Haemodynamics in trauma

Sooraj Motilall

Netcare Union Hospital

Intensive care and Trauma Surgery

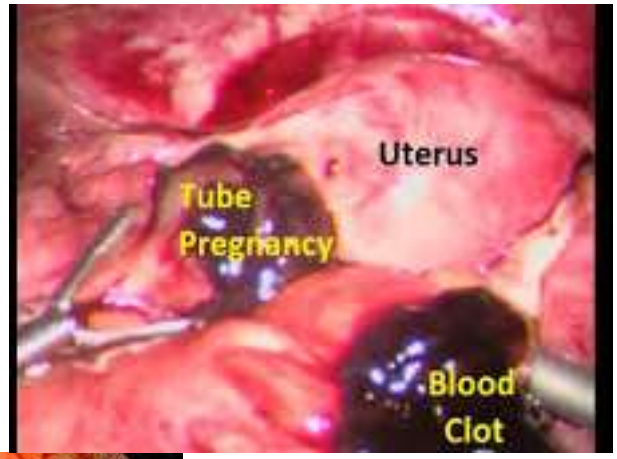
NETCARE

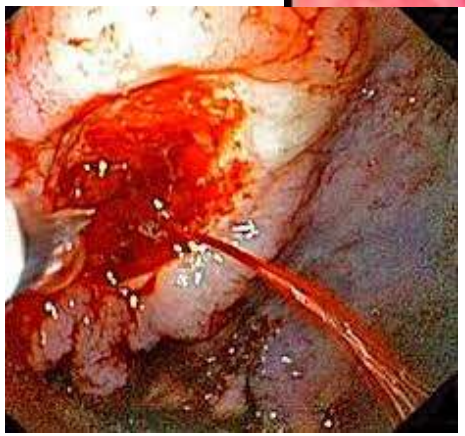
British Journal of Anaesthesia **113** (2): 266–75 (2014)
doi:10.1093/bja/aeu232

Haemodynamic changes in trauma

Simple haemorrhage "blood loss without significant volume of tissue damage"

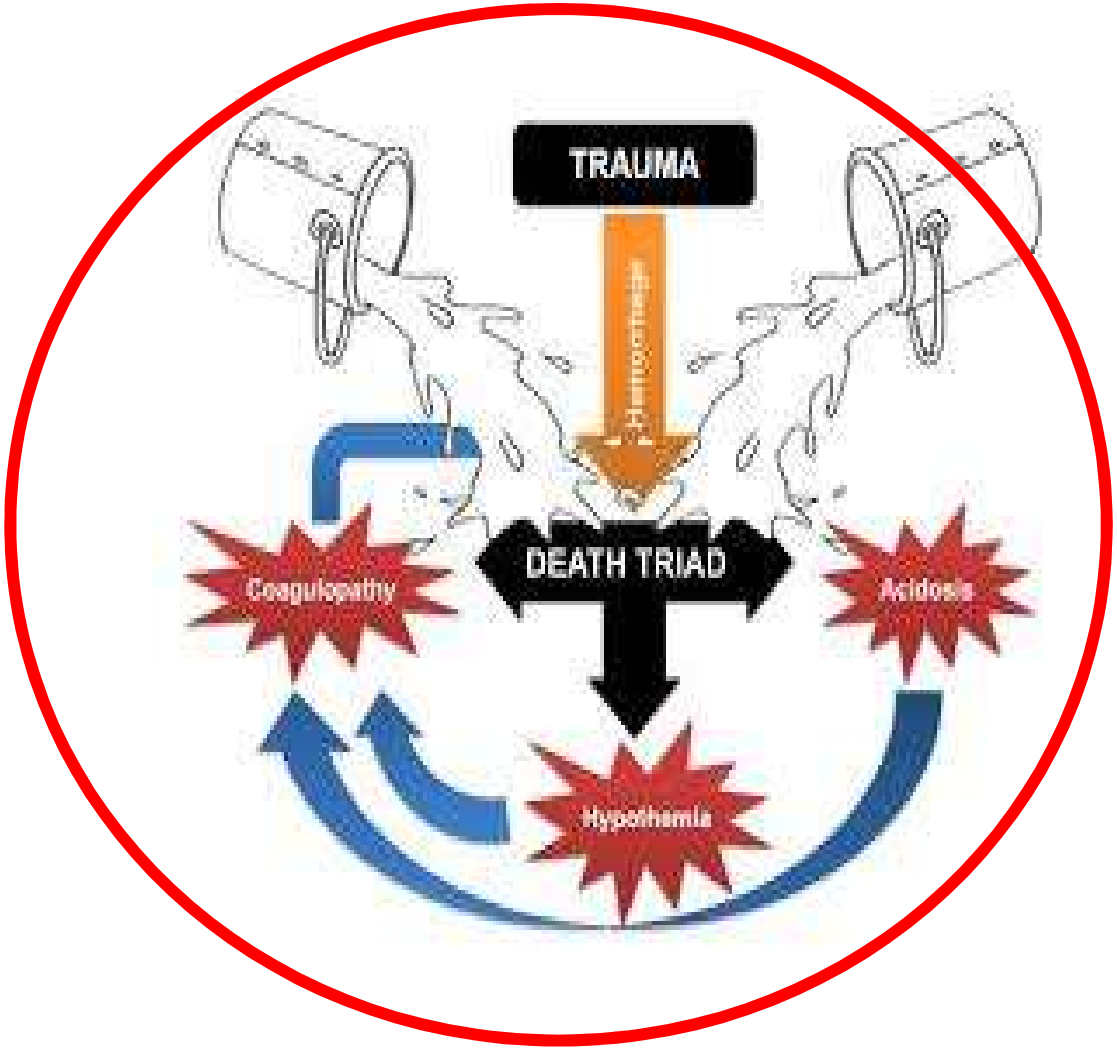
- **Oesophageal varices**
- **Peptic ulcer bleeding**
- **Obstetric bleeding**





