My favorite short-term MCS in postoperative cardiogenic shock

Prof. V. Falk
and MCS Team of DHZB, Berlin, Germany
Annual MCS Program at DHZB

Short-term devices
   ECLS 160 cases
   Impella 20 cases
   Emergency ECMO off-site by DHZB-Team

Heart Failure Team DHZB
   Cardiologist and surgeon

Long-term devices (VAD’s)
   (VAD) Surgery and postoperative care 120-150 new cases
   Ambulatory support 900 visits/year
   Hotline 24/7

Heart Failure Network
LCOS after cardiac surgery

Incidence of LCOS after cardiac surgery – app. 3%

MCS needed in 0.5 – 1% of patients

More often after
  - CABG for acute MI
  - closure of Infarct VSD
  - Surgery in patients with preoperatively reduced LVF
  - High risk surgery

Increased number of older and polymorbid patients with advanced heart failure undergo heart surgery
Short-term mechanical circulatory support for myocardial recovery or bridge to decision

- LV failure
- RV failure
- BVAD failure
- Cardio-pulmonary failure

- Acute setting (severe septic shock in endocarditis, STEMI,…)
- Acute on chronic setting (CABG in HF pts., …)
Support Options

Hemodynamic support

Invasiveness

- IABP
- Impella
- Tandem Heart
- TAH
- External pumps
- implantable VAD
- ECMO
Different levels of LV
Unloading wicht mechanical assistance
Level of unloading depends on Device

- Inotropic Drugs:
  - ESPVR shifts up
  - Increases peak pressure
  - Stroke volume increases
  - Increases work

- IABP:
  - Reduces aortic pressure (“afterload”)
  - Stroke volume increases
  - No change in work

- VAD/Impella:
  - Reduces ventricular volume
  - Reduces peak pressure
  - Reduces work
Level of unloading depends on Device

Haemodynamic effects differ between pVADs, which affects the degree of ventricular unloading. These differences can be recognized on ventricular pressure-volume loops ('on-pump' loops shown in blue). 

- a | Intra-aortic balloon pump. 
- b | Impella® device (ABIOMED, USA). 
- c | TandemHeart® (CardiacAssist, USA). 
- d | Extracorporeal membrane oxygenation. 

Level of unloading depends on Device

Haemodynamic effects differ between pVADs, which affects the degree of ventricular unloading. These differences can be recognized on ventricular pressure-volume loops ('on-pump' loops shown in blue). a | Intra-aortic balloon pump. b | Impella® device (ABIOMED, USA). c | TandemHeart® (CardiacAssist, USA). d | Extracorporeal membrane oxygenation. Abbreviation: pVAD, percutaneous ventricular assist device. Upper panels modified from Thiele, H. et al. Management of cardiogenic shock. Eur. Heart J. 36 (20), 1223–1230 (2015), by permission of OUP and the ESC.
Contemporary Centrifugal Continuous Flow Pump
PV Loops: Disease Progression to LVAD

- Total CO *
- ESP (mmHg)
- EDV
- SV (ml)
- SW (Joule)
- ESP (BSL> Injury > Unloaded)
- SV (BSL > Injury > Unloaded)
- EDV (Injury > Unloaded > BSL)
- SW (BSL > Injury > Unloaded)

*sum of native cardiac and LVAD, based on position of suction (unloading) cannula
Short-term mechanical circulatory support for myocardial recovery or bridge to decision

- Extra Corporeal Membrane Oxygenation
  - ECMO is a temporary support of heart and/or lungs
  - Modern terminology: ECLS (ExtraCorporeal Life Support)

- (L) VAD – ventricular assist device
  - Impella
  - Levitronix (Centrimag)
  - TandemHeart
IABP
IABP for postcardiotomy LCOS

Prognosis After the Implantation of an Intra-Aortic Balloon Pump in Cardiac Surgery Calculated With a New Score

Harald Hausmann, MD; Evgenij V. Potapov, MD; Andreas Koster, MD; Thomas Krabatsch, MD; Julia Stein; Ruhi Yeter, MD; Marian Kukucka, MD; Ralf Sodian, MD; Hermann Kuppe, MD, PhD; Roland Hetzer, MD, PhD

(Circulation. 2002;106[suppl I]:I-203-I-206.)
## IABP Score (1hr after insertion) Multivariate Analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>OR</th>
<th>p</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epinephrine &gt; 0.5 µg/kg/KG</td>
<td>6.6</td>
<td>0.0005</td>
<td>2</td>
</tr>
<tr>
<td>Urine Output &lt; 100 ml/h</td>
<td>2.5</td>
<td>0.026</td>
<td>1</td>
</tr>
<tr>
<td>( \text{SvO}_2 &lt; 60 % )</td>
<td>2.5</td>
<td>0.048</td>
<td>1</td>
</tr>
<tr>
<td>LAP &gt; 15 mmHg</td>
<td>3.0</td>
<td>0.036</td>
<td>1</td>
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</table>
Example

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Score points</th>
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</thead>
<tbody>
<tr>
<td>Epinephrine 0.7 µg/kgKG/min</td>
<td>2</td>
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<tr>
<td>Urine output 70 ml/h</td>
<td>1</td>
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<tr>
<td>SvO₂ 63 %</td>
<td>0</td>
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<tr>
<td>LAP 12 mmHg</td>
<td>0</td>
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</table>

IABP Score Formula

\[
\text{Epinephrine} + \text{Diuresis} + \text{SvO}_2 + \text{LAP} = \text{Score points}
\]

\[
2 + 1 + 0 + 0 = 3
\]
Survival on IABP alone accordingly to score points

$n = 391$

<table>
<thead>
<tr>
<th>Score points</th>
<th>Patients (n)</th>
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<tr>
<td>0</td>
<td>195</td>
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<tr>
<td>1</td>
<td>85</td>
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<td>2</td>
<td>51</td>
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<tr>
<td>4</td>
<td>28</td>
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<tr>
<td>5</td>
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<table>
<thead>
<tr>
<th>%</th>
<th>50</th>
<th>22</th>
<th>13</th>
<th>5</th>
<th>7</th>
<th>3</th>
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<tbody>
<tr>
<td>30 days survival (%)</td>
<td>86.0</td>
<td>57.5</td>
<td>52.2</td>
<td>30</td>
<td>8.3</td>
<td>0</td>
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</tbody>
</table>
Survival on IABP alone accordingly to score points

n = 391

IABP alone most often not sufficient!
Components I – Pumps

- Centrifugal pumps
- Magnetic levitation
- Limited Hemolysis
- No stasis
- Pre and afterload sensitive
  - MAP around 70mmHg
  - RPM and flow independent
Components II - Oxygenators

