The Bern Concept of Minimized Cardiopulmonary Bypass

A «Bloody» Work
SCANSECT
Post Graduate Course
Saturday the 25th of October 2014

Hansjörg Jenni; ECCP; MAS
Clinic for Cardiovascular Surgery
University Hospital Berne

Aim of the presentation

- Introduction:
  - Requirements to a modern perfusion system
    - Volume controlled perfusion
    - Procedure adapted perfusion
  - CABG:
    - Why MECC for CABG
  - MECC: The concept from Bern
  - MECC for aortic valve replacement
- Take home messages

Introduction

Requirements to a modern perfusion system

- Minimized artificial surface
- Minimized priming volume
- No blood – air contact
  → maximum biocompatibility → physiological conditions
- Suction blood processing
- Reduced shear stress
- Reliability
- Economic efficiency

Procedure adapted perfusion

Patient adapted perfusion (tailored perfusion)

- Blood gas analysis (BE; Lactat; pH..)
- Online measurement (SvO₂)
- NIRS - Technology

CABG

Perfusion specific requirements

- Maintenance of the circulation
- Cardioplegia administration
- Suction blood management
- No opening of the heart chambers
- No «vent blood»
- No additional perfusion:
  - SACP
  - visceral perfusion
  - etc.
**Procedure adapted perfusion**

CABG
- Elimination of the venous reservoir:
  - no blood-air contact
  - reduced artificial surface
  - minimal volume shift → Volume controlled perfusion (VCP)
- Closed system:
  - no blood-air contact
  - reduced artificial surface
  - reduced priming volume
- Suction blood separation:
  - reduced inflammatory response
  → improved biocompatibility

**Volume controlled perfusion**

No volume displacement into a reservoir

“the patient is the venous reservoir”

→ Volume controlled perfusion (VCP)

**VCP Components**

Suction unit

Cardioplegia unit

Circulation unit

**Bern concept**

Current systems

- Medtronic Affinity CP & Fusion
- Terumo FX15/25
- MEDOS HILITE 7100 s.Pump

**Circulation**

- Oxygenator
- Tubing set
- Centrifugal pump
  → 600 ml priming volume

**Cardioplegia**

Advantages:
- single shot
- simple application
- minimal volume loading
- economic
- extended effect (> 60 min)
- immediate cardiac arrest

Cardioplexol (Patent pending)
**Cardioplegia**

Solution A (95ml)
- Magnesium sulfate (induction of diastolic cardiac arrest)
- Potassium chloride (membrane stabilizer)
- Xylitol (edema prevention)

Solution B (5ml)
- Procain (membrane stabilizer)

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**Volume controlled perfusion**

**Minimal Extracorporeal Circulation is a Promising Tool**

**Figure 1**: Postoperative incidence of atrial fibrillation (AF) in patients being operated with conventional extracorporeal circulation (CECC) or minimal extracorporeal circulation (MECC) (*p < 0.05*). Patients with a history of atrial fibrillation or postoperative arrhythmia were excluded. MECC = MECC.

**Figure 2**: Myocardial marker.

**Table 1**: Mortality and postoperative complications.

<table>
<thead>
<tr>
<th>Complication</th>
<th>CECC (%)</th>
<th>MECC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
<td>12 (4.8)</td>
<td>5 (4.3)</td>
</tr>
<tr>
<td>Low cardiac output</td>
<td>6 (4.2)</td>
<td>2 (2.2)</td>
</tr>
<tr>
<td>Renal insufficiency</td>
<td>4 (3.2)</td>
<td>3 (2.7)</td>
</tr>
<tr>
<td>Diuresis</td>
<td>3 (2.1)</td>
<td>1 (1.1)</td>
</tr>
</tbody>
</table>

*Data are presented as mean ± SD or as median (range) or as frequency distributions (%) when appropriate. *: *p < 0.05* for MECC vs. CECC.

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The significantly shorter reperfusion time in the MECC group reflects the clinical observation that after a MECC procedure the heart can be weaned earlier from the bypass, due to better perfusion conditions. Additionally, the release of postoperative heart muscle enzymes and the postoperative lactate concentration at 30 minutes and 6 hours after CABG were significantly reduced in the MECC group.
VCP Perfusion physiology

Conventional Bypass

Volume controlled perfusion

Improved myocardial protection as an effect of constant coronary flow?

