When is non-invasive monitoring not enough in shock states?

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Conflicts of interest

- Member of the Medical Advisory Board of **Getinge**
- Lectures for **Edwards LifeSciences**
- Lectures for **Masimo**
- Lectures for **Cheetah**

Various and intricate mechanisms responsible for hemodynamic failure during sepsis

hypovolemia → **fluids**

vascular tone depression → presence of associated **ARDS** → **vasopressors**

myocardial depression → **inotropes**

- Important to assess the **degree** of each **component** to select the most **appropriate therapeutic** option
- Important to assess the **response to treatment**

Intensive Care Med (2016) 42:1350–1359
CONFERENCE REPORTS AND EXPERT PANEL

Less invasive hemodynamic monitoring in critically ill patients

Jean-Louis Teboul[1*], Bernd Saugel[2], Maurizio Cecconi[3], Daniel De Backer[4], Christoph K. Hofer[5], Xavier Monnet[1], Azriel Perel[6], Michael R. Pinsky[7], Daniel A. Reuter[2], Andrew Rhodes[3], Pierre Squara[8], Jean-Louis Vincent[9] and Thomas W. Scheeren[10]

Intensive Care Med (2014) 40:1795–1815
CONFERENCE REPORTS AND EXPE

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 and hemodynamic monito of the European Society o Medicine

REVIEW

How can assessing hemodynamics help to assess volume status?

Daniel De Backer[1*], Nadia Aissaoui[2], Maurizio Cecconi[3,4], Michelle S. Chew[5], André Denault[6,7], Ludhmila Hajjar[8], Glenn Hernandez[9], Antonio Messina[3,4], Sheila Nainan Myatra[10], Marlies Ostermann[11], Michael R. Pinsky[12], Jean-Louis Teboul[13], Philippe Vignon[14], Jean-Louis Vincent[15] and Xavier Monnet[13]

Intensive Care Med (2022) 48:1482–1494

REVIEW Open Access

Effective hemodynamic monitoring

Michael R. Pinsky[1*], Maurizio Cecconi[2,3], Michelle S. Chew[4], Daniel De Backer[5], Ivor Douglas[6], Mark Edwards[7], Olfa Hamzaoui[8], Glenn Hernandez[9], Greg Martin[10], Xavier Monnet[11], Bernd Saugel[12], Thomas W. L. Scheeren[13], Jean-Louis Teboul[14] and Jean-Louis Vincent[15]

Critical Care (2022) 26:294

Intensive Care Med (2016) 42:1350–1359

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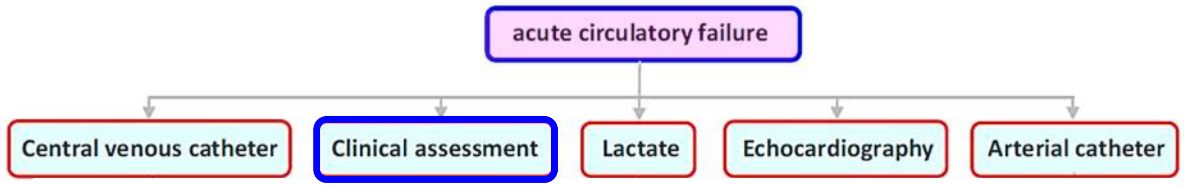

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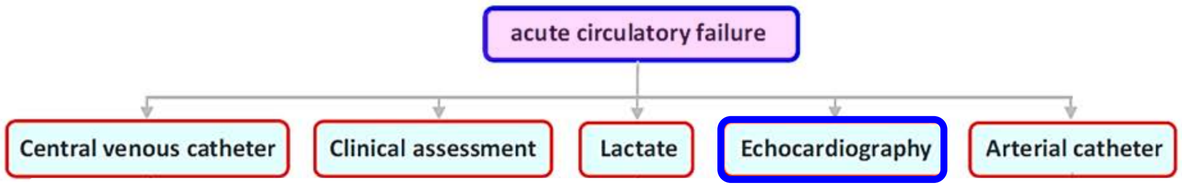

