Minimally invasive ExtraCorporeal Circulation (MiECC)

the state of the art in perfusion

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Professor of Cardiac Surgery, Aristotle University of Thessaloniki
Head Cardiothoracic Department, AHEPA University Hospital
Vice Head of the School of Medicine, Aristotle University
Founder, Past President, Executive Board MiECTiS
consultant / advisory board Medtronic
the technology
John Gibbon: operation with heart-lung machine
MiECC circuit: Alois Phillip
MiECC circuit: Alois Phillip
- Mini-extracorporeal circulation system - MECC (MAQUET, Germany)
- Extra-Corporeal Circulation Optimized system - ECC.O (Dideco, Italy)
- Resting Heart® System - RHS (Medtronic, USA)
- Synergy™ Mini-Bypass System (Cobe, USA)
- CorX (CardioVention, USA)
- NovoSci Ready System® (NovoSci, USA)
- Deltastream® (MEDOS, Germany)
- Capiox® (Terumo, Japan)
type I MiECC

Standard CPB

Venous Reservoir

Roller Pump

oxygenator

MiECC

patient

Suction device

Centrifugal pump

oxygenator
<table>
<thead>
<tr>
<th>Type</th>
<th>Diagram</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td><img src="image1" alt="Image" /></td>
<td>This closed circuit comprises of an afferent tube (blue line) which drains blood from the right atrium to the pump (©), then to the oxygenator (©) and returns it to the arterial circulation with the efferent tube (red line). The oblique arrow indicates cardioplegia line with its pump (©).</td>
</tr>
<tr>
<td>II</td>
<td><img src="image2" alt="Image" /></td>
<td>A venous bubble trap/air removing device (©) is added to the standard MiECC circuit so as to facilitate air handling and avoid air entrainment to the venous line. Venting (green) lines (V) drain blood from the aortic root and/or pulmonary artery/vein.</td>
</tr>
<tr>
<td>III</td>
<td><img src="image3" alt="Image" /></td>
<td>A soft shell reservoir (S) is added to the circuit to collect blood volume from the patient and return it back during perfusion according to the needs.</td>
</tr>
<tr>
<td>IV</td>
<td><img src="image4" alt="Image" /></td>
<td>A hard shell reservoir (H) is added as an extra component integrated to the venous line, so as to convert the system to an open circuit that could facilitate blood management as well as overcome any other intraoperative issue (modular configuration).</td>
</tr>
</tbody>
</table>

*Anastasiadis et al; Perfusion 2015;30:195-200.*
TYPE I MiECC

→

ECLS

+ cardioplegia system

+ Ao root vent
Four Years’ Experience With a Miniaturized Extracorporeal Circulation System and Its Influence on Clinical Outcome

*Christoph Wiesenack, †Andreas Liebold, ‡Alois Philipp, *Markus Ritzka, *Joachim Koppenberg, ‡Dietrich E. Birnbaum, and §Cornelius Keyl

*Department of Anesthesia, University Hospital Regensburg, Regensburg; †Department of Cardiac Surgery, University Hospital Rostock, Rostock; ‡Department of Cardiothoracic Surgery, University Hospital Regensburg, Regensburg; and §Department of Anesthesia, Heart Center Bad Krozingen, Bad Krozingen, Germany

Abstract: It has been suggested that the morbidity associated with cardiopulmonary bypass can be attributed in part to the blood–material and blood–air interactions in the extracorporeal circulation (ECC). A recently introduced miniaturized ECC-system (MECC System) should be able to reduce these negative effects associated with ECC. A retrospective analysis was performed comprising 485 patients who were operated on for elective coronary artery bypass grafting (CABG) using the MECC System with intermittent antegrade warm blood cardioplegia (group 1) from January 2000 to February 2004. A control group consisted of 485 patients (group 2) undergoing elective CABG in the same period using a conventional ECC and cold crystalloid...
cell saver

180-260 mmHg

prime bag

100 ml

35 ml

250 ml

< - 70 mmHg

< - 70 mmHg

50 ml

cardioplegia

root vent

100 ml

100 ml

180-260 mmHg

volume: semi-closed
cell saver

prime bag

180-260 mmHg

VBT

35 ml

250 ml

50 ml cardioplegia

100 ml

< - 70 mmHg

volume: semi-closed

dep-airing

bridge

root vent

type II
cell saver

180 - 260 mmHg

prime bag

VACUUM - 200 mmHg

100 ml

35 ml

250 ml

VARD

VACUUM bridge

hard cell

volume: semi-closed

de-airing

soft bag

< - 70 mmHg

re-circulation line

< - 70 mmHg

35 ml

50 ml cardioplegia

100 ml

100 ml

180-260 mmHg

root vent

PA vent

Suctions when open

modular

type IV

AHEPA circuit
This closed circuit comprises of an afferent tube (blue line) which drains blood from the right atrium to the pump (◯), then to the oxygenator (◯) and returns it to the arterial circulation with the efferent tube (red line). The oblique arrow indicates cardioplegia line with its pump (©).

A venous bubble trap/air removing device (뇌) is added to the standard MiECC circuit so as to facilitate air handling and avoid air entrainment to the venous line. Venting (green) lines (V) drain blood from the aortic root and/or pulmonary artery/vein.

A soft shell reservoir (Ｓ) is added to the circuit to collect blood volume from the patient and return it back during perfusion according to the needs.

A hard shell reservoir (Ｈ) is added as an extra component integrated to the venous line, so as to convert the system to an open circuit that could facilitate blood management as well as overcome any other intraoperative issue (modular configuration).
MiECTiS

- June 2014: 120 Founding Members
- April 2018: 263 Members

Members Profession

- Anesthesiologists: 33%
- Cardiac Surgeons: 29%
- Perfusionists: 29%
- Other / Industry: 8%

33 countries

- Greece
- UK
- Italy
- Germany
- Switzerland
- Belgium
- Netherlands
- Canada
- Russia
- ...others

www.miectis.org
Confusion
DEFINITION

Terminology

- miniaturized extraorporeal circulation (MECC)
- mini extraorporeal circulation (mECC)
- minimized extracorporeal circulation
- mini cardiopulmonary bypass (mCPB, mini-CPB)
- minimal invasive cardiopulmonary bypass (MICPB)
- miniaturized cardiopulmonary bypass (MCPB)
- venoarterial extracorporeal membrane oxygenation
- minimized perfusion circuit
- minimized extracorporeal life support system
- minimized cardiopulmonary bypass
- minimal invasive extracorporeal circulation
In order to be characterized as **MiECC**

the main components of the system must include

- a closed CPB circuit
- biologically inert blood contact surfaces
- reduced priming volume
- a centrifugal pump
- a membrane oxygenator
- a heat exchanger
- a cardioplegia system
- a venous bubble trap / venous air removing device
- a shed blood management system

additional components to be integrated into system are

- pulmonary artery vent
- aortic root vent
- pulmonary vein vent
- soft bag / soft-shell reservoir
- hard-shell reservoir (modular systems)
- regulated smart suction device
- arterial line filtration
MiECC represents a **strategy** and not just a circuit.