MECC Suction procedures

Automatic suction device

Autotransfusion system

Suction blood handling

Integrated suction device

- Maintenance of VCP
- Autologous whole blood transfusion during acute bleeding
- Air handling

Data from Bern

Totally MECC since 2002:

- > 6000 MECC perfusion (Berne/Basle)
- > 270 CABG + PFO closure
- > 100 AVR (ongoing study)

Critical incidents:

- 3 disconnected venous lines
- 5 switch to conventional CPB (intraoperative)

MECC Suction procedures

As such, C.A.T.S® should be preferred in routine CABG, as long as no extensive volume substitution is anticipated.

VCP Perfusion physiology

Additional findings during the last decade

- Cardiac index for VCP: 2.0 l/min²/BSA
- Increased middle arterial pressures
- Reduced Noradrenalin consumption
**Volume controlled perfusion**

**Additional advantages of VCP:**

- Lower CI (Cardiac Index) → 2 l/m²/KOF
  - reduced shearstress
  - lower p1-values

**Example: calculated blood flow**

- Height: 190cm
- Weight: 90 kg
- BSA: 2.2 m²

Calculated blood flow cCPB (Index 2.4 l/m²/KOF): 5.2 l/min
Calculated blood flow VCP (Index 2.0 l/m²/KOF): 4.4 l/min

**Volume controlled perfusion**

**VCP dependent artificial surface reduction**

Example: ECC-O-system (Sorin Group)

- Gas exchange surface: 1.2 m²
- 2.0 m² - 1.2 m² = 0.8 m²
- 42% surface reduction

Terumo FX 15
Gas exchange surface: 1.5 m²

→ 27 m 3/8" - tubing

**MECC Perfusion physiology**

<table>
<thead>
<tr>
<th>ECC (n 1100)</th>
<th>MECC (n 975)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sever vasoplegia</td>
<td>145 (7.2%)</td>
</tr>
<tr>
<td>Moderate vasoplegia</td>
<td>214 (10.7%)</td>
</tr>
</tbody>
</table>

Noradrenaline consumption and different vasoplegia:
- low < 150 µg
- moderate 150-500 µg
- severe > 500 µg


**Data**

**Effect of closed minimized cardiopulmonary bypass on cerebral tissue oxygenation and microembolization**

A. Liétard, MD, PhD, A. Khosravi, MD, B. Wisselbock, MD, C. Simbali, MD, Y. H. Xia, MD, C. Stassen, MD, A. Kramlinski, MD, A. Ahsen, MD, E. Browas, MS, D. Zunzunegui, MD, PhD, and G. Stauder, MD, PhD

Conclusions: Use of closed minimized cardiopulmonary bypass compared with conventional open cardiopulmonary bypass preserves cerebral tissue oxygenation and reduces cerebral microembolization.
Aortic Valve Surgery

Perfusion specific requirements
• Maintenance of the circulation
• Cardioplegia administration
• Suction blood management
• Opening of the heart chambers
• Vent blood management

MECC: AVR

Aortic Valve Replacement

Venous cannula (3747)

Pulmonary artery vent

Y-connector (38-15/15-14)

Venous line = permanent active suction
Prospective randomized trial
N=50, 25/25
Aortic valve replacement
MECC vs. conventional ECC
Endpoints: Inflammation; Coagulation; Blood consumption etc.

Preliminary results:
- EC consumption during MECC: 0 ± 0
- MECC time: 64 min ± 17
- Clamp time: 51 min ± 14
- Volume balance: 626 ml ± 483

Over all:
- More than 100 cases with MECC
- No critical event

Medtronic Academia
Theoretical training:
- 3 presentations:
  - Surgeon
  - Anesthesiologist
  - Perfusionist
- Theoretical MECC specific aspects
- Pitfalls and prevention

Medtronic Academia
Trouble shooting in the perfusion laboratory
- Relaxed ambiance
- How to manage:
  - Air elimination
  - Massive bleeding
- Generally tips and tricks

Medtronic Academia
Live surgery
- Practical demonstration of:
  - Perfusion strategies
  - Management of anesthesiia
  - Surgical tips and tricks
- Pitfalls and solutions
  - Cardioplegia
  - Volume management
  - Coronary blood flow
  - Suction events

Take home messages
The CABG procedure itself offers the opportunity for a maximal reduction of the perfusion system

MECC is a safe perfusion technology for CABG procedures

The advantages of the "CABG-MECC" can be transferred into the "Aortic valve MECC"

Reduced RBC consumption during and after perfusion is a major benefit of MECC Systems