intermittent measurements of several **cardiac function** variables

Intensive Care Med (2016) 42:1350–1359

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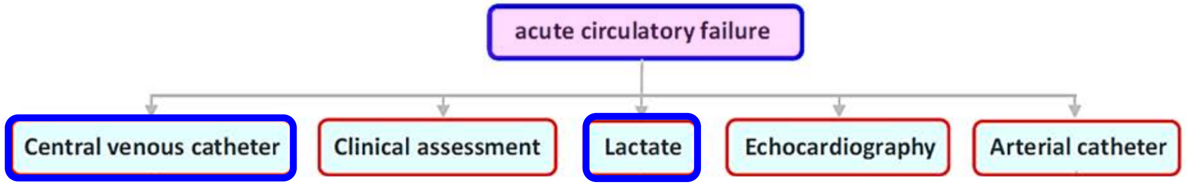
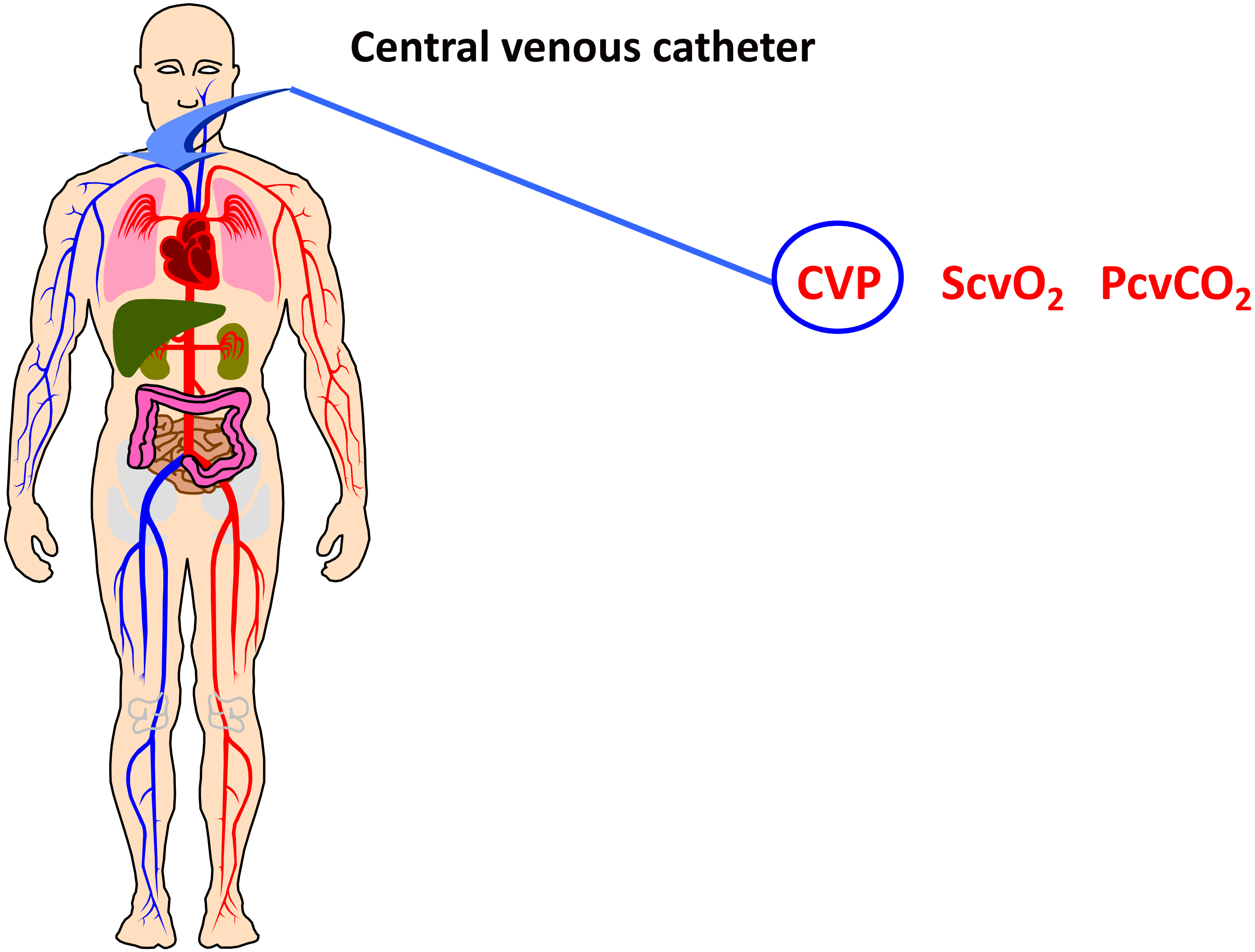




Central venous catheter
CVP
$ScvO_2$
$PcvCO_2$

SPECIAL ISSUE INSIGHT

Central venous pressure (CVP)

Olfa Hamzaoui[1*] and Jean-Louis Teboul[2,3]

Intensive Care Med (2022) 48:1498–1500

Take home messages

Central venous pressure is a **pivotal** hemodynamic **variable**, since it provides important **information** on the **RV function** and on the **mean organ perfusion pressure**

SPECIAL ISSUE INSIGHT

Central venous pressure (CVP)

Olfa Hamzaoui[1*] and Jean-Louis Teboul[2,3]

Intensive Care Med (2022) 48:1498–1500

Take home messages

Central venous pressure is a **pivotal** hemodynamic **variable**, since it provides important **information** on the **RV function** and on the **mean organ perfusion pressure**

Low mean perfusion pressure is a risk factor for progression of acute kidney injury in critically ill patients – A retrospective analysis

Marlies Ostermann[1*], Anna Hall[2] and Siobhan Crichton[3]

BMC Nephrology (2017) 18:151

Mean perfusion pressure (MPP = MAP-CVP) but **not MAP** was an independent factor associated with **AKI progression**.