- Gas-Wärmeaustausch
- Konstruktionsprinzipien
  - Nicht-mikroporöse Polymethylpentenemembran
  - Mikroporöse Polypropylenhohlfaser (nur für HLM)
  - Nicht-mikroporöse Silikonmembran (historisch)
- Plasmadichtigkeit
- Standzeit
  - Tage bis Wochen
- Nachlassende Effektivität des Gastransfers
  - Oxygenator 100%-Gas
Components III - Other

- Steuerungskonsole
  - RPM
- Gasmischer (Blender)
  - Gasfluss (Sweep Gas)
  - \( \text{FiO}_2 \)
- Wärmetauscher HU-35
  - Temperatur 33-39°C
- Messzellen
  - Fluss, Temperatur, Sättigung
- Schläuche, Konnektoren und Kanülen
- Beschichtungen
  - Heparin (z.B. Bioline, Carmeda)
  - Heparin frei (z.B. Softline, Physio)
ECLS Setup
Implantation

- OR, cath lab, bedside
- General or local anesthesia
- Placement
  - Central (sternotomy, left lateral thoracotomy)
  - Peripheral (axillary artery, femoral artery)
  - Open with or without graft or percutaneous
- Ensure adequate extremity perfusion
Percutaneous Cannulation
Femoro-femoral cannulation

Limited dissection ↑

Percutaneous insertion + Proglide →
Percutaneous Access Employing Pre-implanted Proglide Closure System with Distal Leg Perfusion
Problems with venous drainage /backflow

- Careful monitoring of cannula placement (TEE) -> safe SVC position
- Consider add. SVC drainage (via JV or direct)
Configuration V-V ECLS

- Lungenversagen
- Venöse Drainage und Reinfusion
- Keine Kreislaufunterstützung
- Ggf. Besserung der Herzfunktion durch Reduktion von PVR und myokardialer Hypoxie
- SaO$_2$ abhängig von ECMO-Fluss, systemvenösem Rückfluss (CO), Rezirkulation, venöser Sauerstoffsättigung und Lungenfunktion
- SaO$_2$ um 85-90% zu erwarten
Recirculation & mixed blood
SaO₂ 85%, pCO₂ 40mmHg, pO₂ 55mmHg, Sauerstoffgehalt > 17ml/dl
- ggf. zusätzliche venöse Kanüle

Anpassung des Beatmungsregimes
- Tidalvolumina reduzieren
- Beatmungsdrücke reduzieren
- FiO₂ reduzieren
- PEEP

ECMO fahren
- Gasfluss für pCO₂
- Blutfluss und FiO₂ für pO₂
Avalon Elite® Cannula

- Zweilumenkatheter für v-v ECMO
- Wang-Zwischenberger Design
- Implantation in Seldingertechnik
  - Vena jugularis interna rechts
- Kanülengrössen von 16 bis 31 French
- Drainage via obere und untere Hohlvene
- Reinfusion via Trikuspidalklappe
- Keine zwingende Notwendigkeit für Kontrolle mit Echo oder Durchleuchtung
- Patient wach und mobil während der Unterstützung
v-a ECLS – Clinical Considerations

- Aortic regurgitation
- Central hypoxia due to lung failure and preserved LV ejection (“Harlekin”)
  - BGA / pulsoxymetry right arm or head
  - Stop inotropes, venting
- Distal leg perfusion
  - 8 Fr. ArrowFlex introducer
- LV Distension
  - Inotropes, Venting
- Weaning
  - Flow reduction, no gas flow reduction
LV Distension

- Myocardial dysfunction and increased overload through ECLS flow
- Increased LVEDD, LVEDP and wall tension may preclude myocardial recovery
- Increased LVEDP may lead to pulmonary edema and irreversible loss of lung function
Venting Options

- Directly through left atrium
- LV apex
- Transaortic with pigtail catheter
  (Fumagalli R et al., Int J Artif Organs 2004)
- Transseptal access
  (Aiyagari RM et al., Crit Care Med 2006)
- Pulmonary Artery 15F cannula
  (Avalli L et al., ASAIO J 2011)
- Pulmonary Artery with Smartcannula®
  (von Segesser LK et al., Thorac Cardiovasc Surg 2008)
- Impella
Extracorporeal Membrane Oxygenation Support in Postcardiotomy Elderly Patients: The Mayo Clinic Experience

Pankaj Saxena, FRACS, PhD, James Neal, CCP, Lyle D. Joyce, MD, PhD, Kevin L. Greason, MD, Hartzell V. Schaff, MD, Pramod Guru, MD, William Y. Shi, MBBS, Harold Burkhart, MD, Zhuo Li, William C. Oliver, MD, Roxann B. Pike, MD, Dawit T. Haile, MD, and Gregory J. Schears, MD

Division of Cardiovascular Surgery, Perfusion Services, and Departments of Anesthesiology and Biostatistics, Mayo Clinic, Rochester, Minnesota, and University of Melbourne, Melbourne, Australia

Background. We conducted a retrospective study to assess whether extracorporeal membrane oxygenation (ECMO) (ECMO years or more) was necessary after cardiac surgery.

Methods. From 2003 to 2013, 45 patients aged 70 years or more underwent 47 runs of ECMO postoperatively.

Results. There were 31 men (68.9%). The mean age was 76.8 years. Five patients were in cardiogenic shock preoperatively. Forty-four patients required venoarterial ECMO support for cardiogenic shock. Mean duration of support was 103.8 ± 74.3 hours. Twenty-one patients (46.6%) died while on ECMO support. Twenty-four patients (53.3%) were weaned off ECMO initially, and 11 patients were discharged from hospital. Inhospital mortality was 75.6%. Postoperative complications included acute kidney injury in 30 patients (44.4%), pneumonia in 25 patients (55.6%), and 10 patients (22.2%) had a new cerebrovascular accident. Inhospital mortality was 75.6%. Preoperative atrial lactic acidosis on echocardiography were associated with higher mortality.

Conclusions. Postcardiotomy ECMO support in elderly patients is associated with high postoperative morbidity and mortality. Nevertheless, it often provides the last line of therapy for these critically ill patients and may provide positive outcomes in selected subgroups.