Haemorrhage in trauma is complex

- On scene factors
- Emergency Unit
- Multi system
- Multi cavities



Management of haemorrhage

- **Resuscitation**
- **Identify the bleeding**
- **Stop the bleeding**

At each step need to assess the ongoing haemodynamic response to your interventions

Table 1 Clinical indices of the adequacy of tissue/organ perfusion

- Mean arterial pressure

Cerebral and abdominal perfusion pressures

- Urine output
- Mentation
- Capillary refill
- Skin perfusion/mottling
- Cold extremities (and cold knees)
- Blood lactate
- Arterial pH, BE, and HCO3
- Mixed venous oxygen saturation $SmvO_2$ (or $ScvO_2$)
- Mixed venous pCO_2
- Tissue pCO_2
- Skeletal muscle tissue oxygenation (StO_2)

Marik et al. Annals of Intensive Care 2011, 1:1

- **Pulse contour analysis**
- **Straight leg raising**
- **Ultrasound/Echo**

CRITICAL CARE

REVIEW

Clinical review: Does it matter which hemodynamic monitoring system is used?

Davinder Ramsingh, Brenton Alexander and Maxime Cannesson*

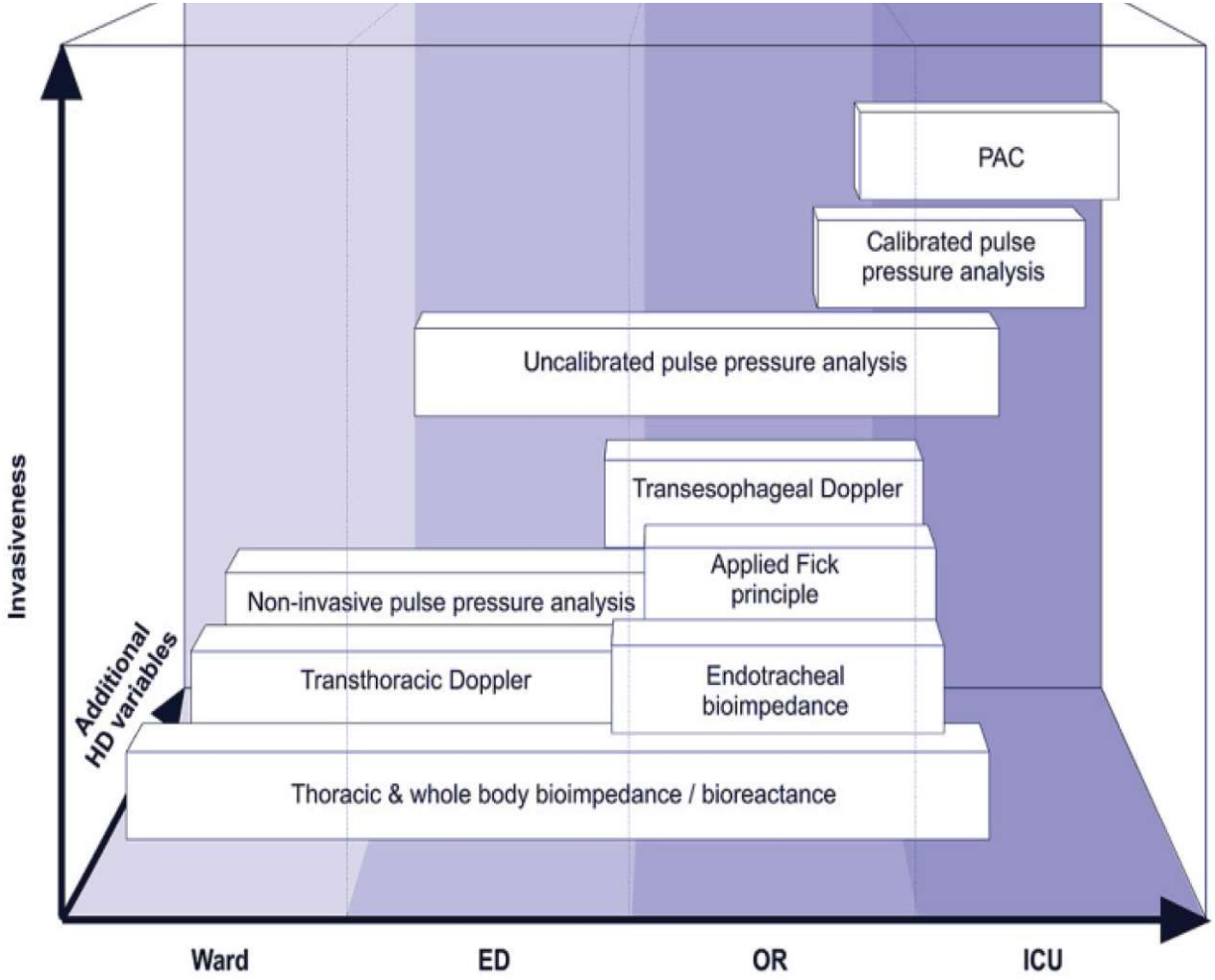


Figure 3. Integrative hemodynamic monitoring approach. ED, emergency department; HD, hemodynamic; OR, operating room; PAC,