A value of **MPP** of **60 mmHg** was found as a cutoff.

SPECIAL ISSUE INSIGHT

Central venous pressure (CVP)

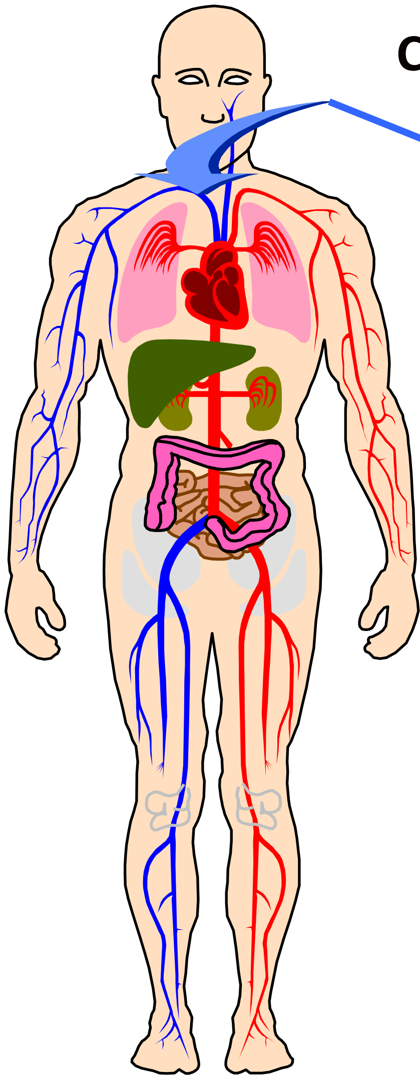
Olfa Hamzaoui[1*] and Jean-Louis Teboul[2,3]

Intensive Care Med (2022) 48:1498–1500

Take home messages

Central venous pressure is a **pivotal** hemodynamic **variable**, since it provides important **information** on the **RV function** and on the **mean organ perfusion pressure**. **CVP cannot** be used to **predict fluid responsiveness**

Central venous catheter



CVP **$ScvO_2$** **$PcvCO_2$**

$$SvO_2 = SaO_2 - \frac{VO_2}{CO \times Hb \times 13.4}$$

Intensive Care Med (2016) 42:1350–1359

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$ScvO_2$ is used as a surrogate of mixed venous blood oxygen saturation (SvO_2), which reflects in real time the balance between oxygen consumption and oxygen delivery.

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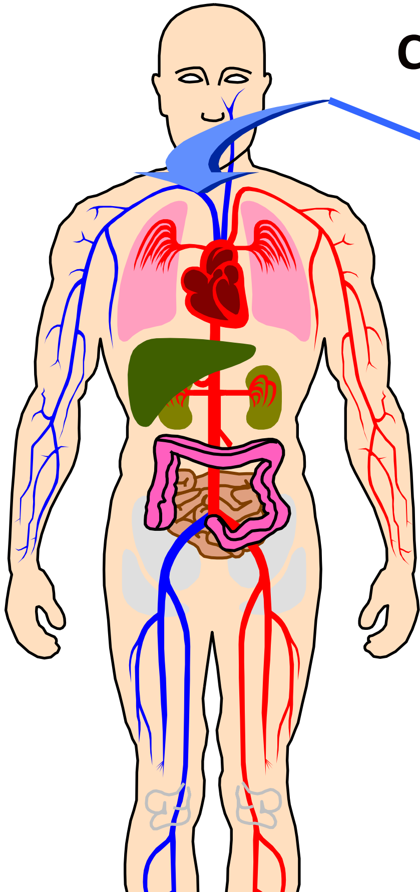
$ScvO_2$ is used as a surrogate of mixed venous blood oxygen saturation (SvO_2), which reflects in real time the balance between oxygen consumption and oxygen delivery. Hence, a low $ScvO_2$ may indicate insufficient global oxygen delivery in case of shock and incite one to increase it.



Central venous catheter

CVP **$ScvO_2$** **$PcvCO_2$**

simplified Fick equation

$$PcvCO_2 - PaCO_2 = k \cdot \frac{VCO_2}{\text{Cardiac Output}}$$

$PcvCO_2$ - $PaCO_2$ marker of the "**adequacy**" of the **venous blood flow** to **clear** the **CO_2 produced** in the **peripheral tissues**

REVIEW Open Access

In some forms of distributive shock, $ScvO_2$ can be > 70% despite ongoing CVI due to impairment of oxygen extraction [84, 86]. A v-aPCO_2 > 6 mmHg (or > 0.8 kPa) identifies patients for whom an increase in CO may be beneficial in sustaining organ perfusion despite a SvO_2 > 70%. If the v-aPCO_2 is < 6 mmHg (or < 0.8 kPa), it is unlikely that increasing CO would reverse organ hypoperfusion.