In hospital mortality 75.6%
Risk factors associated with adverse outcome following extracorporeal life support: analysis from 360 consecutive patients

N Papadopoulos,¹ S Marinos,¹ A El-Sayed Ahmad,¹ H Keller,¹ P Meybohm,² K Zacharowski,² A Moritz¹ and A Zierer¹

Abstract
Objective: Risk factors for adverse outcome after extracorporeal life support (ECLS) are yet to be defined. For this purpose, we reviewed our institutional data from more than a decade, focusing on patients with ECLS.

Methods: Between December 2001 and June 2013, 360 consecutive cardiac surgical patients received ECLS for postcardiopulmonary cardiogenic shock, with high mortality risk despite optimal conventional therapy. Patient demographics, clinical characteristics, ECLS-related morbidity as well as in-hospital and long-term mortality were analysed. Multivariate logistic regression analysis was performed. In-hospital mortality was determined by adverse outcome (failed ECLS weaning, in-hospital mortality).

Results: The 1-year survival was 26%.

Intra-aortic balloon pumps were implanted in 22% of the patients. ECLS weaning was successful in 58% and 30% could be discharged from hospital. The main cause of death was sepsis (69%). Overall, major cerebrovascular events occurred in 12% (bleeding 3%, embolic 9%), limb ischaemia in 13%, gastrointestinal complications in 16% and renal replacement therapy in 61%. Independent risk factors for adverse outcome were prior cardiorespiratory resuscitation (OR: 4.1, 95%CI: 0.34-4.21, p=0.04), pH <7.1 (OR: 2.8, 95%CI: 0.45-3.28, p=0.01), serum lactate >120 mg/dL (OR: 2.6, 95%CI: 0.75-2.96, p<0.01), norepinephrine dosage >0.5 μg/kg/min (OR: 2.4, 95%CI: 0.35-2.92, p=0.02) and age >75 years (OR: 2.0, 95%CI: 0.41-2.88, p=0.02). Kaplan Meier estimates for long-term survival were 26±3% at one year and 22±2% at five years.

Conclusion: ECLS therapy offers one-year survival to one quarter of patients with an otherwise fatal prognosis. Procedural mortality is low and morbidity at the implantation site typically moderate. Thus, prolonged metabolic deterioration in combination with high-dose vasopressor support prior to ECLS therapy should be avoided, particularly in younger patients.
Early and late outcomes of 517 consecutive adult patients treated with extracorporeal membrane oxygenation for refractory postcardiotomy cardiogenic shock

Ardawan Julian Rastan, MD, PhD, Andreas Dege, MD, Matthias Mohr, MD, Nicolas Doll, MD, PhD, Volkmar Falk, MD, PhD, Thomas Walther, MD, PhD, and Friedrich Wilhelm Mohr, MD, PhD

Weaning success 63%
Discharged 24%
1 y Survival 17.6%
better for CABG than Valve Surgery
<table>
<thead>
<tr>
<th>Complication</th>
<th>No. (%)</th>
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</thead>
<tbody>
<tr>
<td><strong>Re-thoracotomy</strong></td>
<td>425 (82.2%)</td>
</tr>
<tr>
<td>For bleeding (no.)</td>
<td>300 (58.0%)</td>
</tr>
<tr>
<td>For sternal wound revision (no.)</td>
<td>20 (3.9%)</td>
</tr>
<tr>
<td>IABP support (d, mean ± SD)</td>
<td>5.93 ± 5.31</td>
</tr>
<tr>
<td><strong>Ventilation</strong></td>
<td></td>
</tr>
<tr>
<td>Total ventilation time (h, mean)</td>
<td>339</td>
</tr>
<tr>
<td>Reintubation (no.)</td>
<td>119 (23.2%)</td>
</tr>
<tr>
<td>Tracheostomy (no.)</td>
<td>95 (18.4%)</td>
</tr>
<tr>
<td>Pneumonia (no.)</td>
<td>111 (21.5%)</td>
</tr>
<tr>
<td>Adult respiratory distress syndrome (no.)</td>
<td>48 (9.3%)</td>
</tr>
<tr>
<td><strong>Postoperative drainage loss (mL)</strong></td>
<td></td>
</tr>
<tr>
<td>First 24 h</td>
<td>3080</td>
</tr>
<tr>
<td>First 48 h</td>
<td>4245</td>
</tr>
<tr>
<td>Blood product transfusion in first 48 h</td>
<td></td>
</tr>
<tr>
<td>Total units, mean ± SD</td>
<td>29.4 ± 25.6</td>
</tr>
<tr>
<td>Red blood cells units, mean ± SD</td>
<td>13.6 ± 12.1</td>
</tr>
<tr>
<td>Fresh-frozen plasma units, mean</td>
<td>14.0 ± 13.0</td>
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<tr>
<td>Platelets units, mean ± SD</td>
<td>1.72</td>
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<td><strong>Renal replacement therapy</strong></td>
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<td>Use (no.)</td>
<td>336 (65.0%)</td>
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<tr>
<td>Duration (d)</td>
<td>9.7</td>
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<tr>
<td><strong>ECMO leg complications</strong></td>
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<tr>
<td>Leg ischemia (no.)</td>
<td>28/141 (19.9%)</td>
</tr>
<tr>
<td>With distal leg perfusion cannula (no.)</td>
<td>3/33 (9.1%)</td>
</tr>
<tr>
<td>Without distal leg perfusion cannula (no.)</td>
<td>25/108 (23.1%)</td>
</tr>
<tr>
<td>Leg fasciotomy (no.)</td>
<td>13/141 (9.2%)</td>
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<tr>
<td>With distal leg perfusion cannula (no.)</td>
<td>1/33 (3.0%)</td>
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<tr>
<td>Without distal leg perfusion cannula (no.)</td>
<td>12/108 (11.1%)</td>
</tr>
<tr>
<td>Gastrointestinal complication (no.)</td>
<td>97 (18.8%)</td>
</tr>
<tr>
<td>Laparotomy (no.)</td>
<td>28 (5.4%)</td>
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<tr>
<td><strong>Cerebrovascular events</strong></td>
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<tr>
<td>Total (no.)</td>
<td>90 (17.4%)</td>
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<tr>
<td>Cerebral bleeding (no.)</td>
<td>19 (3.7%)</td>
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<tr>
<td>Cerebral stroke (no.)</td>
<td>28 (5.4%)</td>
</tr>
<tr>
<td>New atrial fibrillation (no.)</td>
<td>103 (19.9%)</td>
</tr>
</tbody>
</table>