Clinical

- **Brain - mentation**
- **Skin – mottled / cold clammy**
- **Kidney - >0.5 – 1ml/kg/hr**
- **Systolic 90 mmHg in penetrating trauma**

Intensive Care Med (2014) 40:1795–1815
DOI 10.1007/s00134-014-3525-z

CONFERENCE REPORTS AND EXPERT PANEL

Maurizio Cecconi
Daniel De Backer
Massimo Antonelli
Richard Beale
Jan Bakker
Christoph Hofer
Roman Jaeschke
Alexandre Mebazaa
Michael R. Pinsky
Jean Louis Teboul
Jean Louis Vincent
Andrew Rhodes

Consensus on circulatory shock and hemodynamic monitoring. Task force of the European Society of Intensive Care Medicine

Mean arterial pressure (MAP)

- **MAP as an estimation of tissue perfusion pressure**
- **MAP of 65 mmHg in patients with sepsis discriminated between survivors and non survivors**
- **In trauma – MAP of 40mmHg till bleeding controlled**
- **TBI - MAP of 90mmHg once active haemorrhage had been controlled**

Lactate and base excess

- **Prognostic value of lactate levels exceeds that of blood pressure**
- **Lactate targeted therapy improves 48 hour mortality**
- **Both parameters monitor the trend**

CVP

- **Traditionally assumed good indicator of RV preload**
- **Misguided → CVP reflects intravascular volume**
- **Affected by → Intrathoracic pressures**

  → LV and RV compliance

- **> 100 studies no relation between CVP and fluid responsiveness**

Pulmonary artery catheters (Swan Ganz)

- Traditionally the gold standard
- Conventional thermodilution techniques
- Some benefit in pulmonary hypertension and liver transplantation
- Cochrane review 2002 and 2012 “no mortality benefit in combined medical and surgical patients or high-risk surgical patients”
- Surpassed by other modalities PWA and ECHO

Pulse wave form analysis (PWA)
Heart lung interactions

- **Multiple studies demonstrated**
  - → **Pulse pressure variation (PPV)**
  - → **Stroke volume variation (SVV)**
  - → **Cardiac output**
- **Highly predictive of fluid responsiveness**

REVIEW ARTICLE

Hemodynamic monitoring of the injured patient: From central venous pressure to focused echocardiography

Aaron Strumwasser, MD, Heidi Frankel, MD, Sarah Murthi, MD, Damon Clark, MD, Orlando Kirton, MD, MCCM, *and the* **American Association for the Surgery of Trauma Committee on Critical Care,** *Los Angeles, California*

Pulse pressure wave form analysis

- **Limitations**
  - **Tidal volume 6-10 ml/kg**
  - **Sedated/paralyzed**
  - **Not spontaneously breathing**
  - **Sinus rhythm**

