Haemodynamic instability
How to recognize it?

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Jan Bakker

jan.bakker@erasmusmc.nl
Department of Intensive Care
Erasmus MC University Medical Center

• 45+ ICU beds in a 1300 bed hospital
• Trauma center, Only center allowed to do all transplantations in adults and children
• ECMO center (last 4 mo: 22 patients)
• Admitting 2800 patients in ICU and 1000 in PACU
• 70% Mechanical Ventilation
• APACHE II: 20±9
• Research
  – Circulation: 10 PhD students
  – Ventilation: 4 PhD students
  – Ethics/EOL: 2 PhD students
Definition of haemodynamic instability

- Acute deterioration in organ function due to an inadequate organ perfusion/oxygenation
  - Perfusion Pressure
    - S/D/M Arterial Pressure
  - Perfusion
    - Global (cardiac output)
    - Regional (organs)
Regulation of Cardiac Output/Flow

• Healthy 25 year old donates one kidney
• CO measured in stable conditions pre-OP
• Following recovery again CO measured in same conditions

The Cardiac Output post donation will be

• LOWER - SIMILAR - HIGHER

compared to the pre-OP Cardiac Output
Cardiac Output = Total Tissue Blood Flow

- Venous Return (Vena Cava)
  - Right Heart
  - Lungs
  - Left Heart
  - Brain: 20%
  - Heart: 5%
  - GI: 25%
  - Kidneys: 20%
  - Muscle: 20%
  - Skin, etc: 10%

Cardiac Output (Aorta)
Microcirculation

Pulmonary circulation

CO₂ production

Organ

O₂ consumption

CO₂ flow

Circulation

O₂ flow

Expiration

Lungs

Inspiration

QCO₂

VO₂

Dilate

SV

HR

Recruit

Vt

F

HAEMODYNAMIC MONITORING AND MANAGEMENT
Oxygen Transport and Delivery

- $\text{TO}_2 = \text{Hb} \times \text{SaO}_2 \times \text{CO} \times c$
- $\text{DO}_2 = \text{microcirculatory perfusion}$
  - Convection
    » heart failure
  - Diffusion
    » sepsis, hemodilution
Before ECC 10 min after start ECC

Characteristics of haemodynamic instability

• Increased HR
• Increase in Respiratory Rate
• Abnormal Blood Pressure
  – context sensitive!!!!
HAEMODYNAMIC MONITORING AND MANAGEMENT

Jan Bakker
AP mm Hg vs Flow ml/min

- **Normal**
  - Blood pressure: 100, Blood flow: 3.5
  - Blood pressure: 58, Blood flow: 1.0

- **Sympathetic stimulation**

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**HAEMODYNAMIC MONITORING AND MANAGEMENT**
Sympathetic stimulation

Normal

<table>
<thead>
<tr>
<th>Blood pressure</th>
<th>Blood flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>3.5</td>
</tr>
<tr>
<td>58</td>
<td>1.0</td>
</tr>
<tr>
<td>108</td>
<td>1.0</td>
</tr>
</tbody>
</table>

AP mm Hg

Flow ml/min
**Sympathetic stimulation**

- Blood pressure:
  - Normal: 100
  - 108

- Blood flow:
  - Normal: 3.5
  - 1.0

**Flow ml/min**

- AP mm Hg: 0 to 200
- Normal: 100
- 108

HAEMODYNAMIC MONITORING AND MANAGEMENT
• Young male
• double femur #
• HR: 120 /min
• BP: 130/90
• Normal consciousness

What do you want to know, what do you look for?
Haemodynamic instability: vasoconstriction
Clinical assessment
CRT - Subjective Skin temperature

Pressure is applied for 5 sec - nail bed turns white

normal ≤ 2 sec in children and young adults 4.5 sec in older patients

put your hand on the patient and assess temperature (normal, abnormal)

Skin temperature to identify clinical hypoperfusion in the critically ill

– Cool vs warm skin
  • similar HR, BP, PAOP, Hb, FiO₂, PaCO₂ and PaO₂

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Cool</th>
<th>Warm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac Index</td>
<td>2.9 ± 1.2</td>
<td>4.3 ± 1.2*</td>
</tr>
<tr>
<td>Arterial pH</td>
<td>7.32 ± 0.2</td>
<td>7.39 ± 0.07*</td>
</tr>
<tr>
<td>SvO₂</td>
<td>60 ± 4</td>
<td>68 ± 8 *</td>
</tr>
<tr>
<td>Lactate</td>
<td>4.7 ± 1.5</td>
<td>2.2 ± 1.6 *</td>
</tr>
</tbody>
</table>

Kaplan et al. J Trauma 2001;50:620-628
One of the women, the 23-year-old primipara Eva Rumpel, gave birth to a healthy child on 9 January 1843. The same night she developed a painfully swollen abdomen and became ill, feverish, and sweaty, with rapid pulse and severe thirst. The initiated treatment was bloodletting and clystering. The next evening she deteriorated, became delirious, with anxious breathing, a tense abdomen, cold extremities and rapid pulse, finally losing consciousness. Again, bloodletting followed. At 4:30 a.m., 36 h after the onset of the first symptoms, she died. During autopsy, severe purulent endometritis, vaginal pus, pulmonary edema, and shock liver and shock spleen were found.
Definition of haemodynamic instability

• what windows do we have?
  – Brain
    • consciousness
  – Kidney
    • urine output
  – Periphery
    • color, temperature

Vincent, Ince, Bakker (Submitted)
Use of a peripheral perfusion index derived from the pulse oximetry signal as a noninvasive indicator of perfusion

Alexandre Pinto Lima, MD; Peter Beelen, RN; Jan Bakker, MD, PhD

0.3 - 10
median: 1.4 (IQR: 0.7 - 3.0)
The prognostic value of the subjective assessment of peripheral perfusion in critically ill patients

Alexandre Lima, MD; Tim C. Jansen, MD; Jasper van Bommel, MD, PhD; Can Ince, PhD; Jan Bakker, MD, PhD

(Crit Care Med 2009; 37:934–938)

- 50 critically ill patients following initial resuscitation and stabilization (within first 24h of admission)
- Abnormal peripheral circulation was defined as
  - increase in capillary refill time (> 4.5 sec) or cool skin (subjective)
- Measurements: Forearm-Finger Skin temperature difference, Central-Toe temperature difference, Peripheral Perfusion Index, SOFA score
Clinical significance

- Odds for increase in SOFA score during first 48h of admission are **7.4** times higher (CI: 2-19, P<0.05) in patients with abnormal peripheral perfusion.

- Odds to have increased lactate levels following initial resuscitation are **4.6** times higher (CI: 1.4-15, P<0.05) in patients with abnormal peripheral perfusion.

(Crit Care Med 2009; 37:934–938)
- Young male
- double femur #
- HR: 120 /min
- BP: 130/90
- Normal consciousness

The patient will die 20 minutes later

You can do only one or two things, what will you do?
• Young male
• double femur #
• HR: 120 /min
• BP: 130/90
• Normal consciousness

Lactate on admission: 13 mmol/L

Don’t take vitals, take a lactate
Causes of hemodynamic instability
Pipes - Pump - Volume

Never deny your gut feeling

- Hemodynamic instability refers to a condition usually involving inadequate perfusion but at the end it's about the Pipes, the Pump and the Volume
- Global parameters maybe misleading
- Only 2 real windows in clinical judgement
- Don’t forget the signs of the periphery
- Never forget lactate