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

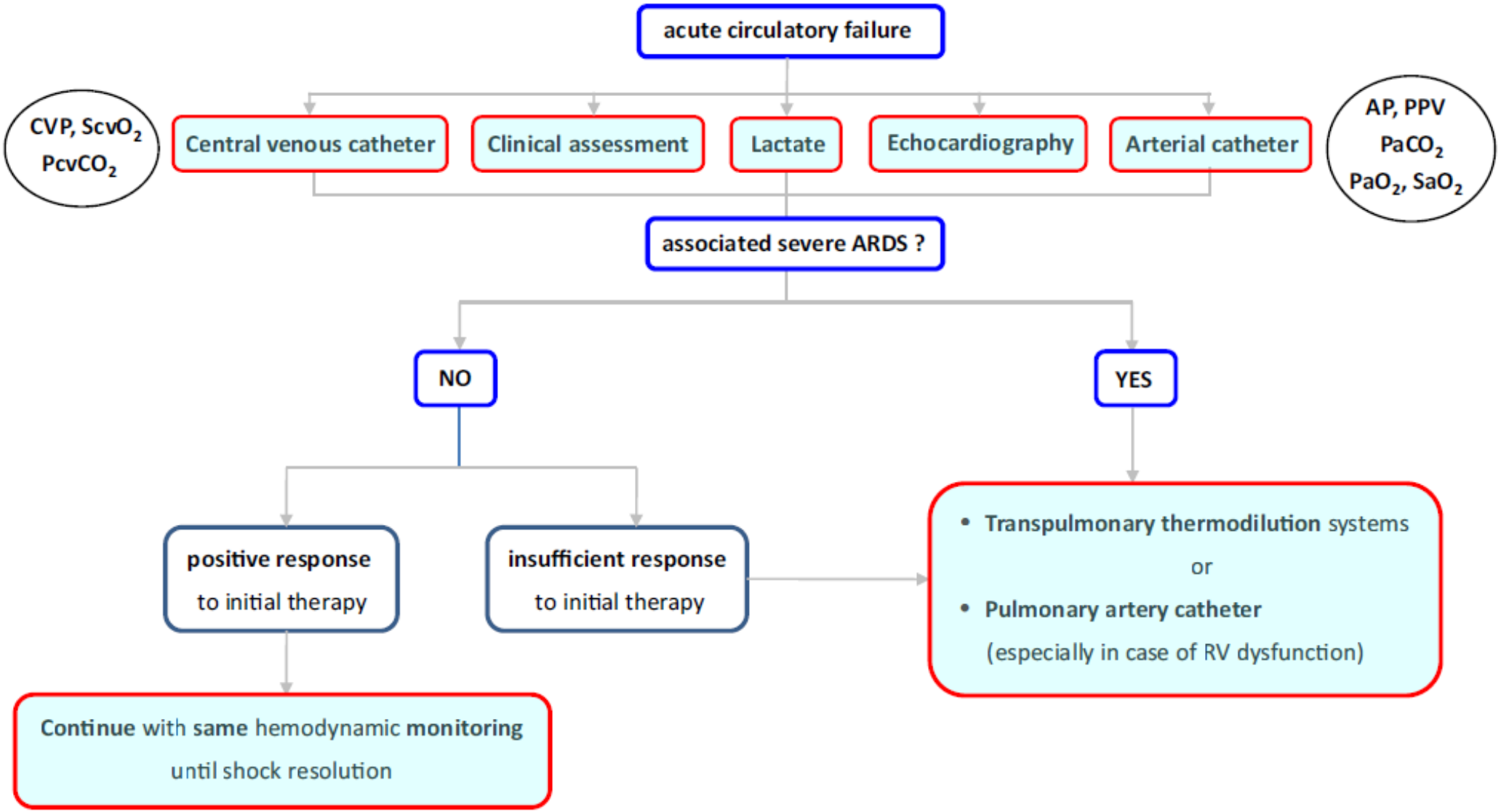
Saugel et al. Critical Care (2016) 20:401

