tr>
<td>Transient renal failure §§§</td>
</tr>
</tbody>
</table>
IABP results

Intraaortic Balloon Pumping in Patients with Right Ventricular Insufficiency after Cardiac Surgery: Parameters to Predict Failure of IABP Support

Table 3  Outcome in group 1 and RV group; outcome in CABG and valve patients.

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (n = 223)</th>
<th>RV group (n = 79)</th>
<th>P (gr. 1 vs. RV gr.)</th>
<th>CABG (n = 172)</th>
<th>Valve procedure (n = 38)</th>
<th>P (CABG vs. valve)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful weaning from IABP (%)</td>
<td>68 (n = 152)</td>
<td>75 (n = 59)</td>
<td>&lt;0.05</td>
<td>71 (n = 122)</td>
<td>64 (n = 24)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Survival to hospital discharge (%)</td>
<td>63 (n = 140)</td>
<td>69 (n = 55)</td>
<td>&lt;0.05</td>
<td>66 (n = 114)</td>
<td>60 (n = 23)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Mean duration of IABP support (hours)</td>
<td>62 (0.5–312)</td>
<td>46 (0.5–132)</td>
<td>&lt;0.05</td>
<td>58 (0.5–312)</td>
<td>63 (2–211)</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>
IABP results

Use of an Intraaortic Balloon Pump in Patients with Impaired Left Ventricular Function

C. Schmid,¹ M. Wilhelm,¹ A. Reimann,¹ J. Rötker,¹ M. Deiwick,¹ M. Loick,² S. Kerber,³ D. Hammel,¹ M. Weyand¹ and H. H. Scheld¹

From the ¹Department of Cardiothoracic Surgery, Westfälische Wilhelms University, Muenster, Germany, ²Department of Anaesthesiology and Operative Intensive Care, Westfälische Wilhelms University, Muenster, Germany and ³Department of Cardiology and Angiology, Westfälische Wilhelms University, Muenster, Germany

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Scand Cardiovasc J 33; 194–198, 1999

Table IV. Left ventricular ejection fraction and risk score in patients with EF < 40%

<table>
<thead>
<tr>
<th></th>
<th>Insertion of IABP</th>
<th>Intraoperative n = 15</th>
<th>Postoperative n = 3</th>
<th>No IABP EF &lt; 40% n = 78</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF</td>
<td>33 ± 4</td>
<td>34 ± 4</td>
<td>36 ± 3</td>
<td>34 ± 4</td>
</tr>
<tr>
<td>Score¹</td>
<td>6.2 ± 3</td>
<td>9.1 ± 4</td>
<td>8.6 ± 3</td>
<td>5 ± 2.3</td>
</tr>
<tr>
<td>Mortality rate²</td>
<td>5 (8.9%)</td>
<td>4 (27%)</td>
<td>1 (33%)</td>
<td>3 (3.8%)</td>
</tr>
</tbody>
</table>

¹ Modified Cleveland score (Roeder et al.): Preop. vs intraop. and postop. p < 0.001.
² Mortality rate preop. vs intraop. and postop. p < 0.01.
“IABP Apps“

PulseCath – iVAC 3L
Concept

IABP

Catecholamines
ECMO

Cannulation of aorta and right atrium
ECMO cannula placement

percutaneous

central
ECMO cannula relocation

• Low(er) oxygenation of the upper body half

Oxygenation through patient’s lung

Oxygenation through oxygenator

Cannula relocation to subclavian artery
“Cardiologic“ systems

Tandemheart (←) and Impella (→) can only be implanted in a cath lab or with fluoroscopy!
ECMO

Short-term bed-side support
Long-term ECMO support is possible, but not a good option!
Will CESAR answer the adult ECMO debate?

Over the past 30 years, extracorporeal membrane oxygenation (ECMO), in both venoarterial and venovenous configuration, has become the standard of care for neonates with severe respiratory failure and for postoperative support after congenital heart repair. However, the use of ECMO in adults is not so straightforward. The ECMO experience in adults has been confined to a few highly specialised centres due to the associated expense and training necessary as well as the disappointing results reported in the only two randomised trials. Recent positive anecdotal experience in hundreds of patients in Europe with the iLA system for CO removal, improvements in ECMO technology and management, and the many changes in critical care since the 1980s cause many to question if it is time to re-evaluate ECMO's role in the care of the severely ill adult. In The Lancet today, Giles Peek and colleagues present the results of the much anticipated (and debated) CESAR trial of ECMO in adults.