Heart lung interactions

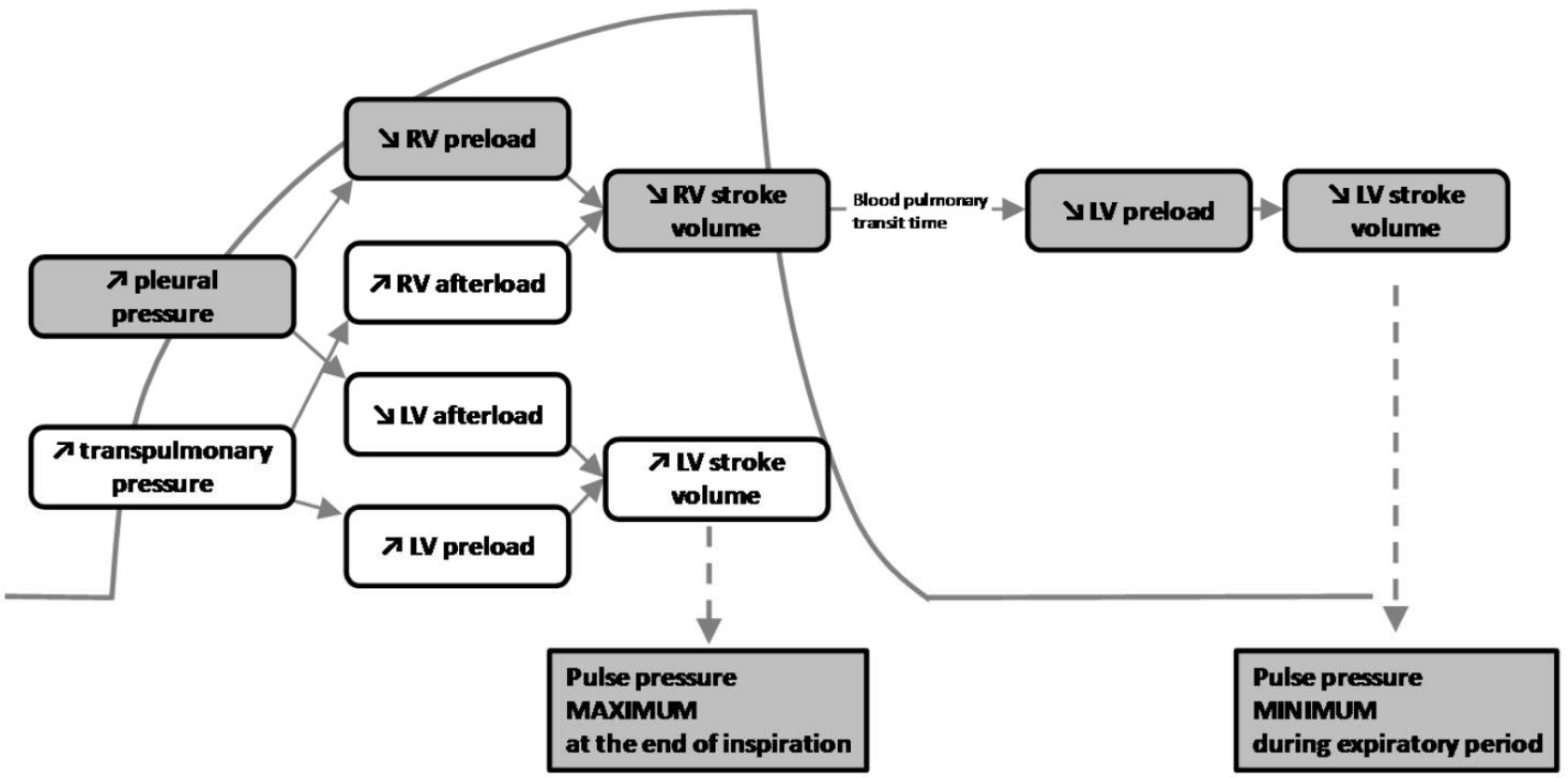
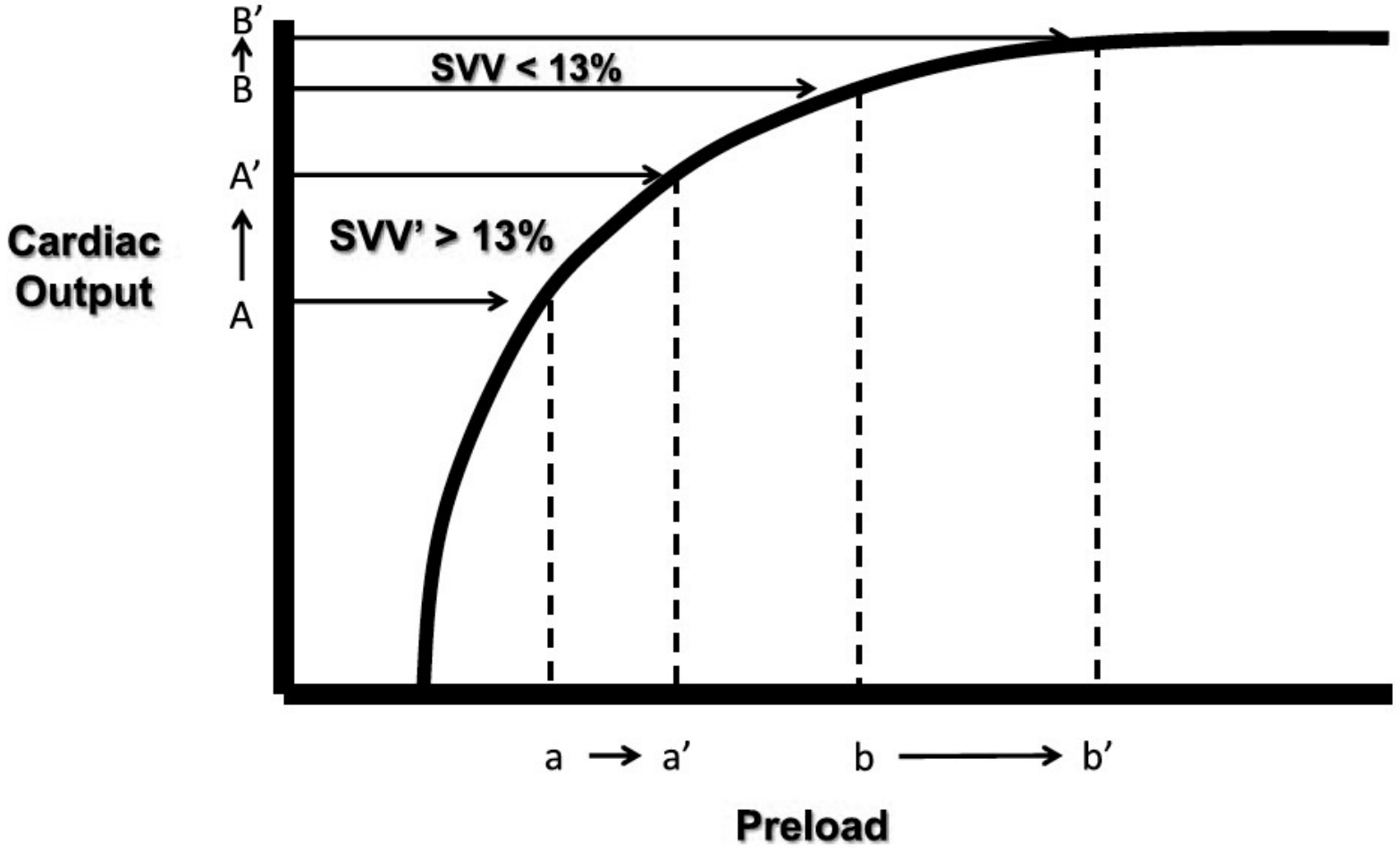