For this reason a **teamwork** approach is mandatory for obtaining maximum clinical benefit.
MiECTiS advocates this **strategy** to obtain the maximal benefits from this technology.
current clinical evidence
“Unless I see the mark of the nails in his hands and put my finger into the nailmarks and put my hand into his side, I will not believe.” — John 20:25
Use of minimal invasive extracorporeal circulation in cardiac surgery: principles, definitions and potential benefits. A position paper from the Minimal invasive Extra-Corporeal Technologies international Society (MiECTiS)


<table>
<thead>
<tr>
<th>Class</th>
<th>Statement</th>
<th>Level of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I</td>
<td>MiECC systems reduce haemodilution and better preserve haematocrit as well as reduce postoperative bleeding and the need for RBC transfusion</td>
<td>A</td>
</tr>
<tr>
<td>Class I</td>
<td>MiECC systems reduce the incidence of postoperative atrial fibrillation</td>
<td>A</td>
</tr>
<tr>
<td>Class I</td>
<td>MiECC systems preserve renal function</td>
<td>A</td>
</tr>
<tr>
<td>Class I</td>
<td>MiECC is associated with improved myocardial protection</td>
<td>A</td>
</tr>
<tr>
<td>Class IIA</td>
<td>Inflammatory response assessed by specific inflammatory markers is attenuated with use of MiECC</td>
<td>B</td>
</tr>
<tr>
<td>Class IIA</td>
<td>MiECC systems can reduce cerebral gaseous microembolism and preserve neurocognitive function</td>
<td>B</td>
</tr>
<tr>
<td>Class IIA</td>
<td>MiECC exerts a subclinical protective effect on end-organ function (lung, liver, intestine) which is related to enhanced recovery of microvascular organ perfusion</td>
<td>B</td>
</tr>
</tbody>
</table>

Class IIB

- Within a MiECC strategy, less thrombin generation may permit reduced heparin dose targeted to shorter ACT times. When such a strategy is followed, individual heparin dose should be determined using heparin dose–response monitoring systems.
- MiECC appears to offer survival benefit in terms of lower 30-day mortality after CABG procedures.
- The use of short-acting opioids in combination with propofol or volatile anaesthetics, and hypnotic effect monitoring by processed EEG, is recommended for induction and maintenance of anaesthesia for MiECC-based surgery. TOE findings pertinent to institutional management of MiECC should be communicated during the preoperative surgical safety time out.
Use of minimal invasive extracorporeal circulation in cardiac surgery: principles, definitions and potential benefits. A position paper from the Minimal invasive Extra-Corporeal Technologies international Society (MiECTiS)

Kyriakos Anastasiadis¹, John Murkin², Polychronis Antonitis³, Adrian Bauer³, Marco Ranucci³, Erich Gygax³, Jan Schaarschmidt³, Yves Fromes¹, Alois Philipp³, Balthasar Eberle³, Prakash Punjab³, Helena Argiriadou⁴, Alexander Kadner³, Hansjoerg Jenni³, Guenter Albrecht, Wim van Boven⁵, Andreas Liebold⁶, Fillip de Somer⁷, Harald Hausmann⁸, Apostolos Deliopoulos⁸, Aschraf El-Essawi⁸, Valerio Mazzei⁹, Fausto Biancari⁹, Adam Fernandez⁹, Patrick Weerwind⁹, Thomas Puehler⁹, Cyril Serrick⁹, Frans Waanders⁹, Serdar Gunaydin⁹, Sunil Ohri⁹, Jan Gummert⁹, Gianni Angelini⁹, Volkmar Falk⁹ and Thierry Carrel⁹

**Recommendation**

| Class | MiECC systems reduce haemodilution and better preserve haematocrit as well as reduce postoperative bleeding and the need for RBC transfusion | A |
| Class | MiECC systems reduce the incidence of postoperative atrial fibrillation | A |
| Class | MiECC systems preserve renal function | A |
| Class | MiECC is associated with improved myocardial protection | A |
| Class IIA | Inflammatory response assessed by specific inflammatory markers is attenuated with use of MiECC | B |
| Class IIA | MiECC systems can reduce cerebral gaseous microembolism and preserve neurocognitive function | B |
| Class IIA | MiECC exerts a subclinical protective effect on end-organ function (lung, liver, intestine) which is related to enhanced recovery of microvascular organ perfusion | B |
| Class IIB | Within a MiECC strategy, less thrombin generation may permit reduced heparin dose targeted to shorter ACT times. When such a strategy is followed, individual heparin dose should be determined using heparin dose–response monitoring systems | B |
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Interactive CardioVascular and Thoracic Surgery (2016) 1–16
2017 EACTS/EACTA Guidelines on patient blood management for adult cardiac surgery

The Task Force on Patient Blood Management for Adult Cardiac Surgery of the European Association for Cardio-Thoracic Surgery (EACTS) and the European Association of Cardiothoracic Anaesthesiology (EACTA)

**PREOPERATIVE**
- Identification of patients at high risk of bleeding
  - Iron deficiency anaemia
  - Non-iron deficiency anaemia (e.g. vit D or folate deficiency)
  - Fibrinogen level testing
  - Platelet function testing in patients taking P2Y12 Inhibitors or DAPT

**INTRAOPERATIVE**
- Maintenance of haemostasis and minimizing blood loss
  - Meticulous surgical haemostasis
    - Minimizing haemodilution, e.g. by MIECC
    - E.g. MIECC, retro- or antegrade autologous priming
  - Individual heparin and protamine titration
  - Normothermia (>36°C) and normal pH (7.35-7.45)
  - Prevention of fibrinolysis
  - Tranexamic acid, aprotinin, EACA
  - Use of cell saver

**POSTOPERATIVE**
- Treatment of microvascular bleeding after CPB
  - Perioperative treatment algorithms for bleeding patients
  - Laboratory or point-of-care tests
  - Insufficient fibrinogen levels (<1.5 g/l) or low clot firmness
  - Fibrinogen concentrate
  - Coagulation factor deficiency (prolonged clotting times)
  - FFP or PCC
  - Low platelet count (<50*10^9/l) and/or antiplatelet therapy
  - Platelet transfusion or DDAVP
  - Anaemia
  - PRBC transfusion based on individual patient condition
### OVERALL MORTALITY

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>MECC Events</th>
<th>Control Events</th>
<th>Weight</th>
<th>Odds Ratio M-H, Random, 95% CI Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.12.1 CABG</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fromes 2002</td>
<td>0</td>
<td>0</td>
<td></td>
<td>Not estimable</td>
</tr>
<tr>
<td>Abdel-Rahman 2005</td>
<td>0</td>
<td>101</td>
<td>6.1%</td>
<td>0.34 [0.01, 8.36] 2005</td>
</tr>
<tr>
<td>Remadi 2006</td>
<td>3</td>
<td>200</td>
<td>30.1%</td>
<td>0.59 [0.14, 2.52] 2006</td>
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<tr>
<td>Beghi 2006</td>
<td>0</td>
<td>30</td>
<td></td>
<td>Not estimable</td>
</tr>
<tr>
<td>Skrabal 2007</td>
<td>0</td>
<td>30</td>
<td></td>
<td>Not estimable</td>
</tr>
<tr>
<td>Huybregts 2007</td>
<td>0</td>
<td>25</td>
<td></td>
<td>Not estimable</td>
</tr>
<tr>
<td>Ohata 2008</td>
<td>1</td>
<td>34</td>
<td>13.1%</td>
<td>0.36 [0.04, 3.19] 2008</td>
</tr>
<tr>
<td>Schottler 2008</td>
<td>0</td>
<td>30</td>
<td></td>
<td>Not estimable</td>
</tr>
<tr>
<td>Kofidis 2008</td>
<td>0</td>
<td>50</td>
<td>6.0%</td>
<td>0.19 [0.01, 4.94] 2008</td>
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<tr>
<td>Ovchina I 2009</td>
<td>0</td>
<td>144</td>
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<tr>
<td>Gunaydin 2009</td>
<td>1</td>
<td>20</td>
<td>10.2%</td>
<td>0.47 [0.04, 5.69] 2009</td>
</tr>
<tr>
<td>Sakwa 2009</td>
<td>0</td>
<td>102</td>
<td></td>
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</tr>
<tr>
<td>Camboni 2009</td>
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<td>52</td>
<td>7.0%</td>
<td>0.10 [0.01, 2.03] 2009</td>
</tr>
<tr>
<td>Bauer 2010</td>
<td>0</td>
<td>18</td>
<td></td>
<td>Not estimable</td>
</tr>
<tr>
<td>El-Essawi 2010</td>
<td>0</td>
<td>146</td>
<td>6.1%</td>
<td>0.33 [0.01, 8.14] 2010</td>
</tr>
<tr>
<td>Anastasiadis 2010</td>
<td>1</td>
<td>50</td>
<td>10.6%</td>
<td>0.48 [0.04, 5.47] 2010</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>1062</td>
<td>1058</td>
<td>89.4%</td>
<td>0.39 [0.17, 0.90]</td>
</tr>
<tr>
<td>Total events</td>
<td>6</td>
<td>20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 0.00; Chi² = 1.37, df = 7 (P = 0.99); I² = 0%
Test for overall effect: Z = 2.15 (P = 0.03)