*ECMO*, Extracorporeal membrane oxygenation; *IABP*, intra-aortic balloon pump.
ECLS Experience 2012 – 2016 in Adults in DHZB

- VAD implanted
- Weaned
- Dead
- External implants
# Institutional SOP for ECLS

<table>
<thead>
<tr>
<th>DHZB Leitlinie</th>
<th>ECMO / ECLS Leitlinie</th>
<th>Version 1</th>
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<tr>
<td>Inhaltsverzeichnis</td>
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<tr>
<td>1. Einführung</td>
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<td>2. Notenklatur</td>
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<td>3. Technische Voraussetzungen</td>
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<td>3.1 Pumpen</td>
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<td>3.2 Oxygenaturen</td>
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<td>3.3 Wärmerteiler</td>
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<td>3.4 Gasmischiger / Blinder</td>
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<td>4. Physiologie</td>
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<td>4.1 Veno-venöse (v-v) ECMO</td>
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<td>5. Indikationen</td>
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<td>9.1.1 Indikationststellung</td>
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<td>9.1.2 Klinischer Ablauf</td>
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<td>9.2 Veno-arterielle (v-a) ECMO</td>
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<td>9.2.1 Indikationststellung</td>
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<td>9.2.2 Klinischer Ablauf</td>
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<td>10. Entwicklung von ECMO</td>
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<td>11. Troubleshooting</td>
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<td>11.1 Telefonnummern</td>
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<td>11.2 Einbrand des Blutflusses</td>
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<td>11.3 Luft im Schlauchsystem</td>
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<td>11.4 Thromben im System</td>
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Institutional v-a ECLS Algorithm

**DHZB v-a ECMO Schema**

**Ziele**: Suffiziente Organperfusion bei myokardialer Entlastung

**Bevorzugt Kanülierung A. axillaris re; unter Rea percutane, femorale Kanülierung**
- **Bevorzugte Kanülen**
- **Kanülenkombinationen** (siehe Tab. 2)
- **Beimperfusion z.B. Arrow Schleuse 8 Fr. (nicht bei REA)**
- **Ausreichende Beatmung sicherstellen**

**Zentrale Hypoxie?**
- **Pulsoxymetrie (rechte Hand, Nase, Ohr)** (SpO₂ < 90%)
- **A. radialis rechts**: pO₂ < 70 mmHg

**ja**

**Errechneter Sollfluss (Tab. 1) erreicht?**

**nein**

**LV-Übung und pulmonalvenöse Hypertonie?**
- **Lagekorrektur der Kanülen**
- **Zusätzliche venöse Kanüle** (z.B. V. jug. int. rights, Biomedicus 18 Fr.)
- **Wechsel auf größere, kürzere arterielle Kanüle**

**ja**

**nein**

**Bestimmen und Inotropika reduzieren, dann**
- **Umkanülierung A. subclavia re.**
- **Wechsel auf vena vena ECMO** (Präoxygierung)
- **Einlage apikaler LV-Vent**

**Flussberechnung**
- **2,5 bis 3 l/min KOF**
- **Körperoberfläche (KOF):**
  - **KOF = (cm³ x kg / 3600)³**

**Mögliche kanülenkombinationen**

<table>
<thead>
<tr>
<th>Fluss</th>
<th>arteriell</th>
<th>venös</th>
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<tbody>
<tr>
<td>~ 3-4 l</td>
<td>15 Fr.</td>
<td>21 Fr.</td>
</tr>
<tr>
<td>~ 4-5 l</td>
<td>17 Fr.</td>
<td>23 Fr.</td>
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<tr>
<td>~ 5-6 l</td>
<td>17-19 Fr.</td>
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**Antikoagulation und Transfusion**

- **Heparin pT 50-60s**
- **Pause bei Blutung oder vor invasivem Eingriff**
- **Je höher der Fluss, desto geringer das Risiko von Thrombosierung im ECMO- Kreislauf**

**Transfusion**
- **Erythrozytenfange bei Hb >10 g/dl** (ggf. 1 FFP pro 2 EK)
- **Thrombozytenfange bei**
  - **Thrombozyten >20**
  - **Thrombozyten <50 und Blutung**
  - **Thrombozyten <100 und bevorstehendem Eingriff**

**Festlegung des weiteren Procedere mit MCS Team**

Abb. 6.5

DHZB v-a ECMO Flowchart, Vorderseite

Abb. 6.6

DHZB v-a ECMO Flowchart, Rückseite
Impella – Microaxial VAD
Impella Recover Microaxiales VAD

SA Falk November 2017
Impella CP und 5.0

12Fr
~2.5L/min

20Fr
~5 L/min

9 F
Impella CP und 5.0

Vent (on top of ECLS)

Full Support

12Fr
~2.5L/min

20Fr
~5 L/min

9 F
Impella for RV support

Outlet into main PA

Inlet at the IVC/Right atrial junction
Tandem Heart
Short-term extracorporeal MCS
TandemHeart

Intended for days-weeks of support
Centrifugal extracorporeal pump
Magnet levitation
Direct or transseptal implantation
Flow up to 4.0 l/min
Curtousy G. Schuler, Leipzig, presented at 5th MCS Symposium in Berlin
TandemHeart RA-PA Cannula (RVAD)

- No re-circulation
- No cannula at the legs
Temporary MCS through VAD cannulas
New Approach in Treatment of Acute Cardiogenic Shock Requiring Mechanical Circulatory Support

Evgenij V. Potapov, MD, Yuguo Weng, MD, PhD, Harald Hausmann, MD, Michael Kopitz, ECCP, Miralem Pasic, MD, PhD, and Roland Hetzer, MD, PhD

Department of Cardiothoracic and Vascular Surgery, Deutsches Herzzentrum Berlin, Berlin, Germany

BerlinHeart pumps. This approach avoids complications associated with repeat sternotomy and use of coronary bypass and decreases the total costs of treatment.