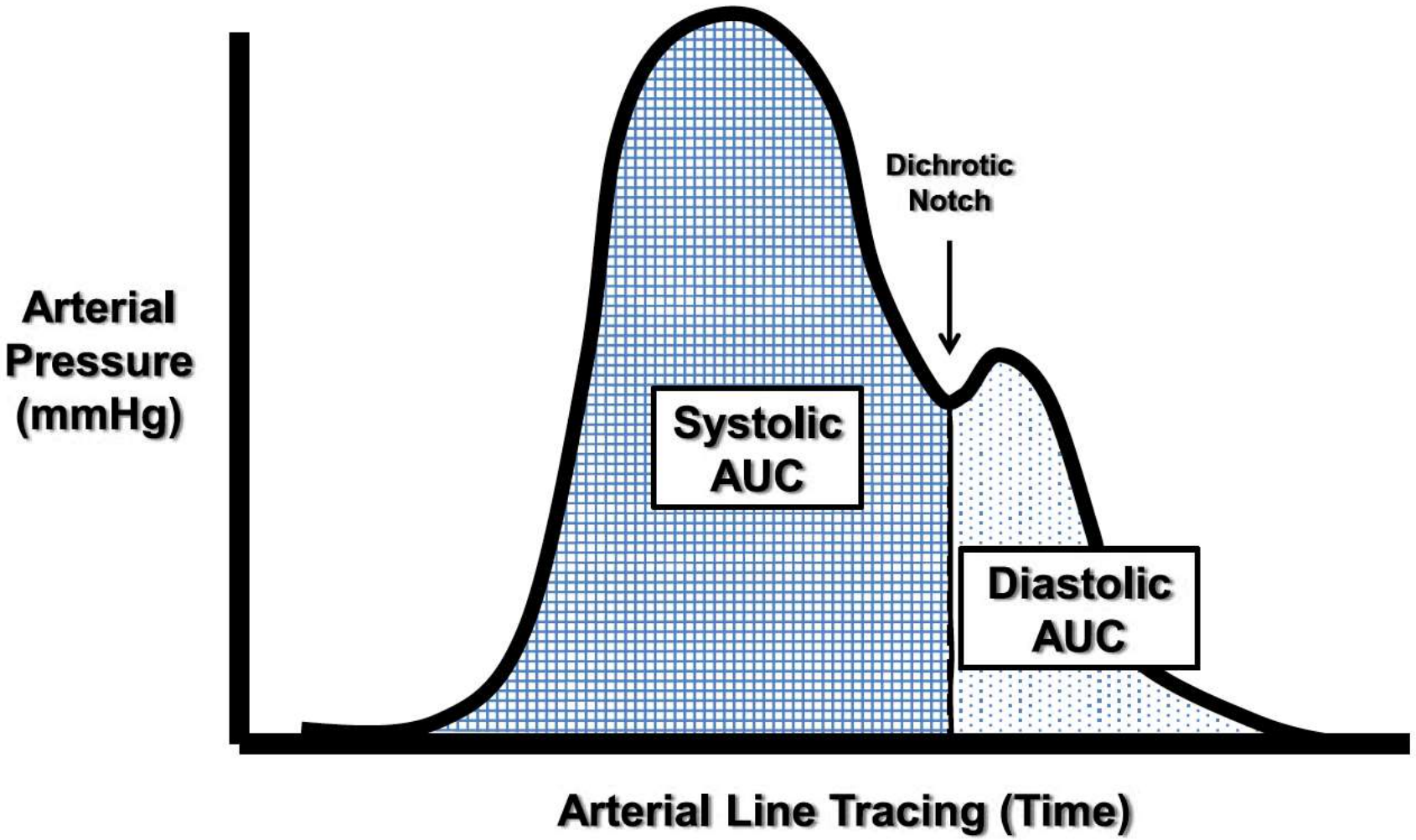
Figure 2 Heart-lung interactions. Hemodynamic effects of mechanical ventilation. The cyclic changes in left ventricular (LV) stroke volume are mainly related to the expiratory decrease in LV preload due to the inspiratory decrease in right ventricular (RV) filling. Reproduced with permission from Critical Care/Current Science Ltd [24].

Stroke Volume Variation (SVV%) and Volume Responsiveness



Arterial Waveform Analysis Principle

Stroke Volume (SV) α $AUC_{Systolic}$ + $AUC_{Diastolic}$



Pulse Waveform Analysis Technologies				
	PiCCO	**LiDCO**	**VolumeView™**	**Flotrac/Vigileo™**
Method of Calibration	Cold-saline transpulmonary thermodilution - uses central vein and arterial line	Lithium Dilution - uses a peripheral vein and peripheral arterial line	Cold-saline transpulmonary thermodilution - uses central vein and arterial line	Uncalibrated
Volume Responsiveness Determination	Good	Good	Good	Good
Cardiac Function (CO) Determination	Good	Good	Good	Average
Advantages	Adjusts well to rapidly changing vascular tone with each calibration (recommended with each patient change in position, new vasoactive medication, or changing compliance of vascular bed)	Adjusts well to rapidly changing vascular tone with each calibration (recommended with each patient change in position, new vasoactive medication, or changing compliance of vascular bed)	Adjusts well to rapidly changing vascular tone, also can assess extravascular lung water content and performs global end-diastolic volume assessment (cardiac filling volumes)	Does not require frequent calibration
Disadvantages	Less accurate than pulmonary artery catheter thermodilution, associated infection risks with central venous catheterization	Cannot use in patients on Lithium therapy or certain muscle relaxants (potentiates neuromuscular blockade with succinylcholine and pancuronium)	Less accurate than pulmonary artery catheter thermodilution, associated infection risks with central venous catheterization	Cannot adjust to rapidly changing vascular tone - effect limited with high dose vasopressors, mechanically ventilated patients > 6 ml/kg tidal volume, atherosclerosis