### 1.12.2 AVR

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>MECC Events</th>
<th>Control Events</th>
<th>Weight</th>
<th>Odds Ratio M-H, Random, 95% CI Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remadi 2004</td>
<td>1</td>
<td>50</td>
<td>10.6%</td>
<td>0.49 [0.04, 5.58] 2004</td>
</tr>
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<td>Bical 2006</td>
<td>0</td>
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<tr>
<td>Castiglioni 2009</td>
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<td>60</td>
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<tr>
<td>Kutschka 2009</td>
<td>0</td>
<td>85</td>
<td></td>
<td>Not estimable</td>
</tr>
<tr>
<td>Subtotal (95% CI)</td>
<td>215</td>
<td>215</td>
<td>10.6%</td>
<td>0.49 [0.04, 5.58]</td>
</tr>
<tr>
<td>Total events</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Not applicable
Test for overall effect: Z = 0.57 (P = 0.57)

Total (95% CI) 1277 1273 100.0% 0.40 [0.18, 0.88]
Total events 7 22
Heterogeneity: Tau² = 0.00; Chi² = 4.10, df = 8 (P = 0.99); I² = 0%
Test for overall effect: Z = 2.23 (P = 0.02)
Test for subgroup differences: Chi² = 0.03, df = 1 (P = 0.86), I² = 0%
# OVERALL MORTALITY

## RCTs

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>MiECC</th>
<th>cCPB</th>
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</thead>
<tbody>
<tr>
<td>Fromes 2002</td>
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<td>30</td>
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<tr>
<td>Abdel-Rahman 2005</td>
<td>101</td>
<td>103</td>
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<tr>
<td>Remadi 2006</td>
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<td>200</td>
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<tr>
<td>Beghi 2006</td>
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<td>30</td>
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<tr>
<td>Skrabal 2007</td>
<td>30</td>
<td>30</td>
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<tr>
<td>Huybregts 2007</td>
<td>25</td>
<td>24</td>
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<tr>
<td>Ohata 2008</td>
<td>34</td>
<td>64</td>
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<tr>
<td>Schottler 2008</td>
<td>30</td>
<td>30</td>
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<tr>
<td>Kofidis 2008</td>
<td>50</td>
<td>30</td>
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<td>Ovcina I 2009</td>
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<td>144</td>
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<tr>
<td>Gunaydin 2009</td>
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<td>20</td>
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<tr>
<td>Sakwa 2009</td>
<td>102</td>
<td>97</td>
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<tr>
<td>Camboni 2009</td>
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<td>40</td>
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<tr>
<td>Bauer 2010</td>
<td>18</td>
<td>22</td>
</tr>
<tr>
<td>El-Essawi 2010</td>
<td>146</td>
<td>145</td>
</tr>
<tr>
<td>Anastasiadis 2010</td>
<td>50</td>
<td>49</td>
</tr>
</tbody>
</table>

**Total (95%)**

- **Total event**
  - **Heterogeneity**: $I^2 = 0.00; Q(10) = 8 (P = 0.99); I^2 = 0$
  - **Test for overall effect**: $Z = 2.23 (P = 0.02)$
  - **Test for subgroup differences**: $Q(10) = 1.33; df = 1 (P = 0.86), I^2 = 0$

---

<table>
<thead>
<tr>
<th>study</th>
<th>year</th>
<th>No pts</th>
<th>MiECC benefit</th>
<th>morbidity</th>
<th>mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benedetto et al.</td>
<td>2009</td>
<td>1051</td>
<td>transfusion</td>
<td></td>
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<tr>
<td>Biancari et al.</td>
<td>2009</td>
<td>1161</td>
<td>blood loss</td>
<td>stroke</td>
<td>±</td>
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<tr>
<td>Zagrillo et al.</td>
<td>2010</td>
<td>1619</td>
<td>transfusion</td>
<td>stroke</td>
<td>myocardial protection</td>
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<tr>
<td>Harling et al.</td>
<td>2011</td>
<td>2355</td>
<td>transfusion</td>
<td>blood loss</td>
<td>± stroke</td>
</tr>
<tr>
<td>Anastasiadis et al.</td>
<td>2013</td>
<td>2770</td>
<td>transfusion</td>
<td>blood loss</td>
<td>myocardial protection</td>
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<table>
<thead>
<tr>
<th>Metric</th>
<th>Ht</th>
<th>PLT</th>
<th>AKI</th>
<th>ICU stay</th>
<th>inotropic support</th>
<th>mech. ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ht</td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
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</tbody>
</table>

+ indicates significant benefit; - indicates no benefit.
<table>
<thead>
<tr>
<th>Publication</th>
<th>Year</th>
<th>n</th>
<th>Procedure</th>
<th>Groups</th>
<th>Significant differences</th>
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</thead>
<tbody>
<tr>
<td>Remadi et al.</td>
<td>2006</td>
<td>400</td>
<td>elective CABG</td>
<td>200 CPB 200 (MECC)</td>
<td>a), b), c), d), e)</td>
</tr>
<tr>
<td>Abdel Rahman et al.</td>
<td>2005</td>
<td>204</td>
<td>CABG</td>
<td>103 MPC 101 (CorX)</td>
<td>a), c), d), f)</td>
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<tr>
<td>Huybregts et al.</td>
<td>2007</td>
<td>49</td>
<td>elective CABG</td>
<td>24 MPC 25 (Syn. ECC.O)</td>
<td>a), c)</td>
</tr>
<tr>
<td>Fromes et al.</td>
<td>2002</td>
<td>60</td>
<td>CABG</td>
<td>30 MPC 30 (MECC)</td>
<td>a), e)</td>
</tr>
<tr>
<td>Beghi et al.</td>
<td>2006</td>
<td>60</td>
<td>elective CABG</td>
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<td>a), d)</td>
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<td>AVR and CABG</td>
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<td>a), f)</td>
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<td>El-Essawi et al.</td>
<td>2011</td>
<td>500</td>
<td>CABG and/or AVR</td>
<td>248 MPC 252 (ROCSafe)</td>
<td>a), b), d), e), f)</td>
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</tbody>
</table>

a) Blood transfusion, Hemodilution  
b) Neurological outcome, c) Renal impairment, d) Myocardial ischemia, e) Inflammatory parameters, f) Length of stay in intensive care unit, respirator time

CABG = coronary artery bypass grafting; AVR = Aortic Valve Replacement; MECC = minimal extracorporeal circulation circuits
CPB = cardiopulmonary bypass; MPC = minimized perfusion circuits
Syn. ECC.O, Sorin, Mirandola, Italy; ROCSafe, Terumo, Eschborn, Germany; MECC, Maquet, Rastatt, Germany.
Reduced 30-day mortality in men after elective coronary artery bypass surgery with minimized extracorporeal circulation—a propensity score analysis

Michael Ried, Reinhard Kobuch, Leopold Rupprecht, Andreas Keyser, Michael Hilker, Christof Schmid and Claudius Diez

<table>
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<tr>
<th>Comparison</th>
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<td>30-day mortality [%]</td>
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<td>ATT&lt;sup&gt;A&lt;/sup&gt;</td>
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<tr>
<td>CECC versus MECC</td>
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<tr>
<td>CECC (n = 2,020)</td>
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<tr>
<td>MECC (n = 1,119)</td>
<td>0.8</td>
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<td>Unadjusted mean difference</td>
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<td>p-value</td>
<td>&lt; 0.001</td>
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<tr>
<td>Adjusted mean difference after matching of 1,005 pairs (95% confidence interval)</td>
<td>-1.5 (-2.6 to -0.4)</td>
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<td>p-value</td>
<td>0.006</td>
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<tr>
<td>ATE&lt;sup&gt;B&lt;/sup&gt;</td>
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<tr>
<td>Adjusted mean difference with 95% bias corrected confidence interval</td>
<td>-1.9 (-2.9 to -1.0)&lt;sup&gt;C&lt;/sup&gt;</td>
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</table>