The benefits observed in CESAR are unlikely to convince a centre to start an adult ECMO programme or convince a tertiary hospital to transfer critically ill patients to an ECMO centre.
Five-Year Results of 219 Consecutive Patients Treated With Extracorporeal Membrane Oxygenation for Refractory Postoperative Cardiogenic Shock

Nicolas Doll, MD, Bob Kiaii, MD, Michael Borger, MD, PhD, Jan Bucerius, MD, Klaus Krämer, Dierk V. Schmitt, MD, Thomas Walther, MD, PhD, and Friedrich W. Mohr, MD, PhD

Department of Cardiac Surgery, Heart Center, University of Leipzig, Leipzig, Germany

Results. Mean duration of ECMO support was 2.8 ± 2.2 days. One hundred thirty-four patients (60%) were successfully weaned from ECMO. Of these, 52 patients (24%) were discharged from the hospital after 29.9 ± 24 days. The main cause of death was myocardial failure.
The use of an intraaortic balloon pump to maintain pulsatility during ECMO support is not uniformly agreed upon in the literature. However, patients with intraaortic balloon pumps had a significantly higher survival rate. Thus, we believe that intraaortic balloon pump counterpulsation is important during ECMO support to increase pulsatility, improve coronary perfusion, and decrease the ventricular afterload. Because the potential gains we recommend concomitant intraaortic balloon pumps for all patients on ECMO support.
The Impact of Intraaortic Balloon Counterpulsation on Bypass Graft Flow in Patients with Peripheral ECMO

Navid Madershahian, M.D., Oliver J. Liakopoulos, M.D., Jens Wippermann, M.D., Shahriar Salehi-Gilani, M.D., Thorsten Wittwer, M.D., Yeong-Hoon Choi, M.D., Hamid Naraghi, M.D., and Thorsten Wahlers, M.D.

Department of Cardiothoracic Surgery, Cologne University Heart Centre, Cologne, Germany

ABSTRACT Objective: Numerous reports have been performed to investigate the hemodynamic effects of intraaortic balloon pumping (IABP) and nonpulsatile circulatory extracorporeal membrane oxygenation (ECMO), but studies on its impact on coronary artery bypass graft flow during concomitant use of IABP and ECMO are lacking. The aim of this study was to assess the impact of additional IABP support on the degree of blood flow increase in bypass grafts in high-risk patients with nonpulsatile femoral venoarterial ECMO. Methods: In six emergency coronary artery bypass graft patients (mean age = 66.3 ± 2.1 years, gender = five males and one female, ejection fraction = 25.0 ± 3.0%) requiring mechanical circulatory support with ECMO hemodynamic parameters and bypass graft flows were measured with and without IABP counterpulsation. A transit time flowsmeter was used for intraoperative graft flow and pulsatility index (PI) measurements. Patients provided their control values. Results: The average value of the mean arterial pressure recorded prior to IABP was 63.6 ± 2.9 mmHg and during IABP support 67.8 ± 2.9 mmHg (p < 0.0001). IABP augmented the mean bypass graft flow from 46.8 ± 9.6 mL/min to 56.4 ± 12.1 mL/min (p < 0.005), resulting in a 17% increase. The difference in the PI was not statistically significant (2.6 ± 1.2 with IABP, 2.6 ± 0.3 without IABP). Conclusions: We conclude that IABP-induced pulsatility significantly improves coronary bypass graft flows during nonpulsatile peripheral ECMO. doi: 10.1111/j.1540-8191.2009.00807.x (J Card Surg 2009;24:265-268)
IABP + ECMO

ECMO + IABP is superior!
IABP + ECMO

Effects of Intra-Aortic Balloon Pump Versus Centrifugal Pump on Myocardial Energetics and Systemic Circulation in a Porcine Model of Rapidly Worsening Acute Heart Failure

Ntalianis, Argyrios S.; Drakos, Stavros G.; Charitos, Christos; Dolou, Paraskevi; Pierrakos, Charalampos N.; Terrovitis, John V.; Papaioannou, Theodoros; Charitos, Efstratos; Nanas, John N.