Acute Cardiovascular Impairments

- Hypovolemia
- Left and right ventricular dysfunction
- Abnormalities of vascular tone
- Microvascular dysfunction
- ± Respiratory failure
- Associated with patient chronic comorbidities

Saugel et al. Critical Care (2016) 20:401

Algorithm for the choice of hemodynamic monitoring



Teboul *et al. Intensive* Care Med. 2016;42

Central venous catheter | Clinical assessment | Lactate | Echocardiography | Arterial catheter

Central venous catheter :

- Central Venous Pressure (CVP)
- ScvO2
- PvCO2

Rivers *et al. N Engl J Med 345 (2001)*
Eskesen *et al.* Intensive Care Med 42 (2016)

Central venous catheter | Clinical assessment | Lactate | Echocardiography | Arterial catheter

Clinical assessment : essential but limited

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

Saugel *et al.* J Crit Care 26 (2011)
Perel *et al. J Clin Monit Comput (2015)*

Central venous catheter | Clinical assessment | Lactate | Echocardiography | Arterial catheter

Lactate measurement :

- Shock diagnosis
- Lactate monitoring to guide therapy ?

Jansen *et al.* Am J Respir Crit Care Med 182 (2010)

Central venous catheter | Clinical assessment | Lactate | Echocardiography | Arterial catheter

Echocardiography :

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

Central venous catheter | Clinical assessment | Lactate | Echocardiography | Arterial catheter

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

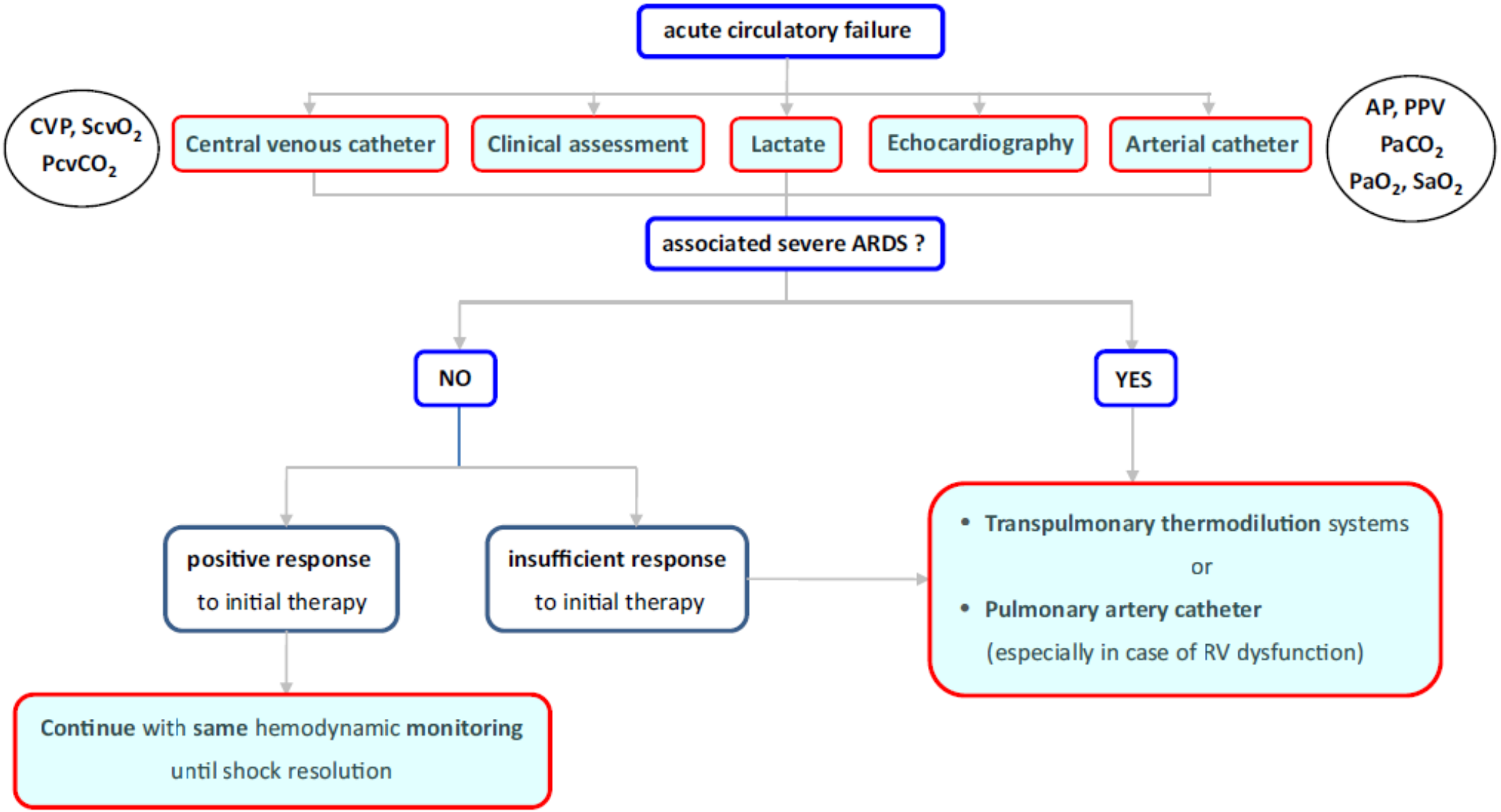
Central venous catheter | Clinical assessment | Lactate | Echocardiography | Arterial catheter