<sup>A</sup> - ATT Average treatment effect for the Treated
<sup>B</sup> - ATE Average treatment effect
<sup>C</sup> - The 95% confidence interval does not include a zero, or p < 0.05 for a two-tailed test
<sup>D</sup> - The 95% confidence interval does include a zero, or p > 0.05 for a two-tailed test
Safety and efficacy of miniaturized extracorporeal circulation when compared with off-pump and conventional coronary artery bypass grafting: evidence synthesis from a comprehensive Bayesian-framework network meta-analysis of 134 randomized controlled trials involving 22,778 patients

Mariusz Kowalewski, Wojciech Pawliszak, Giuseppe Maria Raffa, Pietro Giorgio Malvindi, Magdalena Ewa Kowalkowska, Katarzyna Zaborowska, Janusz Kowalewski, Giuseppe Tarelli, David Paul Taggart and Lech Anisimowicz

<table>
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<tr>
<th>Outcome</th>
<th>MECC</th>
<th>OPCAB</th>
<th>CECC</th>
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<tr>
<td>All-cause mortality</td>
<td>1.20 (0.55–2.48)</td>
<td>1.94 (1.25–2.75)</td>
<td>2.59 (2.10–3.16)</td>
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<td>Myocardial infarction</td>
<td>2.16 (0.54–7.27)</td>
<td>4.56 (3.18–6.42)</td>
<td>5.29 (4.59–6.05)</td>
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<tr>
<td>Cerebral stroke</td>
<td>0.65 (0.30–1.33)</td>
<td>0.92 (0.53–1.42)</td>
<td>1.24 (1.16–2.05)</td>
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<tr>
<td>Renal dysfunction</td>
<td>0.83 (0.40–1.64)</td>
<td>1.21 (0.76–1.76)</td>
<td>1.75 (1.35–2.21)</td>
</tr>
</tbody>
</table>
rationale
Four Years’ Experience With a Miniaturized Extracorporeal Circulation System and Its Influence on Clinical Outcome

*Christoph Wiesenack, †Andreas Liebold, ‡Alois Philipp, *Markus Ritzka, *Joachim Koppenberg, ‡Dietrich E. Birnbaum, and §Cornelius Keyl

MAP and flow rate during bypass

- cCPB
- MiECC

* $p < 0.05$

T1 = following cardioplegia
T2 = in the middle of bypass time
T3 = end of aortic cross clamping time
Evaluation of Hemodynamic and Regional Tissue Perfusion Effects of Minimized Extracorporeal Circulation (MECC®)

Adrian Bauer, ECCP, MCVT;* Claudius Diez, MD, PhD;† Jens Schubel, MD, PhD;‡ Nagi El-Shouki, MD, PhD;§ Dietrich Metz, MD;¶ T. Eberle, MD, PhD;§ Harald Hausmann, MD, PhD§

*Department of Cardiovascular Technology, MediClin Heart Centre Coswig, Sachsen Anhalt, Germany; †Department of Cardiothoracic and Vascular Surgery, University Hospital of Regensburg, Regensburg, Germany; ‡Department of Cardiovascular Surgery, MediClin Heart Centre Coswig, Sachsen Anhalt, Germany; and §Department of Cardio - Anesthesiology, MediClin Heart Centre Coswig, Sachsen Anhalt, Germany

MAP and norepinephrine consumption. Data are shown as mean ± SD (*p = .002; **p = .01; ***p = .015; ****p = .021). T1: preCPB; T2: after start of CPB; T3: after cardioplegia; T4: 15 minutes after cardioplegia; T5: after X-clamp opening; T6: before termination of CPB; T7: 15 minutes after CPB; T8: 1 hour after CPB; T9: 4 hours after CPB.
The effects of conventional extracorporeal circulation versus miniaturized extracorporeal circulation on microcirculation during cardiopulmonary bypass-assisted coronary artery bypass graft surgery

Koray Yuruk\textsuperscript{a,b}, Rick Bezemer\textsuperscript{a,*}, Mariska Euser\textsuperscript{a}, Dan M.J. Milstein\textsuperscript{a}, Hilde H.R. de Geus\textsuperscript{c}, Evert W. Scholten\textsuperscript{b}, Bas A.J.M. de Mol\textsuperscript{b} and Can Ince\textsuperscript{a}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{chart.png}
\end{figure}

CONCLUSIONS: The results from this relatively small study suggest that the use of the miniaturized extracorporeal circulation system is associated with a statistically significant (but clinically insignificant) reduction in haemodilution and microcirculatory hypoperfusion compared with the use of the conventional extracorporeal circulation system.

Comparing microvascular alterations during minimal extracorporeal circulation and conventional cardiopulmonary bypass in coronary artery bypass graft surgery: A prospective, randomized study

Peter Donndorf, MD, Franziska Kühn, MD, Brigitte Vollmar, MD, PhD, Jan Rösner, MD, PhD, Andreas Liebold, MD, PhD, Philipp Gierer, MD, PhD, Gustav Steinhoff, MD, PhD, and Alexander Kaminski, MD, PhD

Minimal extracorporeal circulation (MECC) has been introduced in coronary artery bypass graft surgery offering clinical benefits owing to reduced hemodilution and no blood-air interface. Yet, changes in the intraoperative microvascular perfusion in comparison with conventional extracorporeal circulation have not been studied so far.

We aimed to analyze alterations in microvascular perfusion at 4 predefined time points by using orthogonal polarization spectral imaging. Forty patients were randomly allocated to either MECC or CECC. Changes in functional capillary density (FCD), blood flow velocity, and pressure were analyzed by a blinded investigator.

Compared to conventional extracorporeal circulation (ECC) and aortic crossclamping (T2), both groups showed a significantly higher FCD in the MECC group (206.8 ± 33.6 cm/cm² in ECC and 235.3 cm/cm² in MECC group; P = .034). In the late phase of the ECC (T3), FCD was already recovered, whereas FCD in the CECC group was still significantly higher (216.6 cm/cm² in MECC group; P = .100 vs T1; 211.1 ± 36.9 cm/cm² in CECC group; P = .032 vs T3).

After termination of ECC (T4), FCD recovered in both groups to baseline. Blood flow velocity was found to be higher in the MECC group, with a significant intergroup difference after aortic crossclamping (T2).

Conclusions: Orthogonal polarization spectral imaging data reveal an impairment of microvascular perfusion during on-pump CABG. Changes in FCD indicate a faster recovery of the microvascular perfusion in MECC during the reperfusion period. Beneficial recovery of microvascular organ perfusion could partly explain the perioperative advantages reported for MECC.
Minimally Invasive Extracorporeal Circulation (MiECC): Towards a More Physiologic Perfusion

Kyriakos Anastasiadis, MD, FETCS
Polychronis Antonitsis, MD, DSc
Marco Ranucci, MD, FESC
John Murkin, MD, FRCPC

It is suggested that any benchmark surgery, in addition to being founded upon proven scientific principles, must bestow significant physiologic benefit to the patient. The authors believe that the goal of a “more physiologic” perfusion is mandatory in the modern era of cardiac surgery. Therefore, they advocate that MiECC should be integrated into the clinical practice guidelines and become the standard technique in cardiac surgery.
prerequisites
MiECC

DECISIVE TEAM

- skilful perfusionist
- meticulous surgeon
- bright anesthesiologist

- real teamwork
- stepwise training
- strategy
training

Cardiothoracic Department
AHEPA University Hospital
Thessaloniki, Greece
February 16th-17th 2016

Minimal Invasive Extracorporeal Technologies
MiECT Advanced Course
Medtronic European Experience Center, Kerkrade, The Netherlands
Quantification of Operational Learning in Minimal Invasive Extracorporeal Circulation

Kyriakos Anastasiadis, Polychronis Antonitsis, Christos Asteriou, Helena Argiriadou, Apostolos Deliopoulos, Dimitrios Konstantinou, Vassilios Grosomanidis, and Paschalis Tossios

optimal results are obtained with 50 cases
A multidisciplinary perioperative strategy for attaining “more physiologic” cardiac surgery

Kyriakos Anastasiadis, Polychronis Antonitsis, Apostolos Deliopoulos and Helena Argiriadou

Abstract

Background: Cardiac surgery is, by definition, a “non-physiologic” intervention associated with systemic adverse effects. Despite advances in surgical technique, cardiopulmonary bypass (CPB) technology as well as anaesthesia management and patient care, there is still significant morbidity and subsequent mortality.