<table>
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<th>IABP</th>
<th>Impella&lt;sup&gt;1&lt;/sup&gt;</th>
<th>TandemHeart&lt;sup&gt;2&lt;/sup&gt;</th>
<th>ECLS</th>
<th>CardioWest</th>
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<tr>
<td>LV</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
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</tr>
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<td>RV</td>
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1 – LVAD max. 5 l/min, next generation max. 5.5 l/min; RVAD max 4 l/min
2 – max 4 l/min. Oxygenator may be added to the circuit
How and when to wean
Indicators for recovery during ECLS

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<td>Leucocytes (×10⁹)</td>
<td>14.0 ± 7.9</td>
<td>11.1 ± 3.5</td>
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MDRD-GFR: Modification of Diet In Renal Disease—Glomerular Filtration Rate; MELD-XI: Model for End-stage Liver Disease—excluding INR; FiO₂: fraction of inspired oxygen; ECLS: extracorporeal life support; VAD: ventricular assist device.
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Riebandt J EJCTS 2014
Crucial Questions about Further Treatment after ECLS Implantation

▪ Whom to wean
▪ When to wean - window of opportunity
▪ How to wean
▪ Who is a candidate for VAD?
▪ When should we step back?
Weaning

- Recovery of lung function in ARDS
  - Weeks
  - Improved compliance, X-ray and BGA during similar ECLS setting
  - SaO$_2$ > 90% under 2 l/min flow → weaning trial

- Myocardial recovery
  - Pulsatility, LV ejection
  - Decrease of inotropes and vasopressors
  - Most likely between 2$^{nd}$ and 5$^{th}$ days of support
    (Smedira et al. J Thorac Cardiovasc Surg 2001)
  - No weaning if LV-EF < 30% after 2 days
    (Fiser et al. Ann Thorac Surg 2001)
  - Weaning under ECHO control and almost free from inotropes
67 year old male patient
STEMI with extensive anterior wall infarction

Coro: LM 75% ostial stenosis, LAD proximally occluded, LCx multiple stenosis, RCA 70% and RPDA 90% stenosis

ECHO: LVEF 15% on inotropes; LVEDD 42 mm

Procedures: emergency percutaneous ECLS + PCI of LAD and LCx

ECLS weaning trial on POD 5

Stroke volume 22 ml
LVEF 20%, severe diastolic dysfunction (stiff heart), severe MR, lung edema during weaning; normal RV function
Stable on ECLS, Weaning Not Possible – What to do?

- Decision should be made during first 5-7 days
- Is the patient HTx candidate? – consider waiting time on ECLS
- VAD implantation on ECLS is a high-risk surgery

- VAD should be considered if
  - Organ function may still be compromised, but showing improvement
    - Neurological check-up is essential, CT if required
    - Lung function - on ECLS is difficult to access
    - Renal function - dialysis does not preclude VAD
    - Liver function - bilirubin < 10 mg/dl or decreasing
  - Mostly no switch to CPB is necessary, implant on ECLS

- Mostly LVAD + temporary RVAD ± oxygenator
Conclusions

- For treatment of severe postcardiotomy cardiogenic shock and/or MOF, ECLS is a valid initial option
- Survival between 20 and 50%
- Institutional SOP, mobile team and regular training are crucial
- Leg perfusion reduces leg ischemia and concomitant morbid complications
- Unloading of LV with Impella
- If weaning is not possible and end organ function allows -> VAD therapy
Conclusion

- After stabilization and conditioning on ECLS, VAD implantation can be performed, yielding improved outcome as compared to primary VAD implantation
- Decision about VAD implantation should be done within first 5-7 days of support
- In case of switch to VAD, mostly LVAD + temporary RVAD configuration is necessary
- Preceding CPR or prolonged duration of ECLS does not preclude successful VAD implantation
Thank you!
Decision making in CS

- The question is not whether to use ECLS or LVAD in patients with cardiogenic shock but to define the best treatment algorithm and therapy for each patient.
Decision making in CS

- This decision must be based on:
  - etiology of CS
  - neurologic status
  - RV function
  - pulmonary function
  - end organ function
- Potential for recovery (patient and organ recovery)
- Potential options long term
Choice of Device

- Univentricular assist (LVAD)
  - left heart failure
  - good RV function
- Biventricular assist (BiVAD)
  - biventricular failure
Second generation non pulsatile devices

- Simplified Implantation Technique
- Electromagnetic bearing
- Less blood trauma
Patients with biventricular assist
CS in STEMI

- Acute?
- Is revascularization possible?
- Is reperfusion successful?
- Organ recovery expected?
  → ECLS until organ recovery

- Subacute?
  - Is revascularization too late to expect organ recovery?
  - Large area of infarct
  - Patient eligible for either HTx or Destination therapy?
  → Consider LVAD
CS in STEMI with mechanical complications

- STEMI with large VSD

A case for TAH
CS in Myocarditis

- Acute?
- Known Pathogen, therapy available?
- Cardiac recovery expected?
- Biventricular failure?
  - ECLS until organ recovery
  - LVAD if no organ recovery in < 2 weeks

• Subacute?
• Primary left ventricular failure?
• Cardiac recovery not expected?
  ➤ Consider LVAD
CS in Heart Failure (Acute Worsening)

- ECLS of limited value as only temporary organ recovery can be expected (limited weaning option)

- Primary left ventricular failure?
- RV function ok?
- No irreversible end organ failure?
- No major neurologic impairment?
- Patient eligible for either HTx or Destination therapy?

→ Consider LVAD; temporary RV support may be necessary, on top...
CS in Valvular Disease

- Acute?
- Is valve repair / replacement possible?
- Is LV function likely to recover?
- Organ recovery expected?