Arterial catheter :

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

Slagt *et al.* Br J Anaesth 112 (2014)

Algorithm for the choice of hemodynamic monitoring



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- **Transpulmonary thermodilution** systems

or

- **Pulmonary artery catheter**

(especially in case of RV dysfunction)

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

Monnet *et al.* Crit Care 15 (2011)
Saugel *et al.* J Crit Care 26 (2011)
Jozwiak *et al. Crit Care Med 41 (2013)*

- **Transpulmonary thermodilution** systems

or

- **Pulmonary artery catheter**

(especially in case of RV dysfunction)

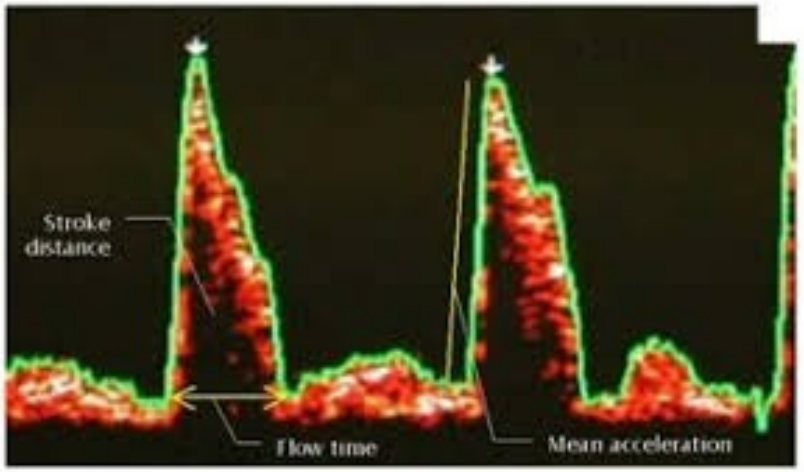
Pulmonary artery catheter (PAC) :

- 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**
Saugel *et al.* J Crit Care 26 (2011)
Perel *et al* J Clin Monit Comput (2015)
Gnaegi *et al.* Crit Care Med 25:213–220 (2007)
Vincent *et al.* Crit Care Med *36 (2008)*
Rajaram *et al.* Cochrane Database Syst Rev 2 (2013)