Aim: We consider that the contemporary demand for further improving patient outcome mandates the upgrade from optimal perfusion during the procedure as the gold standard to the concept of a “more physiologic” cardiac surgery. Our policy is a multidisciplinary perioperative strategy based on goal-directed perfusion throughout surgery incorporating in-line monitoring. This translates to “prevent rather than correct” malperfusion through real-time adjustment rather than correction of derangement detected late by incremental evaluation.

Method: The strategy is based on continuous monitoring of cardiac index, SvO$_2$, DO$_2$, DO$_2$/VO$_2$, and rSO$_2$. Data acquisition is followed by action when needed; this includes stepwise: transfusion, increase of cardiac output and initiation of inotropic/vasoactive support. Moreover, implementation of minimally invasive extracorporeal circulation (MiECC) is considered as a fundamental component of physiologic perfusion when on-CPB, providing improved circulatory support and end-organ protection.

Conclusion: We consider that, with this strategy which establishes optimal perfusion perioperatively, we attain the goal of a “more physiologic” cardiac surgery.
Perioperative Strategy: **Goal-directed Cardiac Surgery** using in line monitoring

towards more physiologic perfusion...

... real-time monitoring / adjustment + MiECC + teamwork
NIRS monitoring GDP
physiologic perfusion during CPB

- Ht: stable
- Pressure & flow: adequate
- DO$_2$i & DO$_2$i/VCO$_2$i: optimal
- Lac & urine output: normal
- Central organs: happy
- O$_2$ER: checked
- rSO$_2$
Traditional Monitoring

- Hct
- Platelet count
- PT, aPTT
- Fibrinogen
- ACT

Contemporary Monitoring

- technology

Coagulation
Heparin – Protamine Management
<table>
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<th>pre-CPB</th>
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<td>SvO\textsubscript{2}</td>
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<tr>
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<tr>
<td>Lac</td>
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<td>urine output</td>
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</table>

**action**

1. Ht
2. CO
3. drugs
MiECTiS advocates this strategy to obtain the maximal benefits from this technology.
MiECC: The Learning Curve

- **Phase 1**: Training
- **Phase 2**: CABG
- **Phase 3**: AVR
- **Phase 4**: TVR
- **Phase 5**: Ao arch

- **MiECC**
- **Type II**
- **Type III**
- **Type IV**

- Modular

Multidisciplinary teamwork

> 50 cases
why change ?
Use of minimal extracorporeal circulation improves outcome after heart surgery; a systematic review and meta-analysis of randomized controlled trials

Kyriakos Anastasiadis a, Polychronis Antonitsis a, Anna-Bettina Haidich b, Helena Argiriadou a, Apostolos Deliopoulos a, Christos Papakonstantinou a

<table>
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</table>

1387 1383 patients

Conclusions: Use of MECC in heart surgery resulted in improved short-term outcome as reflected by reduced mortality and morbidity compared with conventional extracorporeal circulation.

- mortality
- Ht
- PLT
- blood loss
- transfusion
- PMI
- myocardial protection
- inotropic support
- ARF
- arrhythmias
- mechanical ventilation
- ICU stay

Modular minimally invasive extracorporeal circulation systems; can they become the standard practice for performing cardiac surgery?

K Anastasiadis, P Antonitsis, H Argiriadou, A Deliopoulos, V Grosomanidis and P Tossios

Our philosophy is that the MiECC represents a “state-of-the-art” technique and our strategy is to use the modular configuration in all cardiac surgical procedures.

Dures. As indicated in our study, the modular AHEPA circuit design offers a 100% technical success rate in a cohort of random high-risk patients who underwent complex procedures, including reoperations and valve and aortic surgery, together with emergency cases.
Enhanced Recovery After Elective Coronary Revascularization Surgery With Minimal Versus Conventional Extracorporeal Circulation: A Prospective Randomized Study

Kyriakos Anastasiadis, MD, FETCS, Christos Asteriou, MD, Polychronis Anagnostou, MD, Helena Argiriadou, MD, Vassilios Grosomanidis, MD, Magdalena Kyparissi, MD, Nikolaos Deliopoulos, ECCP, Dimitrios Konstantinou, MD, and Petros Tossios, MD

Objective: A minimal extracorporeal circulation (MECC) circuit integrates the advances in cardiopulmonary bypass (CPB) technology into a single circuit and is associated with improved short-term outcome. The aim of this study was to prospectively evaluate MECC compared with conventional CPB in facilitating fast-track recovery after elective coronary revascularization procedures.

Design: Prospective randomized study

Setting: All patients scheduled for elective coronary artery surgery were evaluated, excluding those considered particularly high risk for failure. The fast-track protocol included careful preoperative patient selection, a fast-track anesthetic technique based on minimal administration of fentanyl, surgery at normothermia, early postoperative extubation in the cardiac recovery unit, and admission to the cardiothoracic ward within the first 24 hours postoperatively.

Participants: One hundred twenty patients were assigned randomly into 2 groups (60 in each group).

Interventions: Group A included patients who were operated on using the MECC circuit, whereas patients in Group B underwent surgery on conventional CPB.

Measurements and Main Results: Incidence of fast-track recovery was significantly higher in patients undergoing MECC (25% vs 6.7%, p = 0.006). MECC was also recognized as a strong independent predictor of early recovery, with an odds ratio of 3.8 (p = 0.011). Duration of mechanical ventilation and cardiac recovery unit stay were significantly lower in patients undergoing MECC together with the need for blood transfusion, duration of inotropic support, need for an intra-aortic balloon pump, and development of postoperative atrial fibrillation and renal failure.

Conclusions: MECC promotes successful early recovery after elective coronary revascularization procedures, even in a nondedicated cardiac intensive care unit setting.

KEY WORDS: coronary artery bypass grafting, minimal extracorporeal circulation, fast-track, cardiopulmonary bypass

Minimised versus conventional cardiopulmonary bypass: outcome of high-risk patients

Assad Haneya a, *, Alois Philipp a, Christof Schmid a, Claudius Diez a, Reinhard Kobuch a, Stephan Hirt a, Wolfgang Zink b, Thomas Puehler a

a Department of Cardiothoracic Surgery, University Medical Center Regensburg, Franz-Josef-Strauss-Allee 11, D-93053 Regensburg, Germany
b Department of Anesthesiology, University Medical Center Regensburg, Franz-Josef-Strauss-Allee 11, D-93053 Regensburg, Germany

Received 13 November 2008; received in revised form 15 April 2009; accepted 25 May 2009; Available online 19 August 2009

EJCTS 2009;36:844-848.