Marik *et al. Annals of Intensive Care* 2011, **1**:1
http://www.annalsofintensivecare.com/content/1/1/1

Annals of Intensive Care
a SpringerOpen Journal

REVIEW Open Access

Hemodynamic parameters to guide fluid therapy

Paul E Marik[1*], Xavier Monnet[2], Jean-Louis Teboul[2]

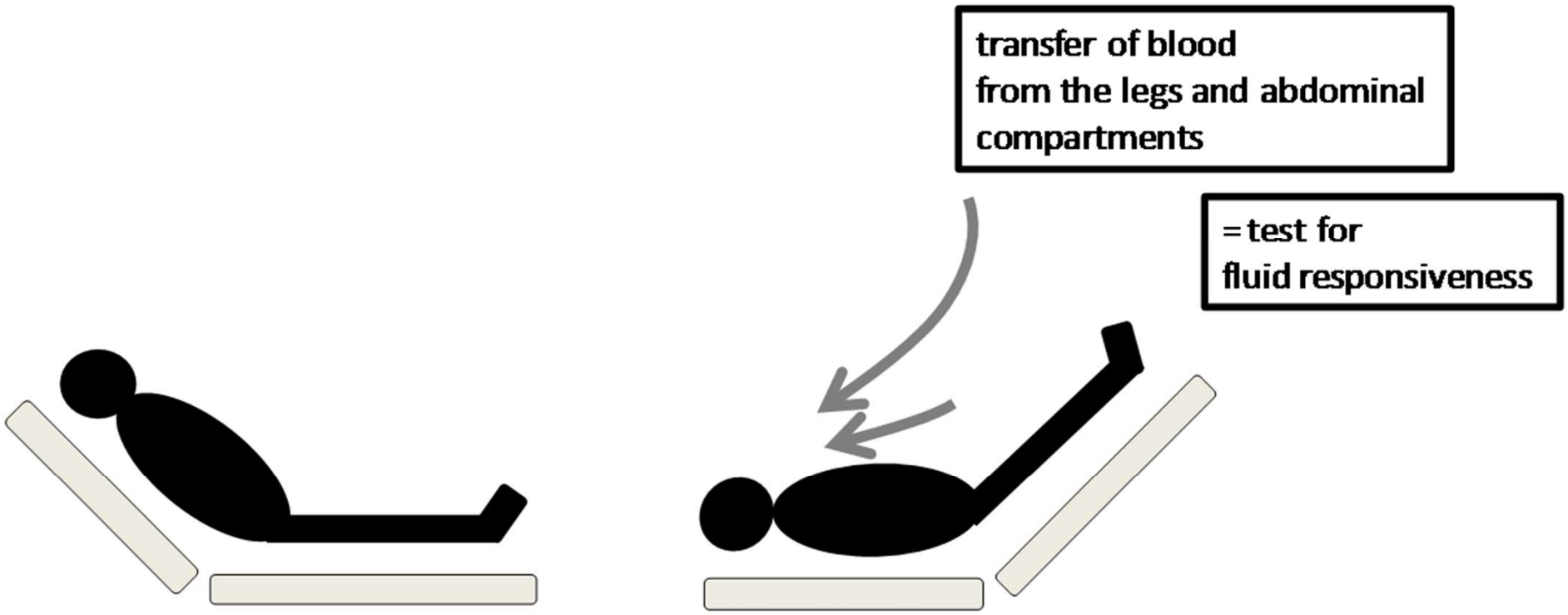
Method	Technology	AUC*
Pulse pressure variation (PPV)	Arterial waveform	0.94 (0.93-0.95)
Systolic pressure variation (SPV)	Arterial waveform	0.86 (0.82-0.90)
Stroke volume variation (SVV)	Pulse contour analysis	0.84 (0.78-0.88)
Left ventricular end-diastolic area (LVEDA)	Echocardiography	0.64 (0.53-0.74)
Global end-diastolic volume (GEDV)	Transpulmonary thermodilution	0.56 (0.37-0.67)
Central venous pressure (CVP)	Central venous catheter	0.55 (0.48-0.62)

Passive/Straight leg raising

- **Transferring a volume of 300 – 500 mL of venous blood from the lower body toward the right heart**

- **PLR mimics a fluid challenge**

- **Advantage**
  - **> No fluid is infused – reduce risk of fluid overload**
  - **> Hemodynamic effects rapidly reversible**
  - **> Can be used**
    - **> spontaneously breathing patients (intubated and non intubated)**
    - **> arrhythmias**