Other Hemodynamic Techniques

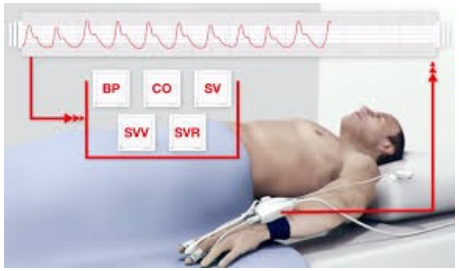
- Esophageal doppler
  - Real-time estimation of blood flow in the descending aorta
  - Assumption of equal distribution between upper and lower territories
  - Estimation of the diameter of the descending aorta



Dark *et al.* Intensive Care Med 2004
Hamilton *et al.* Anesth Analg 2011

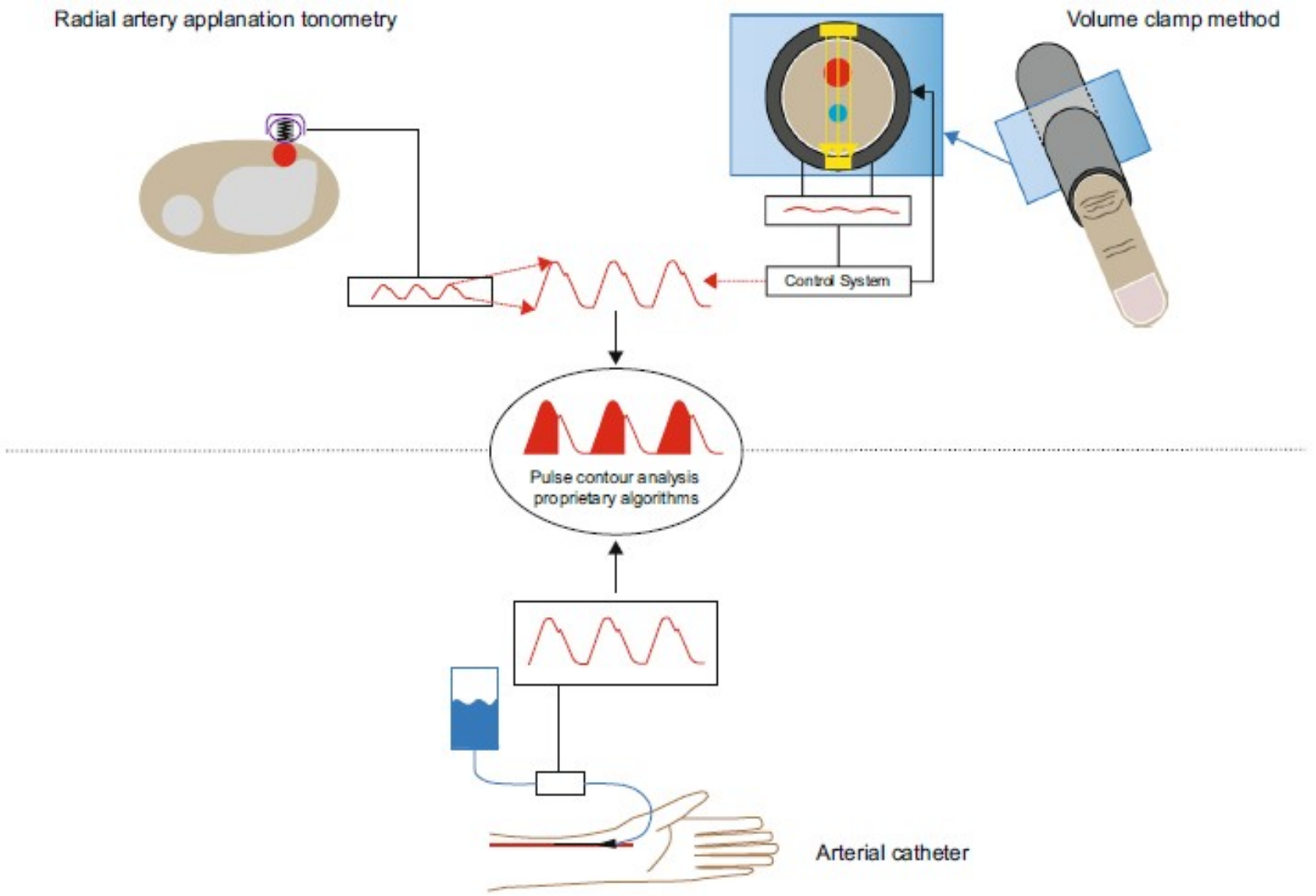
Other Hemodynamic Techniques

- 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 vascoconstriction, peripheral edema