Abstract

Background: Coronary artery bypass grafting (CABG) with extracorporeal circulation (ECC) is the gold standard for surgical coronary revascularisation. Recently, minimised extracorporeal circulation system (MECC) has been postulated as a safe and advantageous alternative for multi-vessel CABG. Method: Between January 2004 and December 2007, 244 high-risk patients (logistic EuroScore (ES) > 10%) underwent CABG in our institution. ECC was used in 139 (57%) and MECC in 105 (43%) patients. Demographic data including age (MECC: 73.4 ± 7.4 years; ECC: 73.3 ± 6.4 years), ES (MECC: 19.2 ± 9.8%; ECC: 21.4 ± 11.9%), left-ventricular ejection fraction (MECC: 45.6 ± 16.1%; ECC: 43.1 ± 15.3%), diabetes mellitus (MECC: 14.3%; ECC: 15.1%) and COPD (MECC: 6.7%; ECC: 7.9%) did not differ between the two groups. Preoperative end-stage renal failure was an exclusion criterion. The clinical course and serological/haematological parameters in the ECC and MECC patients were compared in a retrospective manner. Results: Although the numbers of distal anastomoses did not differ between the two groups (MECC: 3.0 ± 0.9; ECC: 2.9 ± 0.9), ECC time was significantly shorter in the MECC group (MECC: 96 ± 33 min; ECC: 120 ± 50 min, p < 0.01). Creatinine kinase (CK) levels were significantly lower 6 h after surgery in the MECC group (MECC: 681 ± 1505 U l⁻¹; ECC: 1086 ± 1338 U l⁻¹, p < 0.05) and the need of red blood cell transfusion was significantly less after MECC surgery (MECC: 3 [range: 1–6]; ECC: 5 [range: 2–9] p < 0.05). Moreover, 30-day mortality was significantly lower in the MECC group as compared to the ECC group (MECC: 12.4%; ECC: 26.6, p < 0.01). Discussion: MECC is a safe alternative for CABG surgery. A lower 30-day mortality, lower transfusion requirements and less renal and myocardial damage encourage the use of MECC systems, especially in high-risk patients.

Discussion: MECC is a safe alternative for CABG surgery. A lower 30-day mortality, lower transfusion requirements and less renal and myocardial damage encourage the use of MECC systems, especially in high-risk patients.
Minimal extracorporeal circulation reduces the incidence of postoperative major adverse events after elective coronary artery bypass grafting in high-risk patients. A single-institutional prospective randomized study

C Asteriou, P Antonitsis, H Argiriadou, A Deliopoulos, D Konstantinou, C Foroulis, C Papakonstantinou and K Anastasiadis

Abstract
Coronary artery bypass grafting (CABG) using minimal extracorporeal circulation (MECC) has been associated with an improved short-term clinical outcome compared to conventional extracorporeal circulation (CECC). The aim of this study was to evaluate the impact of MECC compared to CECC on postoperative major adverse events in high-risk patients undergoing elective coronary revascularization procedures. Two hundred patients undergoing elective CABG were randomized into two groups. In Group A (n=100), MECC was used while Group B (n=100) included patients who were operated on CECC. The incidence of postoperative major adverse events (myocardial infarction, renal failure, stroke, death) was the primary end-point of the study. MECC was associated with a 77% relative risk reduction in the incidence of major adverse events compared to CECC (p=0.004). The rate of major adverse events occurring in the high-risk patient subgroup (preoperative left ventricular ejection fraction ≤40%, age >65 years, EuroSCORE II >5) operated on with MECC was significantly lower in comparison to their CECC counterparts. Based on our results, cardiac centres

✓ **MiECC = 77% ↓ relative risk in the incidence of major adverse events compared to cCPB (p=0.004).**

✓ **The rate of major adverse events occurred in high-risk patients with MECC preop. LVEF ≤ 40%, age > 65 yrs, EuroSCORE II > 5** favours MiECC.
Minimally Invasive Versus Conventional Extracorporeal Circulation in Minimally Invasive Cardiac Valve Surgery

Hardy Baumbach¹, Christian Rustenbach¹, Jens Michaelsen¹, Gernot Hipp¹, Markus Pressmar¹, Marco Leinweber¹, Ulrich Friedrich Wilhelm Franke¹


<table>
<thead>
<tr>
<th>Postoperative data</th>
<th>CECC (N = 63)</th>
<th>MECC (N = 105)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality, n (%)</td>
<td>1 (1.6)</td>
<td>1 (1.0)</td>
<td>0.688</td>
</tr>
<tr>
<td>Ventilation (h), mean ± SD</td>
<td>9.5 ± 15.1</td>
<td>6.3 ± 3.4</td>
<td>0.054</td>
</tr>
<tr>
<td>ICU stay (d), mean ± SD</td>
<td>1.8 ± 1.3</td>
<td>1.2 ± 1.0</td>
<td>0.005</td>
</tr>
<tr>
<td>Hospital stay (d), mean ± SD</td>
<td>9.5 ± 4.8</td>
<td>8.3 ± 3.6</td>
<td>0.131</td>
</tr>
<tr>
<td>Resuscitation, n (%)</td>
<td>0 (0)</td>
<td>1 (1.0)</td>
<td>0.448</td>
</tr>
<tr>
<td>Rethoracotomy, n (%)</td>
<td>1 (1.6)</td>
<td>1 (1.0)</td>
<td>0.688</td>
</tr>
<tr>
<td>TIA/apoplexy, n (%)</td>
<td>3 (4.7)</td>
<td>4 (3.8)</td>
<td>0.645</td>
</tr>
<tr>
<td>Post-op delirium, n (%)</td>
<td>18 (28.6)</td>
<td>10 (9.5)</td>
<td>0.002</td>
</tr>
<tr>
<td>PRBC, n/patient, mean ± SD</td>
<td>1.1 ± 1.5</td>
<td>0.6 ± 1.3</td>
<td>0.001</td>
</tr>
<tr>
<td>PRBC recipients, n (%)</td>
<td>24 (38)</td>
<td>21 (20)</td>
<td>0.001</td>
</tr>
<tr>
<td>hs-TnT, 1 h postoperative (ng/L), mean ± SD</td>
<td>678.9 ± 918.4</td>
<td>706.4 ± 329.0</td>
<td>0.836</td>
</tr>
</tbody>
</table>

In summary, the MECC circulation in minimally invasive cardiac valve surgery can be used as successfully as the conventional ECC. The use of MECC in minimal access valve procedures provides a decreased inflammatory response, less hemodilution, less platelet consumption, and a lower incidence of postoperative blood transfusion. These differences led to a shorter postoperative ventilation time and a shortened ICU stay.
MICS – MiECC: Can’t have one without the other

Kyriakos Anastasiadis and Polychronis Antonitsis

The Minimal invasive Extracorporeal Technologies International Society (MiECTiS) advocates this MiECC strategy in order to obtain the maximal benefits from this technology. The authors believe that MiECC should be considered as an indispensable tool in the field of minimal invasiveness.

By all means, “it takes two to tango”. Integration of MiECC to MICS could transform it from limited access surgery, largely dependent on careful patient selection based on anatomic factors, to a more “physiologically-based” surgery; this could maximize clinical benefits from MICS and further improve patient outcomes.
unclear if the use of MiECC may allow lower than traditional cardiac index without end-organ damage

- heparin requirements / ACT targets
- use of antifibrinolytics and POC coagulation management
- fast-track algorithms
- redesign components
Minimally invasive extracorporeal circulation improves quality of life after coronary artery bypass grafting

Kyriakos Anastasiadis, Polychronis Antonitsis*, Georgia Kostarellou, Athanassios Kleontas, Apostolos Deliopoulos, Vassilios Grosomanidis and Helena Argiriadou
Coronary artery bypass grafting with minimal versus conventional extracorporeal circulation; an economic analysis

K. Anastasiadis, V. Fragoulakis, P. Antonitsis, N. Maniadakis

Incremental Effect: Life-years and Cost (MiECC vs. cCPB)

Greece

Difference in Life Years
- Simulation
- Bivariate_Normal_95%

Difference in Cost (€)
-0.1 -0.05 0 0.05 0.1 0.15 0.2

Switzerland

Difference in Life Years
- Simulation
- Bivariate_Normal_95%

Difference in Cost (€)
-0.1 -0.05 0 0.05 0.1 0.15 0.2

Germany

Difference in Life Years
- Simulation
- Bivariate_Normal_95%

Difference in Cost (€)
-0.1 -0.05 0 0.05 0.1 0.15 0.2

The Netherlands

Difference in Life Years
- Simulation
- Bivariate_Normal_95%

Difference in Cost (€)
-0.1 -0.05 0 0.05 0.1 0.15 0.2
QALYs: where is MiECC relative to conventional CPB?