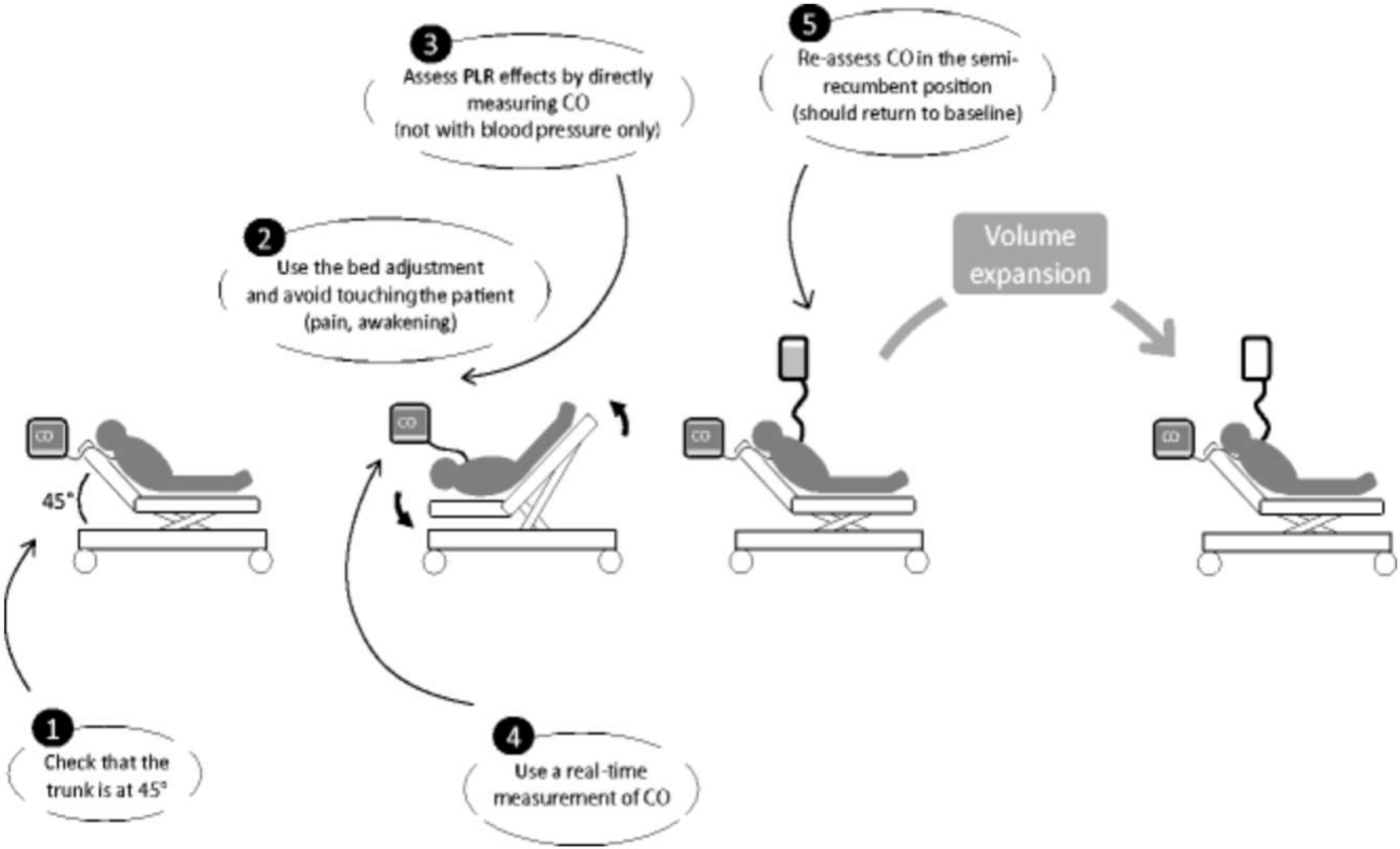


passive leg raising

Passive leg raising: five rules, not a drop of fluid!

Xavier Monnet and Jean-Louis Teboul

Critical Care 2015 **19**:18



- **No side effects**
- **Should be considered as a replacement for the classic fluid challenge**
- **Challenge preload without administering one drop of fluid**
- **A negative PLR**

  → decision to stop or discontinue fluid infusion

  → hemodynamic instability should be corrected by means other than fluid

Echo
Assessment of Fluid Status

- **ECHO provides static and dynamic volume assessment.**
- **Static assessment → measurement of the IVC/SVC/IJV**
- **Dynamic assessment → collapsibilty of the IVC/ SVC/IJV during respiration is a dynamic measure of fluid responsiveness**
- **75% collapse of the IVC during respiration is an indicator of hypovolemia**

- **75% collapse of the IVC during respiration is an indicator of hypovolemia**

- **15% variation in IVC diameter → adequate volume loading**

- **A caveat**
  → pathology that impact filling of the right heart
  - right-sided heart failure
  - cardiac tamponade
  - pulmonary embolism

- **Pressure overload and diminished venous return to the heart**

Echo
Assessment of cardiac function

- **Determine ventricular function (systolic and diastolic)**
- **Assesses for pericardial fluid and structural abnormalities**
- **Information regarding pulmonary physiology**
- **Realtime information on response to therapy.**