➔ Valve Surgery/Intervention + ECLS until organ recovery

➔ LVAD rarely indicated
Treatment algorithm for AHF and cardiogenic shock in patients with unclear neurologic status

Medical therapy
- Inotropic support
- Ventilatory support
- IABP
- Reperfusion
- Revascularisation

Patient stable

No recovery of cardiac function

- Assess neurologic / end organ function

Irreversible neurological deficit

- Weaning

Normal neurological function

- Consider LVAD/BiVAD therapy (BTT/DT)

Cardiac function recovers

- Standard therapy

Patient stable
Treatment algorithm for AHF and cardiogenic shock in patients with unclear neurologic status

- **Patient unstable**: ECMO support
  - Cardiac function recovers: Weaning
  - Irreversible neurological deficit: Weaning

- **Patient stable**: Weaning
  - Cardiac function recovers: Standard therapy
  - No recovery of cardiac function: Assess neurologic / end organ function
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    - Normal neurological function: Consider LVAD/BiVAD therapy (BTT/DT)

- **Medical therapy**: Inotropic support
- **Ventilatory support**: IABP
- **Reperfusion**
- **Revascularisation**
ECLS prior to LVAD in CS – Bridge-to-Bridge Concept

ECLS for immediate hemodynamic stabilization and deferral of permanent VAD implantation to allow patient optimization, defined as:
- recovery of end-organ function
- normalization of volume status
  and right ventricular (RV) filling pressures

Riebandt J EJCTS 2014
Rationale for ECLS prior to LVAD in CS – Bridge-to-Bridge Concept

- Immediate biventricular and pulmonary support with minimal surgical trauma
- can be performed in various settings including emergency departments, ICUs as well as peripheral hospitals
- does not necessarily demand the infrastructure of a VAD centre
- reversal of cardiogenic shock and end-organ damage
- Allows assessment of neurological status/complications prohibiting VAD

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</tr>
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<td>Dobutamine (µg/kg/min)</td>
<td>9.6 ± 0.9</td>
<td>9.6 ± 0.9</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Haemoglobin (mg/dl)</td>
<td>166 ± 111</td>
<td>62 ± 47</td>
<td>0.06</td>
</tr>
<tr>
<td>Platelets (×10⁹)</td>
<td>237 ± 95</td>
<td>237 ± 95</td>
<td>0.80</td>
</tr>
<tr>
<td>C-reactive protein (mg/dl)</td>
<td>35.8 ± 15</td>
<td>35.8 ± 15</td>
<td>0.21</td>
</tr>
<tr>
<td>Leucocytes (×10⁹)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unless otherwise indicated, data expressed as mean ± SD.

MDRD-GFR: Modification of Diet in Renal Disease—Glomerular Filtration Rate; MELD-XI: Model for End-stage Liver Disease—excluding INR; FIO₂: fraction of inspired oxygen; ECLS: extracorporeal life support; VAD: ventricular assist device.
In-hospital mortality 9.1%
1-year survival 86.4%
Immediate LVAD for CS

A one-stop implantable LVAD approach for cardiogenic shock is

- feasible
- better decompression of LV
- higher and consistent cardiac output
- avoids incremental costs
- avoids morbidity associated with...
In-hospital Survival 8%
Actuarial 1y Survival 86%

n = 13
Optimal Therapies for End-Stage Thoracic Organ Failure: The Critical Role of the Surgeon and the Use of ECMO, MCS and Transplantation

Decision Making: ECLS - Bridge to VAD, Transplant, Recovery or Oblivion

Evgenij V. Potapov, MD, PhD,
Felix Hennig, MD and MCS Team of DHZB, Berlin, Germany
Definitions

- **ExtraCorporeal Membrane Oxygenation**
- ECMO is a temporary support of heart and/or lungs with the goal of recovery or bridge to definitive solution
- Modern terminology: ECLS (ExtraCorporeal Life Support)

**Always emergency Indications**

- Acute heart and/or lung failure with high mortality rate
  - ARDS (pneumonia, post-trauma)
  - Cardiogenic shock
    - (post cardiotomy, aMI, intoxication, acute myocarditis…)
- Post HTx or post LTx
Implantation

- OR, cath lab, bedside
- General or local anesthesia
- Placement
  - Central (sternotomy, left lateral thoracotomy)
  - Peripheral (a. axillaris, a. femoralis)
  - Open with or without graft or per punctioem
- Ensure adequate extremity perfusion
Percutaneous Cannulation
LV Distension

- Reason – myocardial dysfunction and increased overload through ECLS flow
- Increased LVEDD, LVEDP and wall tension may preclude myocardial recovery
- Increased LVEDP may lead to pulmonary edema and irreversible loss of lung function
Vent

- Alternatives - fast and less invasive
  - Inotrops, IABP, atrial septostomy

- Directly through left atrium
- LV apex
- Transaortic with pigtail catheter
  (Fumagalli R et al., Int J Artif Organs 2004)
- Transseptal access
  (Aiyagari RM et al., Crit Care Med 2006)
- A. pulmonalis 15F cannula
  (Avalli L et al., ASAIO J 2011)
- A. pulmonalis with SmartCannula®
v-a ECLS – Clinical Considerations

- Aortic regurgitation
- Central hypoxia due to lung failure and preserved LV ejection
  - BGA / pulsoxymetry right arm or head
  - Stop inotropes, venting
- Distal leg perfusion
  - 8 Fr. ArrowFlex introducer
- LV Distension
- Inotrops, Rashkind, Venting
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DHZB v-a ECMO Algorithm

DHZB v-a ECMO Schema
Ziele: Sufficiente Organperfusion bei myokardialer Entlastung

Bevorzugt Kanülierung A. axillaris re; unter Rea percutane, femorale Kanülierung
- Beschichtete Kanülen
- Kanülenkombinationen (siehe Tab. 2)
- Beinperfusion z.B. Arrow Schleuse 8 Fr, (nicht bei Rea)
- Ausreichende Beatmung sicherstellen

Zentrale Hypoxie?
- Pulsloximetry (rechte Hand, Nase, Ohr)
  (SpO₂ < 90%)
- A. radialis rechts: pO₂ < 70 mmHg,

LV-Distension und pulmonalvenöse Hypertonie?
- Echo: zunehmende Ventrikeldilatation (Vorwort)
- Röntgen: Lungendruck, breiter Herzschatten
- PCWP > 20 mmHg

Berechnung des Sollflusses
Sollfluss: 2,5 bis 3 l/min KOF
Körpereoberfläche (KOF): KOF = (cm²) x [kg] / 3600)

Antikoagulation und Transfusion
Antikoagulation
- Heparin pTT 50–60s
- Pause bei Blutung oder vor invasivem Eingriff
- Je höher der Fluss, desto geringer das Risiko von Thrombenbildung im ECMO-Kreislauf

Transfusion
- Erythrozyten gab bei Hb < 10 g/dl
  (ggf. 1 FFP pro 2 EK)

Thrombzytengabe
- Thrombos <20
- Thrombos <50 und Blutung
- Thrombos <100 und bevorstehendem Eingriff

Errechneter Sollfluss (Tab. 1) erreicht?

