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CPB AND AORTIC SURGERY

The State of the Art

From a Theoretical to a Practical Approach
INTRODUCTION

- Prevention

Michel JB, et al.  
*Novel aspects of the pathogenesis of aneurysms on the abdominal aorta in humans.*  
Golledge J, Norman PE,

- Medical treatment

*Current status of medical management for abdominal aortic aneurysm.*  

- Endovascular aortic repair

Nienaber CA, et al.  
*Randomized comparison of strategies for type B aortic dissection: the INvestigation of STEnt Grafts in Aortic Dissection (INSTEAD) trial.*  

Hao Z, et al.  
*Endovascular stent-graft placement or open surgery for the treatment of acute type B aortic dissection: a meta-analysis.*  
AIM OF THE TOPIC
CPB for aortic surgery: state of the art

- Knowledge
- Anatomical and pathophysiologica pre-requests
- Flexibility
- Equipment

M-G LAGNY, F. BLAFFART, ECCP CHU de Liège
Ascending aortic surgery and arterial cannulation:

Surgical repairment

- Ascending aorta
- Left subclavian/axillary
- Femoral
- Other
The arterial cannulation

<table>
<thead>
<tr>
<th>Cannulation site</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Femoral artery</td>
<td>Ease of access</td>
<td>Retrograde flow</td>
</tr>
<tr>
<td></td>
<td>Size</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adequate flow rates</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Proximal embolization</td>
</tr>
<tr>
<td>Axillary/subclavian</td>
<td>Reports of reduced mortality and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>stenosis and severity/twisting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brachial plexus injury</td>
<td></td>
</tr>
<tr>
<td>Aortic cannulation</td>
<td>Speed of cannulation</td>
<td></td>
</tr>
<tr>
<td>Ventricular apex</td>
<td>Adequacy of flow</td>
<td></td>
</tr>
<tr>
<td>Direct</td>
<td>Antegrade flow</td>
<td>Ventricular injury</td>
</tr>
<tr>
<td></td>
<td>Direct cannulation of true lumen</td>
<td></td>
</tr>
</tbody>
</table>

**Malperfusion**

**Arm numbness**

**Embolic event**

**eTable 3:** The potential advantages and disadvantages of the different cannulation sites utilized in acute type A aortic dissection

**Bonser RS, et al.**

*Acute Aortic Dissection. JAAC Vol. 58, No. 24, 2011.*
Arterial cannulation complication and perfusion: local dissection

- Pressure monitoring

SWITCH TO ANOTHER CANNULATION SITE

Anticipation: Y Line
Arterial cannulation complication and perfusion: malperfusion (FLAP)

- Sudden increase of arterial line pressure
- Inequate cerebral perfusion?: NIRS, TCD
- Inadequate spinal cord perfusion (MEP)
- Late diagnostic (lactates)
- Left radial pressure

Pre and post arch arterial lines (+ left femoral)
Switch to another cannulation site
RE-INSTORE ANTEGRADE FLOW

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Arterial femoral cannulation complication and perfusion: false lumen

- Pressure monitoring
- Transesophageal echocardiography (TOE)
- Arterial pressure (left radial)

CHECK THE CANNULATION
Switch to another cannulation site
Arterial cannulation complication and perfusion: embolic event

- Doppler
- Specific cannula

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**Table I. Preoperative Patient Characteristics (n=15 Patients)**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years), mean ± SD</td>
<td>71.6 ± 11.5</td>
</tr>
<tr>
<td>Range</td>
<td>50–93</td>
</tr>
<tr>
<td>Male</td>
<td>12 (80%)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td></td>
</tr>
<tr>
<td>&gt;30</td>
<td>3 (20%)</td>
</tr>
<tr>
<td>25–30</td>
<td>7 (47%)</td>
</tr>
<tr>
<td>&lt;25</td>
<td>5 (33%)</td>
</tr>
<tr>
<td>Pre-CPB serum creatinine (µmol/L), mean ± SD</td>
<td>85.6 ± 24.2</td>
</tr>
<tr>
<td>Range</td>
<td>(58.0–141.0)</td>
</tr>
<tr>
<td>Lipid index</td>
<td></td>
</tr>
<tr>
<td>Pathologic (&gt;5)</td>
<td>7 (47%)</td>
</tr>
<tr>
<td>Normal (5 or less)</td>
<td>8 (53%)</td>
</tr>
</tbody>
</table>

*Body mass index (BMI) = body weight in kilograms / height in meters

**Lipid index = [Total serum cholesterol (mmol/L) / HDL cholesterol (mmol/L)] – [Serum triglycerides (mmol/L) / 2.2]

CPB = cardiopulmonary bypass

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**Fig. 1** Schematic drawing shows the deployment and location of the intra-aortic filter.