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

Other Hemodynamic Techniques



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Hemodynamic Monitoring in the Era of Evidence Based Medicine

- Hemodynamic Monitoring as a way to minimize uncertainties concerning hemodynamic status
- Shortcomings of Evidence Based Medecine 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

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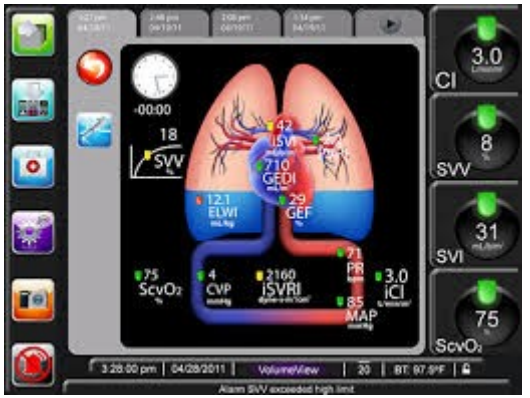
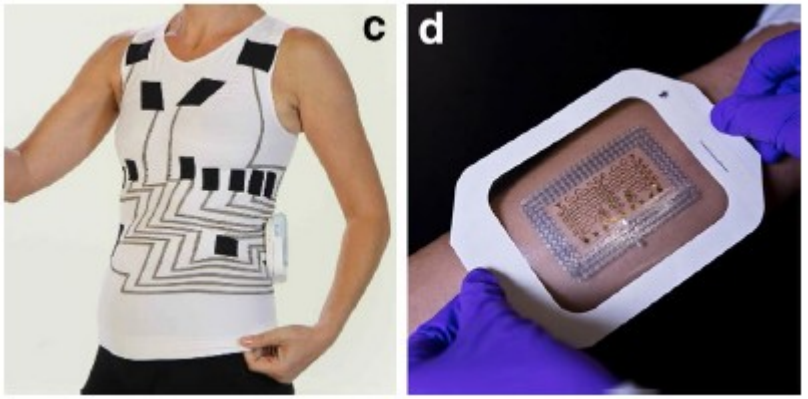
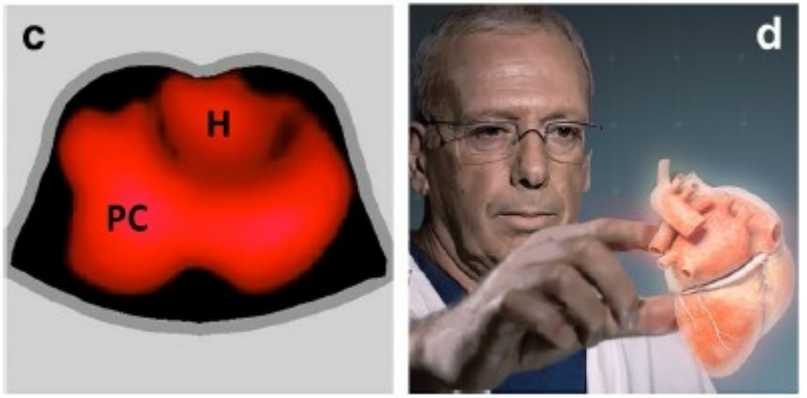
Future of Hemodynamic Monitoring