$c_{CPB}$

MiECC

Maniadakis N, Anastasiadis K, et al; 2018
perspective
MiECC – the AHEPA concept

type IV
AHEPA circuit

... modularity
<table>
<thead>
<tr>
<th>Feature</th>
<th>Braunschweig</th>
<th>Thessaloniki</th>
<th>Regensburg</th>
<th>Bern</th>
<th>Coswig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced Anticoagulation (ACT&lt;350 sec)</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Surface coating</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Centrifugal pumps</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Cellsaver (masklood separation)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Venous deairing (Venous bubble trap)</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Modular systems (outclamped or ready recevier)</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Priming (amount ml)</td>
<td>850 &amp; 500FX</td>
<td>650</td>
<td>650</td>
<td>680</td>
<td>850</td>
</tr>
<tr>
<td>Open heart surgery (Valve surgery any cases)</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Emergency patients (use for pat. in cardiogenic shock)</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>
The need for conversion from closed to open circuit in the modular (type IV) MiECC systems

Polychronis Antonitsis, Apostolos Deliopoulos, Helena Argiriadou, Kyriakos Anastasiadis

Cardiothoracic Department, AHEPA University Hospital, Thessaloniki, Greece

200 consecutive patients (all-comers: emergency or elective)

- CABG - 50%
- AVR1 - 7%
- complex cases - 33%
- reoperations - 4.5%
- emergency Ao dissection - 2.5%
- frozen elephant trunk – 0.5%

100% technical success rate using the MiECC system

- mean CPB time: 98±33 min
- cross-clamp time: 67±27 min

need for open CPB circuit - 6% (12/200 pts)

considering that modular configuration is indispensable in Ao dissection and arch procedures during the circulatory arrest period

ture conversion rate - 3% (6/194 procedures)

- mean absolute duration of the open configuration: 31.7±28.9 min
  25±17% of total CPB time
- cause for conversion to open circuit: massive air entrainment - 67%
  massive bleeding / inadequate venous return - 33%
MiECC – AHEPA system

- PA vent
- hard-shell reservoir
- VARD oxygenator
- arterial line
- venous line
- baby babble trap
- Ringer’s
- > -70 mmHg
- -200 mmHg
- blood collection sterile reservoir
- Ao root vent (PV vent)
- one-way valve
- cardioplegia
- roller pump
- > -70 mmHg
- to cell-saver process
- cell-saver line (from patient)
- one-way valve
- 180-260 mmHg
- oxygenator
- pump
- one-way valve
- soft bag
- hard-shell reservoir
- one-way valve
MiECC Safety Review

- # of records identified through database searching:
  - Pubmed: 4446 (until 12/2017)
  - Cochrane Library: 30395 (until 12/2017)

- # of additional records identified through other sources:
  - MiECT congress (1st-2nd): 36
  - ESCVS congress (53rd-60th): 15
  - EACTS congress (20th-28th): 18
  - STS congress (50th-53rd): 1

# of records after duplicates removed: 5053

# of records screened: 5053

# of records excluded: 5014

- # of full-text articles assessed for eligibility: 39
- # of full-text articles excluded, with reasons: 27
  - Overlapping articles: 19
  - Outcome of interest not reported: 8

# of studies included in qualitative synthesis: 12

AHEPA University Hospital
Miniaturized Cardiopulmonary Bypass in Coronary Artery Bypass Surgery: Marginal Impact on Inflammation and Coagulation but Loss of Safety Margins

Georg Nollert, MD, Ina Schwabenland, MD, Deniz Maktav, MD, Felix Kur, MD, Frank Christ, MD, Peter Fraunberger, MD, Bruno Reichart, MD, and Calin Vicol, MD

Clinics of Cardiac Surgery, Anesthesiology, and Clinical Chemistry, University of Munich, Munich, Germany

Purpose. Inflammation and coagulation disturbances are common consequences of cardiopulmonary bypass (CPB). Recently, miniaturized closed CPB circuits without cardiotomy suction and venous reservoir have been proposed to reduce complication rates. We compared outcomes with conventional (CCPB) and miniaturized cardiopulmonary bypass (MCPB) after coronary artery bypass operations (CABG) with respect to inflammation and coagulation.

Description. Thirty patients (23% female; aged 67.9 ± 9.0 years) were prospectively randomly assigned to undergo isolated CABG with CCPB or MCPB. Conventional CPB had a pump prime of 1,600 mL. Miniaturized CPB consisted of a centrifugal pump, arterial filter, heparinized tubing, and oxygenator with a priming volume of 800 mL. Shed blood was removed by a cell-saving device and reinfused. Measurements included interleukin (IL)-2 receptor, IL-6, IL-10, tumor necrosis factor receptor 55 and 75, C-reactive protein, leukocyte differentiation, d-dimers, fibrinogen, and thrombocytes at six time points.

Evaluation. In both groups no major complication occurred. However, two dangerous air leaks occurred in the closed MCPB circuit, demonstrating the narrow safety margins. Operative handling was also more difficult owing to limitations in venting and fluid management. International normalized ratio (INR = 0.83) and antithrombin III (ANT = 0.04) levels were elevated during CPB in the CCPB group, most likely owing to differences of the intraoperative anticoagulation management. Repeated measures analysis revealed that not a single parameter of inflammation or clinical outcome showed significant differences among groups.

Conclusions. Use of a MCPB affected inflammation and coagulation variables only marginally and did not lead to clinical relevant changes as assessed by blood loss, need for blood products, and intensive care unit and clinical stays. However, safety margins for volume loss, air emboli, and weaning from CPB decrease, because of the closed MCPB circuit.

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THE IMPORTANCE OF SIZE: WHEN A ‘MINI’ BECOMES A ‘MAXI’

When dealing with issues of dimension we often use extremes to emphasize the point. Evolution has transcended four billion years which makes those extra minutes spent in traffic seem rather inconsequential in the time continuum, yet monumental in the daily scheme of things. Such is the case with perfusion as well.

The development of devices used in the cardiopulmonary bypass circuit is based upon two main tenets: **mechanical efficiency and clinical safety**. Mechanical efficiency is dependent upon numerous variables including the synthetic materials utilized, and the geometrical design of the device. These in turn control the physical movement of fluid through the device, which effects overall performance. Clinical safety issues are likewise a factor of the synthetic materials utilized as well as operating within the operational constraints of the device. During the last several decades a tremendous amount of effort was directed at reducing the overall size of perfusion equipment with the hope of reducing surface area exposure to circulating blood. This had the desirable effect of reducing patient inflammatory response to extracorporeal flow, and lowering dependency upon allogeneic blood products. Despite the interest in such a plausible quest, safe adult cardiopulmonary bypass circuits still require between 1200 and 1800 milliliters of prime solution, while pediatric circuits range from 250 to 1000 milliliters.

Sincerely,

Alfred H. Stammers, MSA, CCP

Editor
THE IMPORTANCE OF SIZE: WHEN A ‘MINI’ BECOMES A ‘MAXI’

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The development of devices used in the cardiopulmonary bypass tenets: mechanical efficiency and clinical safety. Mechanical efficiency is associated with numerous variables including the synthetic materials utilized, design, and new device. These in turn control the physical movement of fluid that is required for overall performance. Clinical safety issues are likewise a factor in the system’s design, as well as operating within the operational constraints of the patient. Over the last few decades a tremendous amount of effort was directed at reducing the number of equipment with the hope of reducing surface area exposure to the patient. The desirable effect of reducing patient inflammatory response to extracorporeal flow, and lowering dependency upon allogeneic blood products. Despite the interest in such a plausible quest, safe adult cardiopulmonary bypass circuits still require between 1200 and 1800 milliliters of prime solution, while pediatric circuits range from 250 to 1000 milliliters.