The present experimental study compared the effectiveness of counterpulsation provided by the intra-aortic balloon pump (IABP) versus that of a nonpulsatile, radial-flow centrifugal pump (CFP) in rapidly worsening acute heart failure (HF). Eighteen pigs were included in the study. After the induction of acute moderate HF, circulatory support was randomly provided with either the IABP or CFP. No significant change in cardiac output (CO) and mean aortic pressure (MAP) was observed with either pump. The IABP caused a significantly greater decrease than the CFP in: 1) double product (13,138 ± 2,476 mmHg/min vs. 11,217 ± 2,673 mmHg/min), 2) left ventricular end-systolic pressure (LVSP) from 88 ± 6 mmHg to 78 ± 9 mmHg, (p = 0.008), and end-diastolic pressure from 57 ± 9 mm Hg to 49 ± 14 mm Hg, (p = 0.044), whereas the CFP exerted its effects mainly on preload, lowering LV end-diastolic pressure from 19 ± 5 mm Hg to 11 ± 4 mm Hg, (p = 0.002). CO and MAP were similarly increased by both assist systems. The IABP (by lowering afterload) and CFP (by lowering preload) both offered significant mechanical support in acute HF. However, afterload reduction offered principally by the IABP seems preferable for the recovery of the acutely failing heart.
The aim of postcardiotomy ECMO

- Is weaning & recovery from short-term support

otherwise long-term support is needed
Extracorporeal Life Support to Left Ventricular Assist Device Bridge to Heart Transplant
A Strategy to Optimize Survival and Resource Utilization

Francis D. Pagani, MD, PhD; William Lynch, MD; Fresca Swaniker, MD; David B. Dyke, MD; Robert Bartlett, MD; Todd Koelling, MD; Mauro Moscucci, MD; G. Michael Deeb, MD; Steven Bolling, MD; Hilary Monaghan, BS; Keith D. Aaronson, MD

Conclusions—In appropriately selected high-risk patients, the rate of LVAD survival after initial ECMO support was not significantly different from the survival rate after LVAD support alone. An initial period of resuscitation with ECMO is an effective strategy to salvage patients with extreme hemodynamic instability and multiorgan injury. Use of LVAD resources is improved by avoiding LVAD implant in a very-high-risk cohort of patients who do not survive ECMO. (Circulation. 1999;100[suppl II]:II-206–)

In summary, ECMO to LVAD bridge to heart transplant therapy provides an alternative means of circulatory support for patients who might not otherwise be candidates for an implantable LVAD or who represent a very high-risk for poor outcome. ECMO to LVAD bridge to heart transplant therapy improves utilization of LVAD resources by avoiding LVAD implantation in circumstances for which poor outcomes can be anticipated.
LVAD systems
Good candidates: LVAD

Long-term support with LVAD
Implant Dates: June 23, 2006 – March 31, 2009

Device Type

% Survival

LVAD n=1104, deaths=200

Bi-VAD n=186, deaths=62

TAH n = 50, deaths=10

RVAD n=18, deaths=3

p (overall) < .0001

Event: Death (censored at transplant or recovery)
LVAD @ right heart failure

Right heart failure:
LVAD + rotary pump or

LVAD + RVAD
Bad candidate: Bridge-to-decision

- Implantation of paracorporal LVAD cannulas
- Connection of centrifugal pump (Rotaflow, Maquet)
Compared with the hemodynamic support offered by the CP alone, addition of the IABP increased mean aortic pressure from 40±15 to 50±16 mm Hg (p<0.001), cardiac output from 810±194 to 1,200±234 ml/min (p<0.003), and left anterior descending artery flow from 26±10 to 39±14 ml/min (p<0.001).
Bad candidate: CF-BiVAD

Bridge-to-decision with 2 rotary pumps as LVAD + RVAD
Bad candidate: BiVAD

Final goal: Implantation of a (Bi-)VAD after stabilization of end-organ function:
→ Better results
→ Lower costs
Implant Dates: June 23, 2006 – March 31, 2009

Bi-VAD: n=186

- 35% Transplant
- 31% Alive (device still in place)
- 23% Death (before transplant)
- 11% Explanted (recovery)

Proportion of Patients

Months after Device Implant
Conclusion

- Stepwise enhancement of mechanical support may be adapted to the clinical needs - optimize the resources - improve outcome after MCS
University Medical Center Regensburg

...thank you