ja

nein

Mögliche Kanülenkombinationen

<table>
<thead>
<tr>
<th>Fluss</th>
<th>arteriell</th>
<th>venös</th>
</tr>
</thead>
<tbody>
<tr>
<td>~ 3–4 l</td>
<td>15 Fr.</td>
<td>21 Fr.</td>
</tr>
<tr>
<td>~ 4–5 l</td>
<td>17 Fr.</td>
<td>23 Fr.</td>
</tr>
<tr>
<td>~ 5–6 l</td>
<td>17–19 Fr.</td>
<td>23–25 Fr.</td>
</tr>
</tbody>
</table>

Abb. 9.5
DHZB v-a ECMO Flowchart, Vorderseite

Abb. 9.6
DHZB v-a ECMO Flowchart, Rückseite
Number of PubMed Publications on “ECMO”
2015 SCAI/ACC/HFSA/STS Clinical Expert Consensus Statement on the Use of Percutaneous Mechanical Circulatory Support Devices in Cardiovascular Care

Endorsed by the American Heart Association, the Cardiological Society of India, and Sociedad Latino Americana de Cardiologia Intervencion; Affirmation of Value by the Canadian Association of Interventional Cardiology-Association Canadienne de Cardiologie d'Intervention
Crucial Questions about Further Treatment

- When to implant - window of opportunity
- What to implant – HTx, LVAD or BVAD
- Whom to implant
- When should we step back
<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Total</th>
<th>Age (SD)</th>
<th>Male</th>
<th>IABP</th>
<th>Cardiac arrest</th>
<th>Peripheral ECMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postcardiotomy</td>
<td>29(29.6%)</td>
<td>50.6(15.4)</td>
<td>19 (65.5%)</td>
<td>5 (17.2%)</td>
<td>12 (41.4%)</td>
<td>25 (86.2%)</td>
</tr>
<tr>
<td>Acute graft failure</td>
<td>12(12.2%)</td>
<td>42.2(14.5)</td>
<td>8 (66.7%)</td>
<td>0</td>
<td>2 (16.7%)</td>
<td>12 (100%)</td>
</tr>
<tr>
<td>Chronic cardiomyopathy</td>
<td>18(18.4%)</td>
<td>39.3(13.7)</td>
<td>16 (88.9%)</td>
<td>1 (5.6%)</td>
<td>2 (11.1%)</td>
<td>9 (50.0%)</td>
</tr>
<tr>
<td>Acute myocardial infarction</td>
<td>17(17.3%)</td>
<td>46 (10.3)</td>
<td>10 (58.8%)</td>
<td>6 (35.3%)</td>
<td>9 (52.9%)</td>
<td>13 (76.5%)</td>
</tr>
<tr>
<td>Myocarditis</td>
<td>5 (5.1%)</td>
<td>26 (12.7)</td>
<td>1 (20.0%)</td>
<td>0</td>
<td>2 (40.0%)</td>
<td>5 (100%)</td>
</tr>
<tr>
<td>Others</td>
<td>17(17.3%)</td>
<td>34.7(13.4)</td>
<td>5 (29.4%)</td>
<td>1 (5.9%)</td>
<td>9 (52.9%)</td>
<td>14 (82.4%)</td>
</tr>
<tr>
<td>Toxics</td>
<td>5</td>
<td>34 (17.6)</td>
<td>1 (20.0%)</td>
<td>0</td>
<td>3 (60.0%)</td>
<td>5 (100%)</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>3</td>
<td>43.2(12.6)</td>
<td>2 (50.0%)</td>
<td>0</td>
<td>3 (75.0%)</td>
<td>3 (75.0%)</td>
</tr>
<tr>
<td>Peripartum</td>
<td>4</td>
<td>33.5 (4.0)</td>
<td>0</td>
<td>1 (25.0%)</td>
<td>3 (75.0%)</td>
<td>4 (100%)</td>
</tr>
<tr>
<td>Tako-Tsubo syndrome</td>
<td>1</td>
<td>43</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Thyroiditis</td>
<td>1</td>
<td>48</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Clarkson’s Syndrome</td>
<td>1</td>
<td>41</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pheochromocytoma</td>
<td>1</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Septic shock</td>
<td>1</td>
<td>11</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td>42.8(15.1)</td>
<td>59 (60.2%)</td>
<td>13 (13.3%)</td>
<td>37 (37.8%)</td>
<td>78 (79.6%)</td>
</tr>
</tbody>
</table>
Extracorporeal life support in cardiogenic shock: Impact of acute versus chronic etiology on outcome

Vincenzo Tarzia, MD,1 Giacomo Bortolussi, MD,1 Roberto Bianco, MD,1 Edward Buratto, MBBS,1 Jonida Bejko, MD,1 Massimiliano Carrozzini, MD,1 Marco De Franceschi, BSS,1 Dario Gregori, MA, PhD,1b Dario Fichera, CCP, MS,1 Fabio Zanella, CCP,1 Tomaso Bottio, MD, PhD,1 and Gino Gerosa, MD1

ABSTRACT

Background: The role of extracorporeal life support (ECLS) in primary cardiogenic shock (PCS) is well established. In this study, we evaluated the impact of etiology on outcomes.

Methods: Between January 2009 and March 2013, we implanted a total of 249 patients with ECLS; we focused on 64 patients for whom peripheral ECLS was the treatment for PCS. Of these, 37 cases (58%) were “acute” (mostly acute myocardial infarction: 39%); 27 (42%) had an exacerbation of “chronic” heart failure (dilated cardiomyopathy: 30%; post-ischemic cardiomyopathy: 9%; and congenital: 3%).

Results: In the group with chronic etiology, 23 patients were bridged to a left ventricular assist device (52%) or heart transplantation (33%). In the group with acute etiology, ECLS was used as a bridge-to-transplantation in 3 patients (8%), a bridge-to-bridge in 9 (24%), and a bridge-to-recovery in 18 (49%). One patient in each group was bridged to conventional surgery. Recovery of cardiac function was achieved in only the group with acute primary cardiogenic shock (18 vs 0 patients, \( P = .0001 \)). A mean flow during support of \( \leq 60\% \) of the theoretic flow (body surface area \( \times 2.4 \)) was a predictor of successful weaning (\( P = .02 \)). Median duration of ECLS support was 7 days (range: 2-11.5 days). Nine patients (14%) died during support; 30-day overall survival was 80% (51 of 64 patients); and 59% of patients were discharged, in whom survival at 48 months was 90%. Thirty-day survival was correlated with duration of ECLS support.