- A **high PCO_2** gap suggests that **elevation** of **CO can** be a **good** therapeutic option

- A **normal PCO_2** gap suggests that **elevation** of **CO cannot** be a **priority** in the therapeutic strategy

Intensive Care Med (2016) 42:1350–1359

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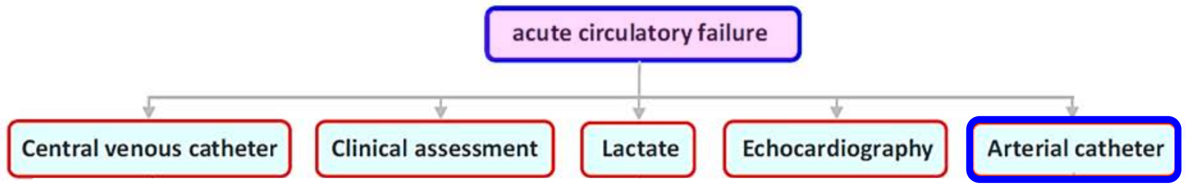

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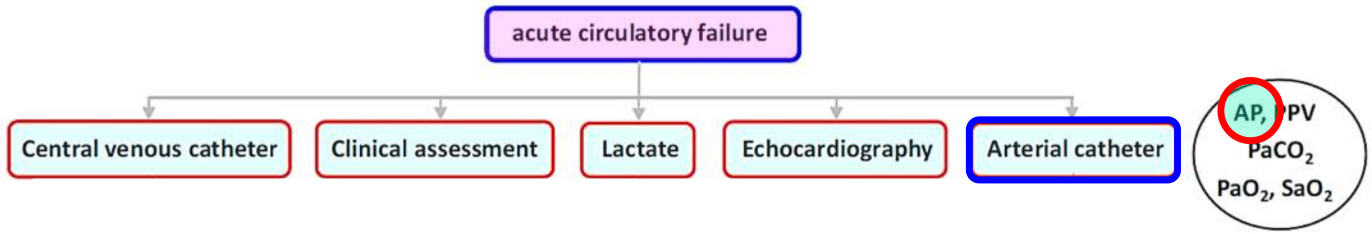
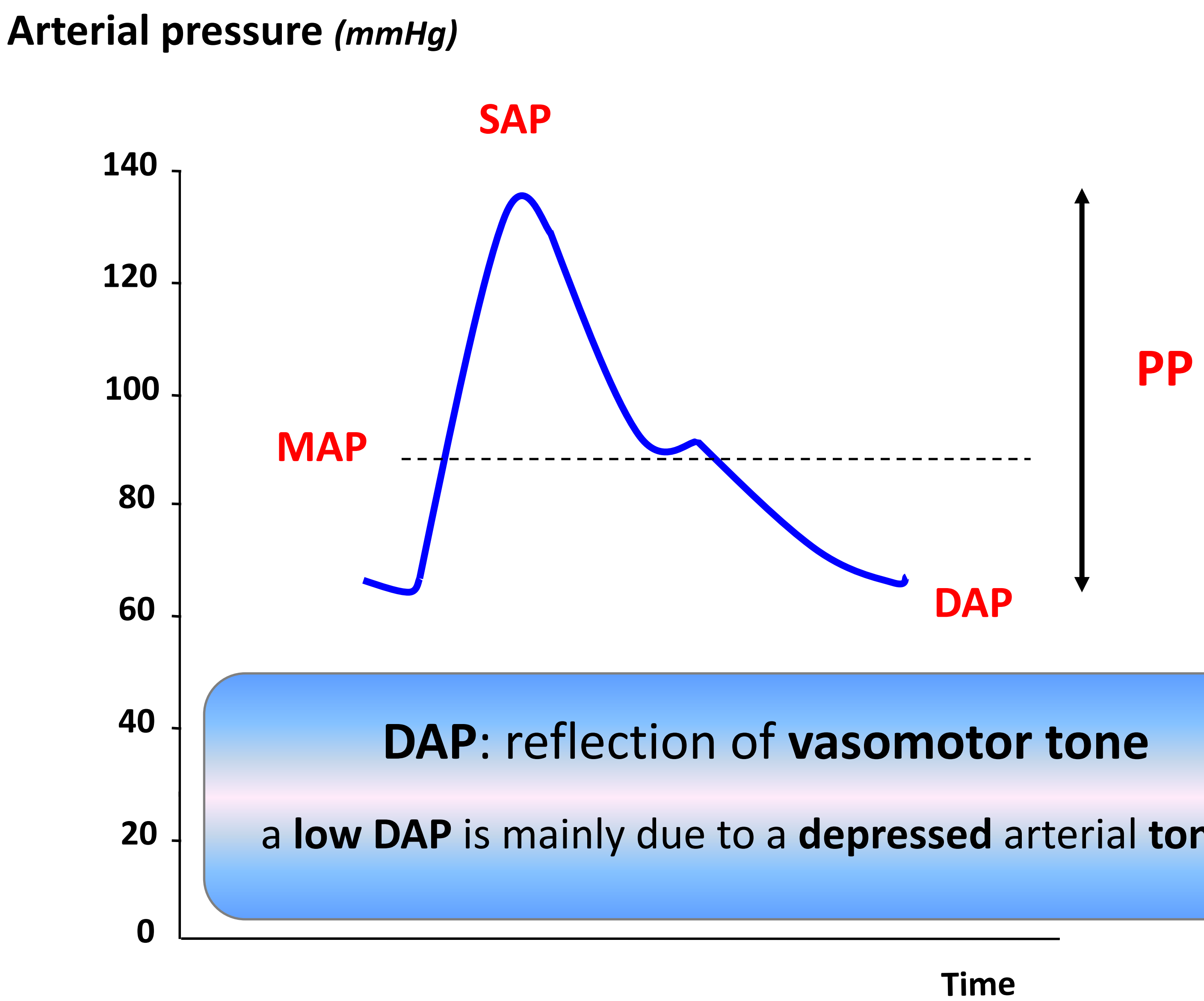
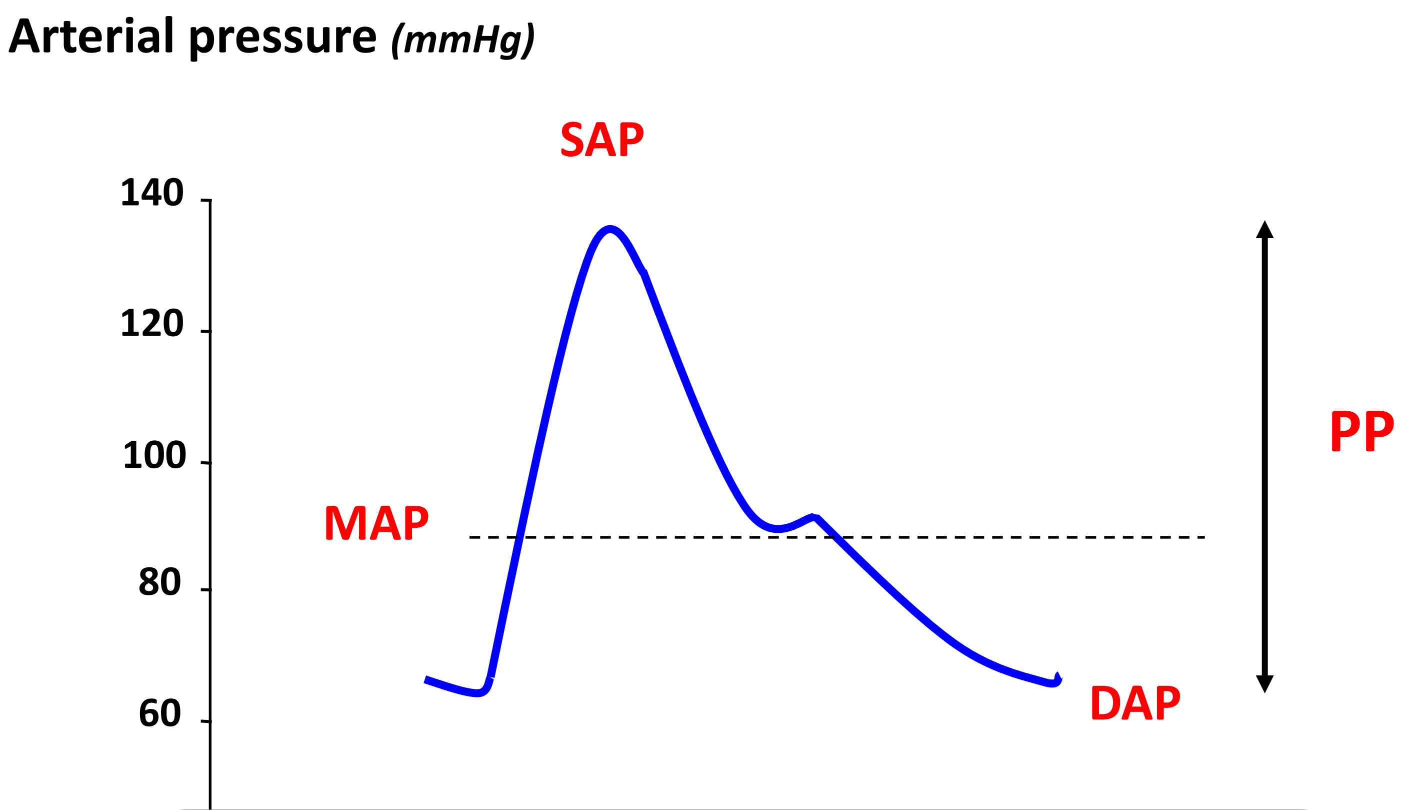




