Hemodynamic Monitoring in Critically ill Patients in 2017

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Rationale for Hemodynamic Monitoring

• Identify the presence of hemodynamic instability
• Identify the causes of hemodynamic instability
• Target therapeutic approaches
Acute Cardiovascular Impairments

• Hypovolemia
• Left and right ventricular dysfunction
• Abnormalities of vascular tone
• Microvascular dysfunction
• ± Respiratory failure
• Associated with patient chronic comorbidities
Algorithm for the choice of hemodynamic monitoring

CVP, ScvO₂, PcvCO₂
- Central venous catheter

Clinical assessment

Lactate

Echocardiography

Arterial catheter

AP, PPV, PaCO₂, PaO₂, SaO₂

acute circulatory failure

associated severe ARDS?

NO

positive response to initial therapy

insufficient response to initial therapy

Continue with same hemodynamic monitoring until shock resolution

YES

- Transpulmonary thermodilution systems or
- Pulmonary artery catheter (especially in case of RV dysfunction)

Teboul et al. Intensive Care Med. 2016;42
Central venous catheter:
- Central Venous Pressure (CVP)
- ScvO2
- PvCO2

Clinical assessment: essential but limited

- Skin: degree of cutaneous perfusion
- Kidneys: urine output
- Brain: mental status
Lactate measurement:

- Shock diagnosis
- Lactate monitoring to guide therapy?

Echocardiography:

- Systolic and diastolic ventricular functions
- Valvular competency
- Diagnose / exclude obstructive shock
- Cardiac output
- Diagnostic or monitoring tool?
Arterial catheter:

- Systolic arterial pressure: left ventricular afterload
- Diastolic arterial pressure: indicator of arterial tone
- Mean arterial pressure: determinant of organ perfusion pressure
- Pulse pressure: indicator of stroke volume
- CO2 gap
- Pulse pression variation
- Repeated blood sampling
Arterial catheter:

- Arterial pulse contour analysis
  - Left ventricular stroke volume
  - Arterial impedance
  - Cardiac output changes induced by therapeutic tests
  - FloTrac, LiDCCOrapid, ProAQT

Algorithm for the choice of hemodynamic monitoring

- **Acute circulatory failure**
  - **CVP, ScvO₂, PcvCO₂**: Central venous catheter
  - **AP, PPV, PaCO₂, PaO₂, SaO₂**: Arterial catheter
  - Clinical assessment
  - Lactate
  - Echocardiography

- Associated severe ARDS?
  - **NO**
    - Positive response to initial therapy
      - Continue with same hemodynamic monitoring until shock resolution
  - Insufficient response to initial therapy
    - Insufficient response to initial therapy

- **YES**
  - Transpulmonary thermodilution systems or
  - Pulmonary artery catheter (especially in case of RV dysfunction)

*Teboul et al. Intensive Care Med. 2016;42*
Transpulmonary thermodilution systems:

- PiCCO:
  i) Cardiac output
  ii) Global end-diastolic volume
  iii) Cardiac function index and global ejection fraction
  iv) Extra-vascular lung water
  v) Pulmonary vascular permeability index

- Volume View

Pulmonary artery catheter (PAC):  

- Declining use  
- Valuable if correct measurement, correct data interpretation, and correct application  
- Severe right ventricular dysfunction +++

Binanay et al. JAMA (2005) ESCAPE  
Harvey et al. LANCET (2005) PAC-Man  
Wiedemann et al. NEJM (2006) FACTT  
Other Hemodynamic Techniques

• Esophageal doppler
  • Real-time estimation of blood flow in the descending aorta
  • Assumption of equal distribution between upper and lower territories
  • Estimation of the diameter of the descending aorta

Dark et al. Intensive Care Med 2004
Hamilton et al. Anesth Analg 2011
Other Hemodynamic Techniques

- Continuous analysis of the arterial pressure waveform
  - Radial artery applanation tonometry
    - Limitation: impairment of the signal by sensor movement
  - Volume clamp method CLEARSIGHT
    - Limitation: severe vasoconstriction, peripheral edema

- Impedance Cardiography (Bioz)
- Bioreactance (NICOM)
- Pulse wave transit time method (essCO)
Other Hemodynamic Techniques

Teboul et al. *Intensive Care Med.* 2016;42
Hemodynamic Monitoring in the Era of Evidence Based Medicine

- Hemodynamic Monitoring as a way to minimize uncertainties concerning hemodynamic status
- Shortcomings of Evidence Based Medicine in the field of hemodynamic monitoring
  - Heterogeneous patient populations
  - « One size fits all » approach
- Shortcomings of hemodynamic monitoring
  - Data interpretation, limitations, confounding factors
  - Make the right intervention

Saugel et al. Critical Care (2016) 20:401
Future of Hemodynamic Monitoring

- Visualization of complex information
- Processing of hemodynamic data
- Monitoring of the microcirculation: the hemodynamic coherence concept

Michard Ann Intensive Care 6 (2016)
Ince Crit Care 2015;19
Microcirculatory alterations associated with loss of hemodynamic coherence.

**Type 1: Heterogeneity**

**Type 2: Hemodilution**

**Type 3: Constriction/tamponade**

**Type 4: Edema**