Conclusions: In “chronic” heart failure, ECLS represents a bridge to a ventricular assist device or heart transplantation, whereas in “acute” settings, it offers a considerable chance of recovery, and is often the only required therapy.

(J Thorac Cardiovasc Surg 2015; 14:1-8)
In “chronic” heart failure, ECLS represents a bridge to VAD or HTx whereas in “acute” settings it offers a considerable chance of recovery, and is often the only required therapy.
Weaning Trial

After obtaining hemodynamic stabilization and improvement of organ function (either neurologic, respiratory, renal, or hepatic), ECLS support was progressively decreased to 1 L per minute. Standard management involved serial echocardiograms during this phase, but we relied mostly on persistence of satisfactory hemodynamics and organ function, on low-to-medium dose inotropic support, to assess the feasibility of weaning from ECLS. Specifically, we performed echocardiographic evaluation of ventricular function (left ventricular ejection fraction >35%; good right ventricular contractility) and volume (absence of excessive ventricular distension, or severe tricuspid regurgitation), as well as clinical parameters, such as normal systemic pressure (systolic blood pressure >85 mm Hg) and central venous pressure, normal blood lactate level, and urine output.

Extracorporeal life support as a bridge to bridge: a strategy to optimize ventricular assist device results

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Abstract

OBJECTIVES: Extracorporeal life support (ECLS) devices provide temporary mechanical circulatory assistance and are usually implanted under emergency conditions in critical patients. If weaning off ECLS is not possible, heart transplantation or implantation of long-term mechanical circulatory support (LTMCS) is required. The purpose of our study was to evaluate the bridge-to-bridge (BTB) concept.

METHODS: Between 1 January 2004 and 1 August 2010, 97 patients were assisted by LTMCS. The implantation was the first-line intervention in 48 patients (the bridge group), and was performed after a period of ECLS support in 49 others (the BTB group).

RESULTS: The long-term survival rate was 51.6%, with a mean follow-up of 30.7 months, and there were no differences for biological parameters between the two groups. Patients in the BTB group whose condition was initially more severe, improved under ECLS support, and those in whom biological parameters did not revert to normal died after LTMCS. Risk factors for mortality in the BTB group were total bilirubin and lactate before LTMCS, and alkaline phosphatase before ECLS support.

CONCLUSIONS: The BTB concept allows the implementation of LTMCS in severe patients, for whom it was not originally envisaged, with the same long-term survival as in first-line settings. ECLS in the evolution of patients is predictive of survival after LTMCS.
Weaning

- Recovery of the lung function
  - Weeks
  - Improved compliance, X-ray and BGA during similar ECLS setting
  - $\text{SaO}_2 > 90\%$ under 2 l/min flow $\rightarrow$ weaning trial

- Myocardial recovery
  - Pulsatility, LV ejection
  - Decrease of inotropes and vasopressors
  - Most likely between 2$^{\text{nd}}$ and 5$^{\text{th}}$ days of support
    (Smedira et al. J Thorac Cardiovasc Surg 2001)
  - No weaning if LV-EF < 30$\%$ after 2 days
    (Fiser et al. Ann Thorac Surg 2001)
Stable on ECLS, Weaning Not Possible – What to do?

- Decision should be made during first 5-7 days
- Is the patient HTx candidate? – consider waiting time on ECLS
- VAD implantation on ECLS is a high-risk surgery

- VAD should be considered if
  - Organ function may be compromised, but showing improvement
    - Neurological check-up is essential, CT if required
    - Lung function - on ECLS is difficult to access
    - Renal function - dialysis does not preclude VAD
    - Liver function - bilirubin < 10 mg/dl or decreasing
  - Mostly no switch to CPB is necessary, implant on ECLS
DHZB ECMO / ECLS Experience 2014

- 149 adults (+ 25 children)
- 103 male vs. 46 female

- v-a ECMO in 125 patients
- v-v ECMO in 24 patients

- Peripheral cannulation 104 patients
- Central cannulation 45 patients
DHZB ECMO / ECLS Experience 2014

- aMI 15 patients
- cardiogenic shock 34 patients
- post Tx 15 patients
- post cardiotomy 75 patients
- ARDS 10 patients

- switch to LVAD 19 patients (after median 6 days, 3-20 days)
- weaned 17 patients (after median 12 days, 4-47 days)
- expired 107 patients
ECMO / ECLS as Bridge to VAD

- Data of patients who underwent ECMO / ECLS prior to VAD implantation between 01/2013 and 10/2014 were analyzed retrospectively.

- 22 patients
  - 15 male, 7 female
  - 12 dilative cardiomyopathy
  - 4 ischemic cardiomyopathy
  - 4 myocarditis
  - 2 acute myocardial infarction
  - In 10 patients CPR was necessary at least once before VAD
ECMO / ECLS as Bridge to VAD

- The femoral artery and vein were accessed in all but one case.
- Antegrade leg perfusion was established in 20 patients.
- Median time on ECLS was 4 days (range 1-31 days).
- 30-day mortality after VAD implantation was 45%.
- Six patients survived to hospital discharge.
- No differences in clinical parameters were noted between survivors and non-survivors.
ECMO / ECLS as Bridge to VAD

- Patients receiving long-term ventricular assist devices (VADs) for refractory cardiogenic shock (rCS) with multi-organ failure present substantial postoperative mortality and morbidity.
- Conditioning these patients preoperatively with extracorporeal life support (ECLS) could offer an improved outcome.
Conclusions

- For treatment of severe cardiogenic shock with unclear neurological status and/or MOF, ECLS is a valid initial option
- Survival remains between 25 and 50%
- Institutional SOP, mobile team and regular training are crucial
- Leg perfusion reduces leg ischemia and concomitant morbid complications
- In decompensated acute heart failure (e.g. myocarditis, Takotsubo, AMI, acute poisoning) weaning is an option
- In decompensated chronic heart failure (e.g. DCMP or ICMP) subsequent VAD implantation is the only option
Conclusion

- After stabilization and conditioning on ECLS, VAD implantation can be performed, yielding improved outcome as compared to primary VAD implantation
- Decision about VAD implantation should be done within first 5-7 days of support
- In case of switch to VAD, mostly LVAD + temporary RVAD configuration is necessary
- Preceding CPR or prolonged duration of ECLS does not preclude successful VAD implantation