DAP: reflection of **vasomotor tone**

a **low DAP** is mainly due to a **depressed** arterial **tone**



PP depends on **stroke volume** and **arterial stiffness**

PP is **high** in cases of **stiff** arteries (for a normal SV)

Intensive Care Med (2016) 42:1350–1359

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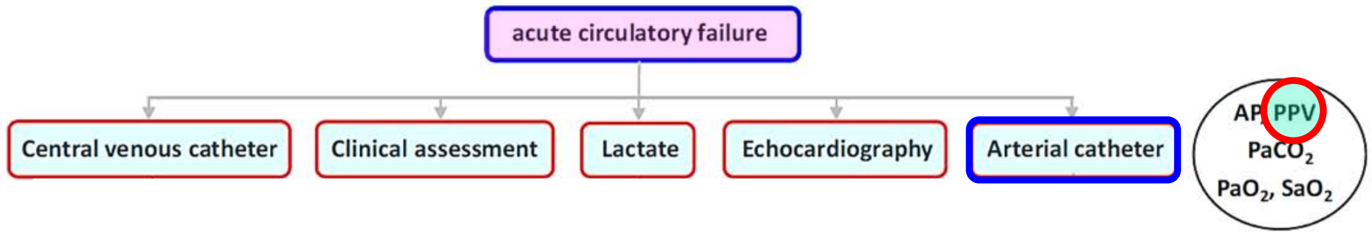
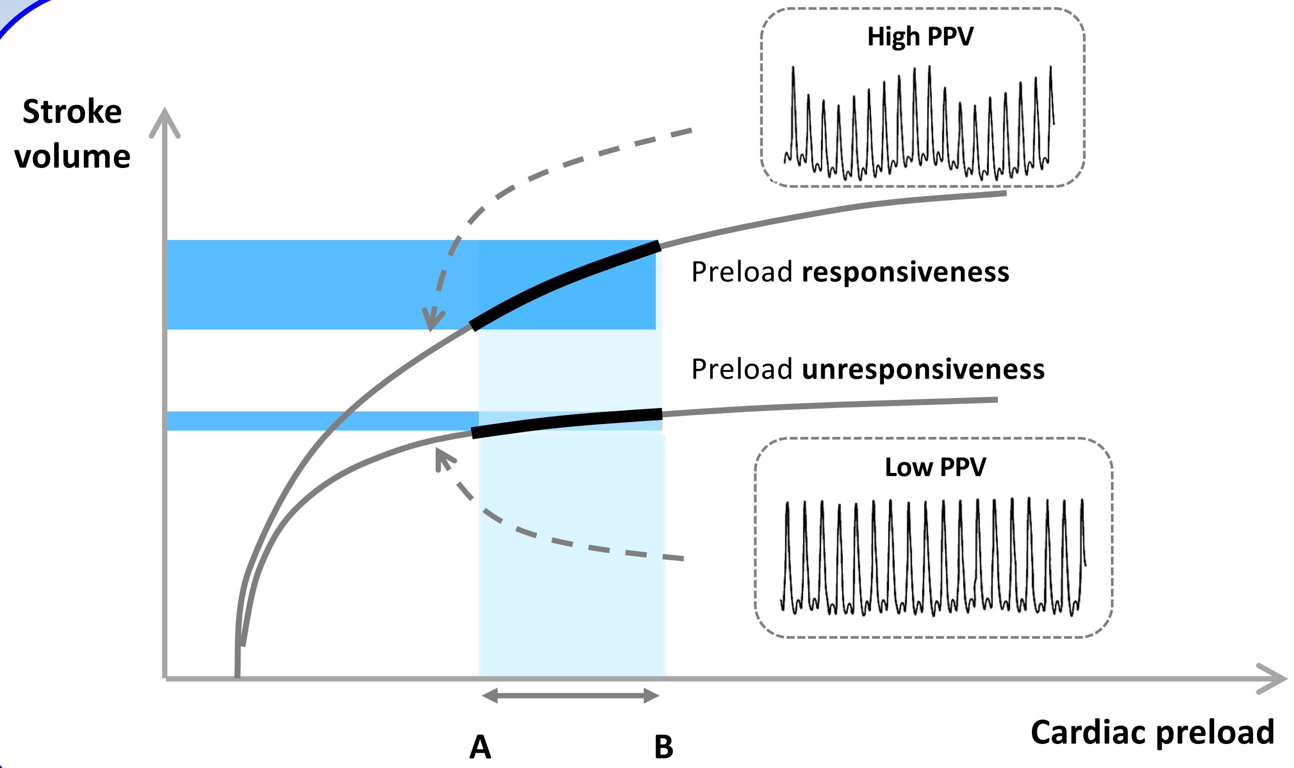


Arterial Pulse Pressure Variation with Mechanical Ventilation

Jean-Louis Teboul[1], Xavier Monnet[1], Denis Chemla[2], and Frédéric Michard[3]

Am J Respir Crit Care Med Vol 199, Iss 1, pp 22–31, Jan 1, 2019



Applicability of pulse pressure variation: how many shades of grey?