- Visualization of complex information
- Processing of hemodynamic data



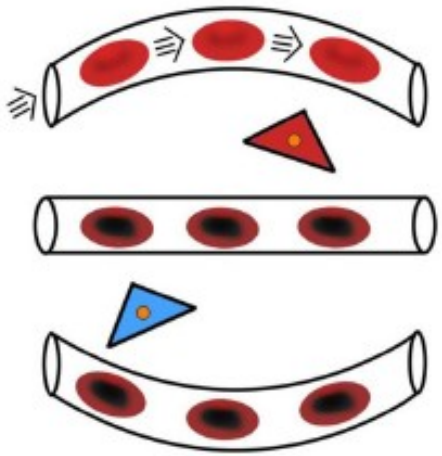




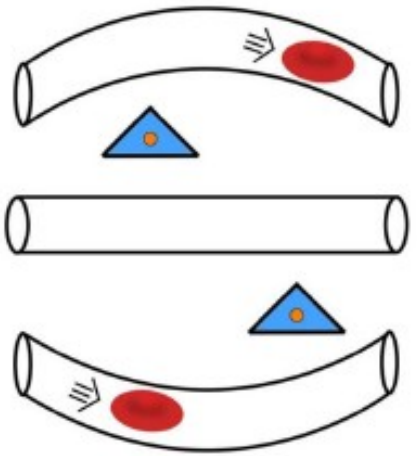
- Monitoring of the microcirculation : the hemodynamic coherence concept

Michard Ann Intensive Care 6 (2016)
Ince Crit Care 2015;19

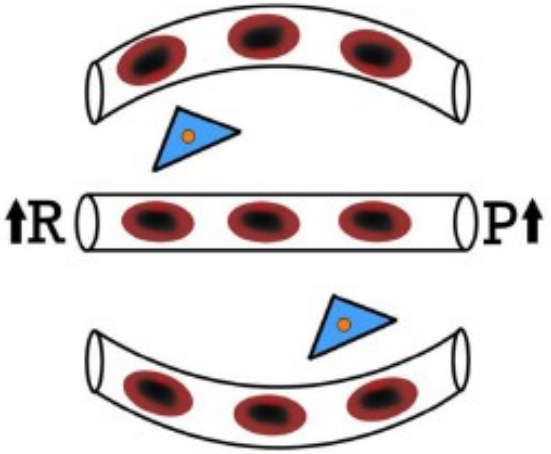
Microcirculatory alterations associated with loss of hemodynamic coherence.