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Cerebral protection

Protecting the brain during aortic surgery: an enduring debate with unanswered questions.

Stein LH, Elefteriades JA,
Section of Cardiothoracic Surgery, Yale University School of Medicine, New Haven, CT 06510, USA.
Surgery on the ascending aorta and the arch cerebral protection
Selective cerebral perfusion:

SCP

ANT

R+L carot

R axillary or SS Clav.

SVC

JUG

Retro
# Antegrade selective cerebral perfusion: Complications and monitoring

<table>
<thead>
<tr>
<th>Pro</th>
<th>Cons</th>
<th>Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control of flow delivery</td>
<td>Local dissection Downstream dissection</td>
<td>Pression Nirs, Doppler</td>
</tr>
<tr>
<td>Embolic load</td>
<td></td>
<td>Doppler</td>
</tr>
<tr>
<td>Cerebral oedema in case of overflow and or over pressure</td>
<td></td>
<td>Flow and pressure control</td>
</tr>
<tr>
<td>Integrity of the circle of Willis? in case of single carotid perfusion</td>
<td>NIRS, transcranial doppler, Left radial arterial pressure (60mmHg) (JbSVO₂) (S100 protein; NSE)</td>
<td></td>
</tr>
</tbody>
</table>

M-G LAGNY, F. BLAFFART, ECCP CHU de Liège
Retrograde cerebral perfusion: complications and monitoring

<table>
<thead>
<tr>
<th>Pro</th>
<th>Cons</th>
<th>monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy of access</td>
<td>Poor control of flow delivery, Dispersion of the flow through the Azygos vein</td>
<td>NIRS, transcranial doppler</td>
</tr>
<tr>
<td>Retrograde flush of the carotids</td>
<td>Cerebral oedema in case of overflow And or overpressure</td>
<td>Flow control and Venous pressure (30 mmHg)</td>
</tr>
</tbody>
</table>

![Diagram of retrograde cerebral perfusion](image1)

![Diagram of retrograde cerebral perfusion](image2)
Deep hypothermia circulatory arrest: state of the art

- Respect of temperatures gradients (6-10°C max)
- Normoxia
- Hct level versus viscosity (25% Hct max)
- Homogenization of temperatures (cerebral and systemic)
- Hardware:
  - Heater cooler device
  - Efficient heat exchanger
  - Cooling helmet
  - Blanket
Deep hypothermic circulatory arrest: state of the art: blood gases management

![Graphs showing temperature corrected and non-temperature corrected PaCO2 vs CBF, CMRO2 vs CPP relationships.](image)

- **A1**: Temperature corrected PaCO2 = 40 mmHg, with CBF (ml/100g/min), CMRO2 (ml/100g/min), and CPP (mmHg) relationships.
  - n = 26, r = -0.11, y = 29.7x + p > 0.2

- **B1**: Non-temperature corrected PaCO2 = 40 mmHg, with CBF (ml/100g/min), CMRO2 (ml/100g/min), and CPP (mmHg) relationships.
  - n = 32, r = 0.50, y = 7.16x, p < 0.0005

- **A2**: Similar to A1 but with a different dataset.
  - n = 26, r = 0.59, y = 39.3x, p < 0.002

- **B2**: Similar to B1 but with a different dataset.
  - n = 32, r = -0.16, y = 16.2 - 0.03x, p > 0.2
Avoiding Stroke During Cardiac Surgery

Kristine Kellermann, DVM¹, and Bettina Jungwirth, MD¹

Abstract
The life saving benefits of cardiac surgery are frequently accompanied by negative side effects such as stroke, that occurs with an incidence of 2%-13% dependent to type of surgery. The etiology is most likely multifactorial with embolic events considered as main contributor. Although stroke presents a common complication, no guidelines for any routine use of pharmacological substances or non-pharmacological strategies exist to date.