Frederic Michard[1*], Denis Chemla[2] and Jean-Louis Teboul[3]

Critical Care (2015) 19:144

		False positive	False negative
L	**Low** HR/RR ratio (Extreme bradycardia or high frequency ventilation)		✓
I	**Irregular** heart beats	✓	
M	**Mechanical** ventilation with low tidal volume		✓
I	**Increased** abdominal Pressure (Pneumoperitoneum)	✓	
T	**Thorax** open		✓
S	**Spontaneous** breathing	✓	✓

The Changes in Pulse Pressure Variation or Stroke Volume Variation After a "Tidal Volume Challenge" Reliably Predict Fluid Responsiveness During Low Tidal Volume Ventilation*

Sheila Nainan Myatra, MD, FCCM[1]; Natesh R Prabu, MD, DM[1]; Jigeeshu Vasishtha Divatia, MD, FCCM[1]; Xavier Monnet, MD, PhD[2]; Atul Prabhakar Kulkarni, MD, FICCM[1]; Jean-Louis Teboul, MD, PhD[2]

Crit Care Med 2017; 45:415–421

Tidal volun

Transient (1

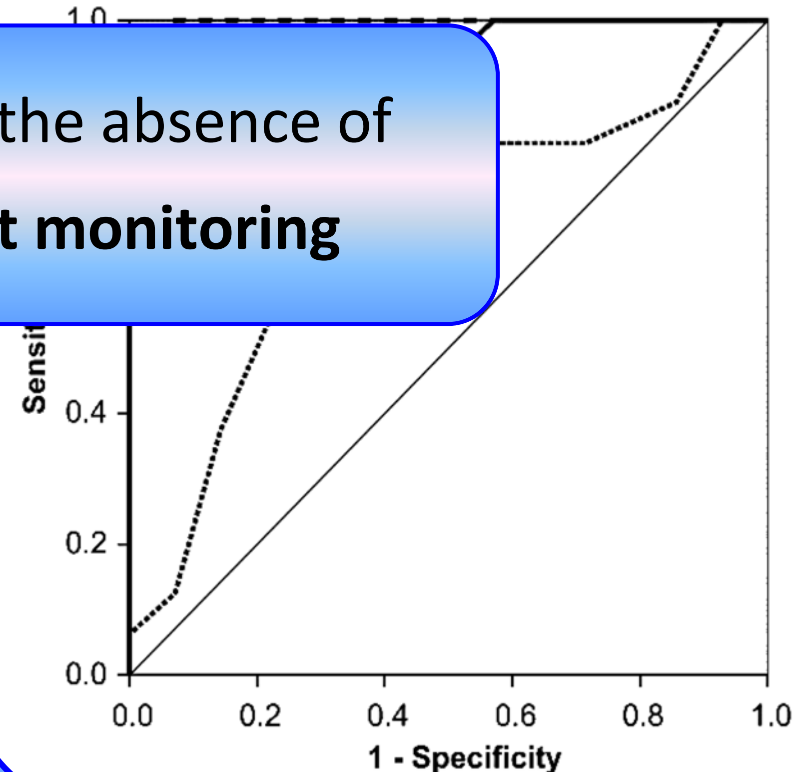
in **tidal volume**

from **6** to **8 mL/kg**

Very **helpful** in the absence of

cardiac output monitoring

$PPV_8 - PPV_6$ cut-off 3.5

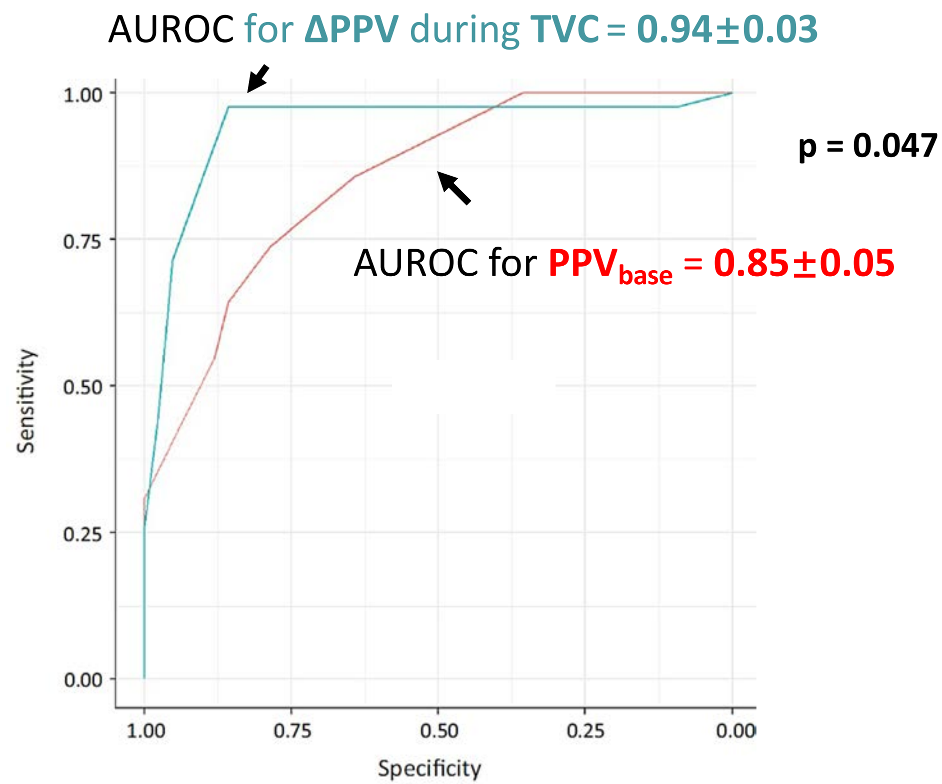


RESEARCH **Open Access**

Tidal volume challenge to predict preload responsiveness in patients with acute respiratory distress syndrome under prone position

Rui Shi[1], Soufia Ayed[1], Francesca Moretto[1], Danila Azzolina[2], Nello De Vita[1], Francesco Gavelli[1], Simone Carelli[1], Arthur Pavot[1], Christopher Lai[1], Xavier Monnet[1] and Jean-Louis Teboul[1*]

Critical Care (2022) 26:219



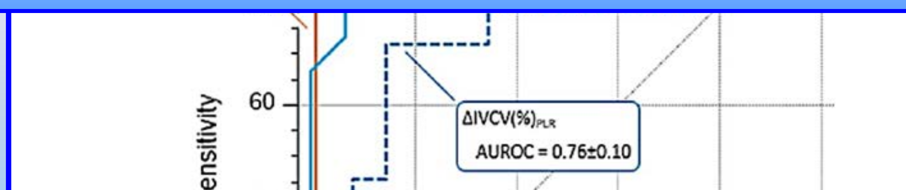
RESEARCH Open Access

Do changes in pulse pressure variation and inferior vena cava distensibility during passive leg raising and tidal volume challenge detect preload responsiveness in case of low tidal volume ventilation?

