Post-Cardiopulmonary Bypass Physiology:
an Intensivist’s Perspective

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Disclosures

- None
Learning Objectives

At the end of this presentation, participants will be able to:
1. Understand the general pathophysiology behind post-cardiopulmonary bypass (CPB) changes
2. Describe the general clinical course of post-CPB patients
3. Understand the management strategies following CPB

Intra- and post-operative events

Stephens et al., Crit Care Med, 2015
Post-CBP: The Inflammatory Response

Components of the Inflammatory Response to CPB

Early Phase
‘Contact Activation’

Cellular Components
- Endothelial Cells
- Neutrophils
- Monocytes
- Lymphocytes
- Platelets

Humoral Components
- Contact
- Intrinsic Coagulation
- Extrinsic Coagulation
- Complement
- Fibrinolysis


Milli Vanilli No Longer Blames It on the Rain, Blames Anesthesia Instead

MUNICH, GERMANY – German R&B group Milli Vanilli is back in the spotlight. After...
Post-CBP: The Inflammatory Response

Components of the Inflammatory Response to CPB

Early Phase
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- Cellular Components
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- Humoral Components
  - Contact
  - Intrinsic Coagulation
  - Extrinsic Coagulation
  - Complement
  - Fibrinolysis

Late Phase

- I/R Injury

- Endotoxaemia

- Leukocyte-Dependent
  - Neutrophil-Endothelial Cell Interaction
  - Reactive O₂ Species
  - Arachidonic Acid Metabolites
  - Cytokine Release

- Leukocyte-Independent
  - Complement Activation
  - Cytokine Release
  - Nitric Oxide Release
  - O₂ Consumption

Base Deficit
pH
CO
BP

Pre - Post 1 hr - Post 3 hr - Post 6 hr - Post 12 hr - Post 24 hr

Figure 1. For patients with a preoperative ejection fraction (EF) of >50%, this graph with standard deviations represents the deterioration and then improvement in EF in the first 24 hrs after cardiac surgery ($x$-axis is preoperative (PRE-OP) time and $y$-axis is ejection fraction). Reproduced with permission from Roberts et al (114).
Post-CBP: The Inflammatory Response

Overall Clinical Changes

"Usual" CPB
"Prolonged CPB"

Pre Post 1 Post 3 Post 6 Post 12 Post 24
hr hr hr hr hr hr

Safe time limits of aortic cross-clamping and cardiopulmonary bypass in adult cardiac surgery

Juha Nissinen,¹,4 Fausto Biancari,2 Jan-Ola Wistbacka,3 Timo Peltola,1 Pekka Tarkkainen,¹,4 Pekka Tarkkainen,¹,4 Markku Virkkilä,³ Matti Tarkka⁴
Post-CBP: Managing the Inflammatory Response

- Patient handover
- Integrating:
  - Pt history/comorbidities
  - Intraop events
  - Monitoring (PAC, CO/CI, BP)
  - Physical exam
  - Laboratory findings

- Hemodynamic management
  - Vasoplegia
  - Hypovolemia
  - Decreased inotropy
Post-CBP: Managing the Inflammatory Response

- Vasoplegia → improve the BP!
  - Norepinephrine
  - Vasopressin
  - Phenylephrine

- Vasoplegia → Vasoplegic syndrome
  - Hypotension → MAP < 50 mmHg
  - Low filling pressures → CVP < 5, PAOP < 10
  - Normal or elevated CI → > 2.5
  - Low SVR → < 800
  - Vasopressor requirement → Norepi > 0.5 mcg/kg/min

Post-CBP: Managing the Inflammatory Response

Vasoplegia → improve the BP!
- Norepinephrine
- Vasopressin
- Phenylephrine
- Methylene blue
- Limited evidence for steroids
Angiotensin II for the Treatment of Vasodilatory Shock

- 321 patients with vasodilatory shock
- Angiotensin II vs placebo
Angiotensin II for the Treatment of Vasodilatory Shock

- ATII increased MAP, decreased (other) vasopressor requirement
- No difference in adverse events overall
- No difference in rate of stopping infusion due to adverse event

<table>
<thead>
<tr>
<th>Table 2. Primary and Secondary End Points.</th>
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<tr>
<td><strong>End Point</strong></td>
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<tr>
<td>All-cause mortality at day 7 — no. (%)</td>
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<td>All-cause mortality at day 28 — no. (%)</td>
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</table>
Vasoplegia → improve the BP!
  - Norepinephrine
  - Vasopressin
  - Phenylephrine

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  - Methylene blue
  - Limited evidence for steroids
  - In the future, maybe Angiotensin II

Patient handover

Hemodynamic management
  - Vasoplegia
  - Hypovolemia
  - Decreased inotropy
Post-CBP: Managing the Inflammatory Response

- **Hypovolemia**
  1. Relative hypovolemia - vasodilation
  2. Capillary leak/endothelial glycocalyx

  Type of fluid does not seem to matter
  (i.e. crystalloid vs colloid)

- **Patient handover**

- **Hemodynamic management**
  → Vasoplegia
  → Hypovolemia
  → **Decreased inotropy**
    → Epi, milrinone > dobutamine > dopamine
Post-CBP: Managing Consequences

- Bleeding/hemorrhage
  - Chest tube output, hemodynamics, labs (H/H, TEG)
  - Blood products, PCCs (i.e. FEIBA), return to OR
- Hypothermia
- Hyperglycemia
- Delirium (50-60% in cardiac surgery!)
- Arrhythmias/Atrial fibrillation

Post-CBP Physiology

- Large inflammatory response → vasoplegia
- Volume resuscitation/management
- Myocardial contractility/performance
- Hemorrhage
- Various other consequences
Thank you!

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