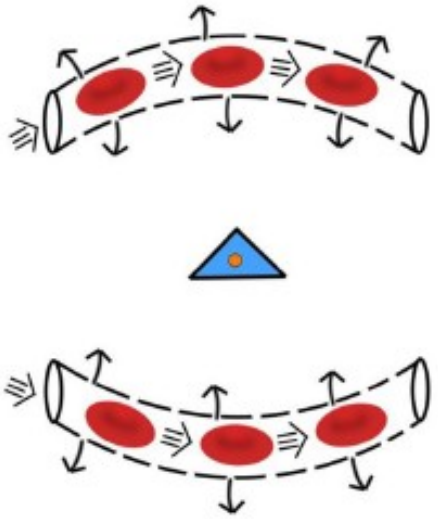
Type 1: Heterogeneity



Type 2: Hemodilution



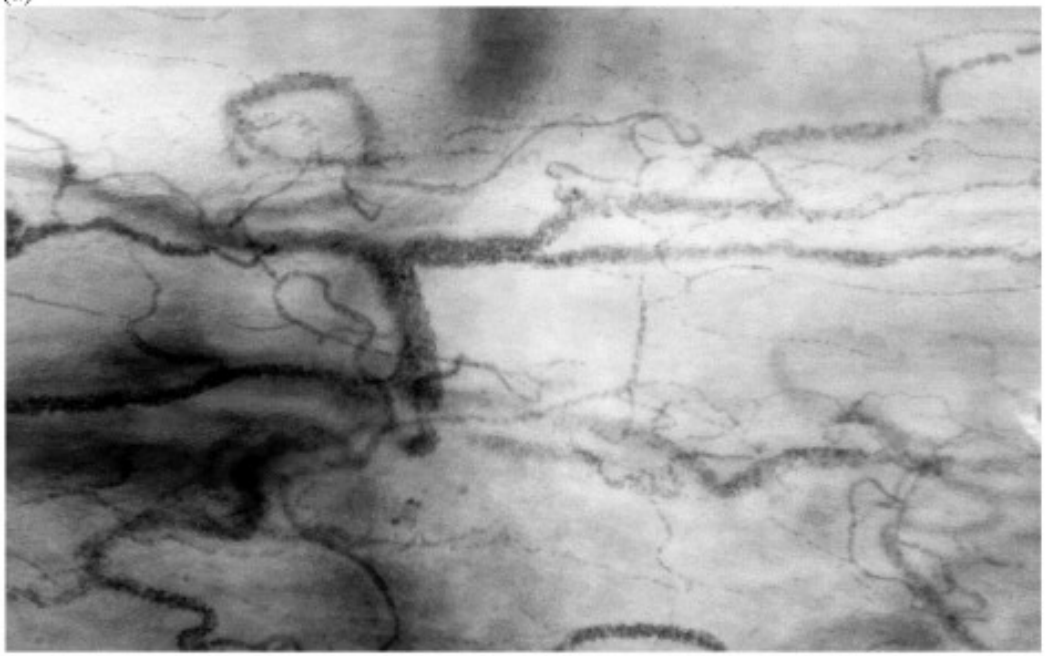
Type 3: Constriction/tamponade



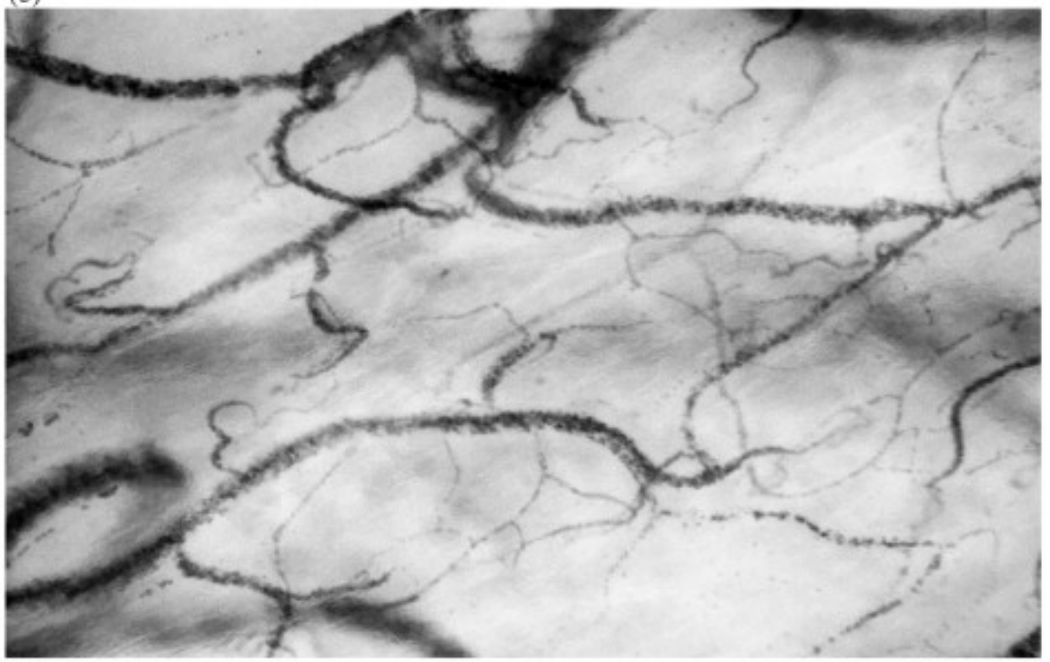
Type 4: Edema

Ince Crit Care 2015;19

(a)



(b)



Ince Crit Care 2015;19