Non-pharmacological strategies include monitoring of brain oxygenation and perfusion with devices such as near infrared spectroscopy and Transcranial Doppler help. Epiaortic and transesophageal echocardiography visualize aorta pathology, enabling the surgeon to sidestep atheromatous segments. Additionally can the use of specially designed aortic cannulae and filters help to reduce embolization. Brain perfusion can be improved by using antero- or retrograde cerebral perfusion during deep hypothermic circulatory arrest, by tightly monitoring mean arterial blood pressure and hemodilution. Controlling perioperative temperature and glucose levels may additionally help to ameliorate secondary damage.

Many pharmacological compounds have been shown to be neuroprotective in preclinical models, but clinical studies failed to confirm these results so far.

Remacemide, an NMDA-receptor-antagonist showed a significant drug-based neuroprotection during cardiac surgery. Other substances currently assessed in clinical trials whose results are still pending are acadesine, an adenosine-regulating substance, the free radical scavenger edaravone and the local anesthetic lidocaine.

Stroke remains as significant complication after cardiac surgery. Non-pharmacological strategies allow perioperative caregivers to detect injurious events and to ameliorate stroke and its sequelae. Considering the multi-factorial etiology though, stroke prevention will likely have to be addressed with an individualistic combination of different strategies and substances.
Deep hypothermia circulatory arrest and reperfusion injury

- Low pressure
- Normoxia
- Reperfusion solution?

Deep hypothermic circulatory arrest and global reperfusion injury: Avoidance by making a pump prime reperfusate—A new concept
Bradley S. Allen, MD

J Thorac Cardiovasc Surg 2003; 125:625-32

- Hyperkaliemia (?) ➔ hemodiafiltration
Descending aortic surgery

Surgical repair

- Left-left Bypass
- Right-left Bypass
- Conventional CPB
- None
## Descending aortic surgery: CPB circuit

<table>
<thead>
<tr>
<th>Left-left bypass</th>
<th>Left-right bypass</th>
<th>Conventional miniaturized CPB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left atrium – distal aorta</td>
<td>Right atrium (femoral access) – distal aorta</td>
<td></td>
</tr>
<tr>
<td>Right atrium distal aorta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centrifugal pump</td>
<td>Centrifugal or roller pump</td>
<td></td>
</tr>
<tr>
<td>Autoregulation of the volemia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat exchanger + oxygenator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low heparin level</td>
<td>Full heparinized</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Easy shunt for selective perfusion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quick response to acute hemorrhagic event</td>
<td></td>
</tr>
</tbody>
</table>
Surgery on the descending aorta medullar and splanchnic selective perfusion

- Perfusion
- Local hypothermia
- Systemic mild hypothermia (32°C)
Medullar and splanchnic perfusion: complications and monitoring

<table>
<thead>
<tr>
<th>Complications</th>
<th>monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local dissection</td>
<td>Q-Pressure</td>
</tr>
<tr>
<td>oedema in case of overflow and or over pressure or brain herniation</td>
<td>CSF drainage (10mmHg)</td>
</tr>
<tr>
<td>Malperfusion Upstream embolism</td>
<td>Flow, regional pressure (60mmHg), Doppler flowmetry MEP (motor evoquated potential). Mucosal pH tonometry NIRS ?</td>
</tr>
</tbody>
</table>
Coagulation management

Thromboelastometry-guided administration of fibrinogen concentrate for the treatment of excessive intraoperative bleeding in thoracoabdominal aortic aneurysm surgery

Niels Rahe-Meyer, MD, MSc, PhD, Cristina Solomon, MD, Michael Winterhalter, MD, Siegfried Piepenbrock, MD, Kenichi Tanaka, MD, MSc, PhD, Axel Haverich, MD, and Maximilian Pichlmaier, MD

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PM of coagulation and fibrinolysis, consumption coagulopathy, and hemostatic deleterious effect on hemostasis through activation.
Blood management

- Selective suction blood management
- Specific filtration
- Cell saving process
- Selective allogenic blood component transfusion
Conclusions

- Aorta surgery is a team work
- Multiple modal approaches
- Engineering developments
- EBM and EBP
Thank you for your attention