Algorithm for Rapid Cardiac and Volume Assessment by ECHO

Type 1: "Vasodialted/High-Output" Hyperdynamic, high-output, vasodialted	**EF: >70%, CI:>3.5, SVi: > 45,** HR: Any, often >90 and <110 LV/RV eye: full LViDi: norm/low-normal IVCd: <2cm IVCΔ: 25%-50%, >50% SVV:10-15%, >15% **SVR: (<800)**
Type 2: "Hummingbird Heart" Normal/hyperdynamic function, low SV, small, taccycardic	EF: >55%, often>70%, CI: <3.5, **SVi: <35** HR: >100 **LV/RV eye: small LViDi:** low IVCd: <2cm IVCΔ: >50% SVV: >15% SVR: >800
Type 3: "Normal X 3" Normal function, normal volume status, normal resistance	EF: 55-70%, CI: 2.5-4, **SVi: >35** HR: <100, LV/RV eye: full LViDi: norm IVCd:1-2cm IVCΔ: 25-50% SVV: 10-15% SVR: (800-1200)
Type 4: "Dysfunctional Heart" Moderate or severe LV or RV systolic dysfunction	**EF:** ≤40%, CI: <3, **SVi: <35,** HR: Any RV: moderate/severe dysfunction LV/RV eye: full , LViD: norm/high, IVCd: >2cm IVCΔ: <50 SVV: <15% SVR: Any, usually >1200

CRITICAL CARE

REVIEW

Clinical review: Does it matter which hemodynamic monitoring system is used?

Davinder Ramsingh, Brenton Alexander and Maxime Cannesson*

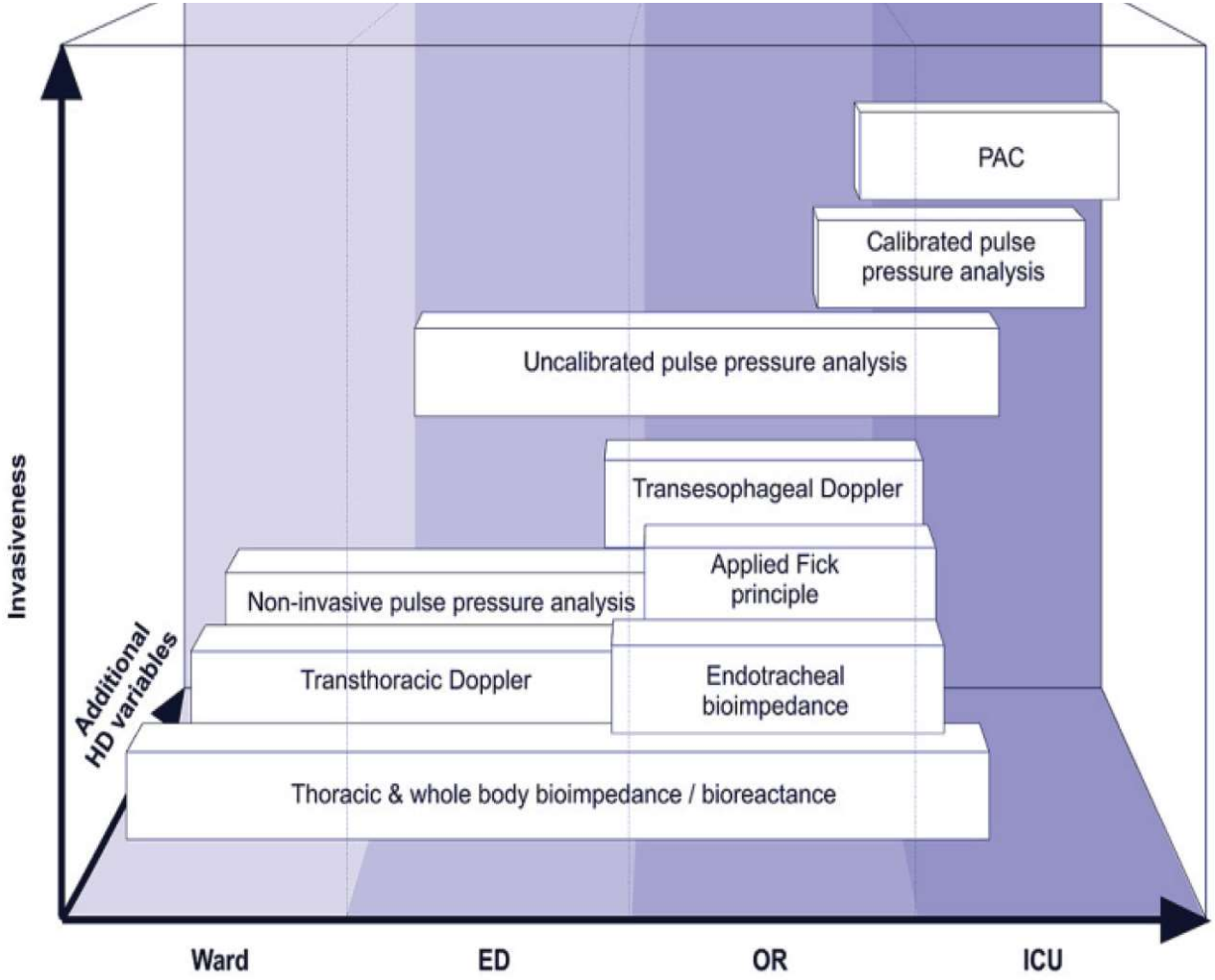


Figure 3. Integrative hemodynamic monitoring approach. ED, emergency department; HD, hemodynamic; OR, operating room; PAC,

‘Finally, no monitoring tool, no matter how accurate, by itself has improved patient outcome”

Michael Pinsky


Thank you!