Sincerely,
Alfred H. Stammers, MSA, CCP
Editor

modular MiECC systems:
- air-handling
- volume management
- blood management

* create a “safety-net”
* enable surgery to all case-mix
AIM:
- to test the hypothesis that MiECC is **effective** and **cost-effective** compared to CECC for most cardiac surgery operations using ECC

Objectives:
I. To estimate the difference (CECC-MiECC) in the **% of participants having the primary, composite outcome** at 30 days post-op.
II. To estimate differences (CECC-MiECC) in **secondary outcomes**:
III. To estimate the **cost-effectiveness** of MiECC versus CECC.
All patients having CABG, AVR or CABG+AVR surgery using extra-corporeal circulation without circulatory arrest

Eligible patients providing written informed consent

Randomise prior to surgery

**CECC**
Conventional extra-corporeal circulation
(n=1,750)

30 day/60-90 day follow up

**MiECC**
Type II or III MiECC system
(n=1,750)

30 day/60-90 day follow up

---

**Target sample size:**
- 3,500

**Target difference:**
- Risk ratio
  - ≈ 0.75
- Outcome % CECC
  - ≈ 15% to 18%
- Risk difference
  - ≈ 3.25% to 4%
**Outcome**

**PRIMARY:**
- **Composite of 12 post-op serious adverse events:**
  - Death
  - MI; serum troponin and ECG (adjudicated)
  - Reintubation
  - Tracheostomy
  - Gut infarction (laparotomy or post mortem report)
  - Mechanical ventilation >48 hrs, incl. multiple episodes
  - Stage 3 AKI (AKI Network)
  - Stroke (CT or MRI), with new focal/generalised deficit
  - Reoperation
  - PCI
  - Sternal wound infection with dehiscence
  - Septicaemia confirmed by microbiology

**SECONDARY:**
- Blood products transfused; cardiac ICU & hospital stay; other serious adverse events; resource use; generic QoL
<table>
<thead>
<tr>
<th>Participating Centres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thessaloniki</td>
</tr>
<tr>
<td>Greece</td>
</tr>
<tr>
<td>Coswig</td>
</tr>
<tr>
<td>Germany</td>
</tr>
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<td>Ulm</td>
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<td>Italy</td>
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<td>London</td>
</tr>
<tr>
<td>Canada</td>
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</tr>
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<td></td>
</tr>
</tbody>
</table>
conclusions
Clinical Experience With the Mini-Extracorporeal Circulation System: An Evolution or a Revolution?

Jean-Paul Remadi, MD, Paul Marticho, MD, Irina Butoi, MD, Zava Rakotoarivelo, MD, Faouzi Trojette, MD, Amar Benamar, MD, Sadek Beloucif, MD, Dominique Foure, MD, and Henri J. Poulain, MD

Cardiovascular Surgery Unit, Anesthesiology Department, South Hospital, Amiens, France

**Purpose.** We studied a cohort of 150 patients operated on with a new cardiopulmonary bypass (CPB) system. This is the mini-extracorporeal circulation (MECC) system.

**Description.** The MECC is a fully heparin coated closed-loop CPB system that includes a centrifugal pump and has a priming volume of 450 mL. Between March 2001 and September 2002, 150 consecutive patients were operated on using the mini-CPB (MECC) method. This includes 105 coronary artery bypass graft and 45 aortic valve replacement patients. The median age was 66.7 ± 10.7 years with a gender ratio of 3.27 males to 1 female.

**Evaluation.** The 30-day operative mortality was 1.3%. The hemoglobin concentration was stable and perioperative transfusion was needed in only 6% of all patients. The renal and neuropsychiatric complications were less than 1%.

**Conclusions.** In our experience, the MECC system is a reliable new concept for CPB with good clinical results.

Minimal invasive Extra-Corporeal Circulation (MiECC): a revolutionary evolution in perfusion

Kyriakos Anastasiadis⁴, Adrian Bauer⁵, Polychronis Antonitsis⁴, Erich Gygax⁵, Jan Schaarschmidt⁵,* and Thierry Carrel⁵

Stable and perioperative transfusion was needed in only 6% of all patients. The renal and neuropsychiatric complications were less than 1%.

Conclusions. In our experience, the MECC system is a reliable new concept for CPB with good clinical results.

MiECC – the AHEPA concept

CANT ADULTS LEARN?
MiECC – the AHEPA concept

... should !!!
MiECC – the AHEPA concept

“It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change”
- Charles Darwin

1953

... should !!!
2017 EACTS/EACTA Guidelines on patient blood management for adult cardiac surgery

The Task Force on Patient Blood Management for Adult Cardiac Surgery of the European Association for Cardio-Thoracic Surgery (EACTS) and the European Association of Cardiothoracic Anaesthesiology (EACTA)

**PREOPERATIVE**
- Identification of patients at high risk of bleeding
  - Iron deficiency anaemia
  - Non-Iron deficiency anaemia (e.g. vit D or folate deficiency)
  - Fibrinogen level testing
  - Platelet function testing in patients taking P2Y12 Inhibitors or DAPT
  - Oral or I.V. iron to improve erythropoiesis
  - EPO +/- iron

**INTRAOPERATIVE**
- Maintenance of haemostasis and minimizing blood loss
  - Meticulous surgical haemostasis
  - Minimizing haemodilution, e.g. by MIECC
  - Individual heparin and protamine titration
  - Normothermia (>36°C) and normal pH (7.35–7.45)
  - Prevention of fibrinolysis
  - Use of cell saver

**POSTOPERATIVE**
- Treatment of microvascular bleeding after CPB
  - Perioperative treatment algorithms for bleeding patients
  - Insufficient fibrinogen levels (<1.5 g/l) or low clot firmness
  - Coagulation factor deficiency (prolonged clotting times)
  - Low platelet count (<50 x 10^9/l) and/or antiplatelet therapy
  - Anaemia

E.g. MIECC, retro-or antegrade autologous priming
ACT, heparin or FVIII measurements
Patient warming, maintenance of tissue perfusion
Tranexamic acid, aprotinin, EACA
Laboratory or point-of-care tests
Fibrinogen concentrate
FFP or PCC
Platelet transfusion or DDAVP
PRBC transfusion based on individual patient condition
MiECC is associated with improved end-organ protection and SIRS, which translates into improved clinical outcome.

Reported benefits include:
- ↓ haemodilution
- ↓ mediastinal bleeding
- ↓ need for blood transfusion
- ↑ myocardial protection
- ↓ length of ICU stay

This results in ↓ morbidity, ↓ mortality, and improved circulatory support, renal, cerebral, and lung function.
real world

onset of CPB

CABG / cCPB

CABG / off-pump

CABG / MiECC

onset of CPB
We believe that the goal of a “more physiologic” perfusion is mandatory in the modern era of cardiac surgery.

Therefore, we advocate that MiECC should be integrated in the clinical practice guidelines and become the standard technique in cardiac surgery.
Minimally invasive ExtraCorporeal Circulation

- embrace technology
- employ physiology
- work as a team
- use strategy
- apply modularity
1st International Symposium on Minimal Invasive Extracorporeal Circulation Technologies
June 13th-14th 2014
Thessaloniki, Greece
3rd MiECT Symposium
of the Minimal Invasive Extra Corporeal Technologies International Society

BERN
BERN | SWITZERLAND | 22 – 23 JUNE 2018

INNOVATION AND FUTURE

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- Multidisciplinary
- Teamwork
- Technology
- Physiologic
- Strategy

Scientific Societies
- Surgeons
- Anesthesiologists
- Perfusionists

surgery should not be just stitching!

scientists

industry

results

research

patients

innovation

advancement of patient care