Temistocle Taccheri*, Francesco Gavelli, Jean-Louis Teboul, Rui Shi and Xavier Monnet

Crit Care (2021) 25:110

Very **helpful** in the absence of **cardiac output monitoring**



A **decrease** in **PPV** during **PLR** is **reliable** to predict fluid responsiveness

Intensive Care Med (2016) 42:1350–1359

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Less invasive hemodynamic monitoring in critically ill patients

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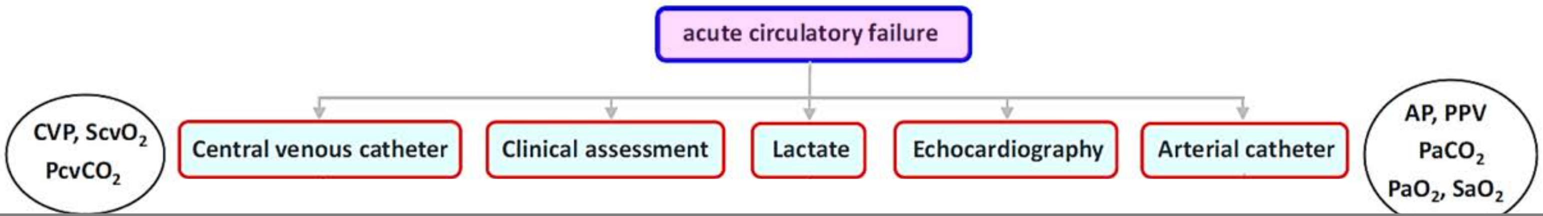

This **basic** monitoring should be **enough** for the **simplest** cases

Advanced monitoring is indicated in complex cases

Intensive Care Med (2014) 40:1795–1815

CONFERENCE REPORTS AND EXPERT PANEL

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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

We suggest the use of **transpulmonary thermodilution** or **PAC**

in patients with severe shock especially in the case of associated **ARDS**

Level 2; QoE low (C)

REVIEW

Open Access

Check for updates

Effective hemodynamic monitoring

Michael R. Pinsky[1*], Maurizio Cecconi[2,3], Michelle S. Chew[4], Daniel De Backer[5], Ivor Douglas[6], Mark Edwards[7], Olfa Hamzaoui[8], Glenn Hernandez[9], Greg Martin[10], Xavier Monnet[11], Bernd Saugel[12], Thomas W. L. Scheeren[13], Jean-Louis Teboul[14] and Jean-Louis Vincent[15]

Critical Care *(2022) 26:294*

leading [80, 84]. Bedside echocardiographic evaluation is necessary to diagnose and direct the management of these patients in both a static and dynamic fashion but is not well suited to continual monitoring.

Intensive Care Med (2016) 42:1350–1359

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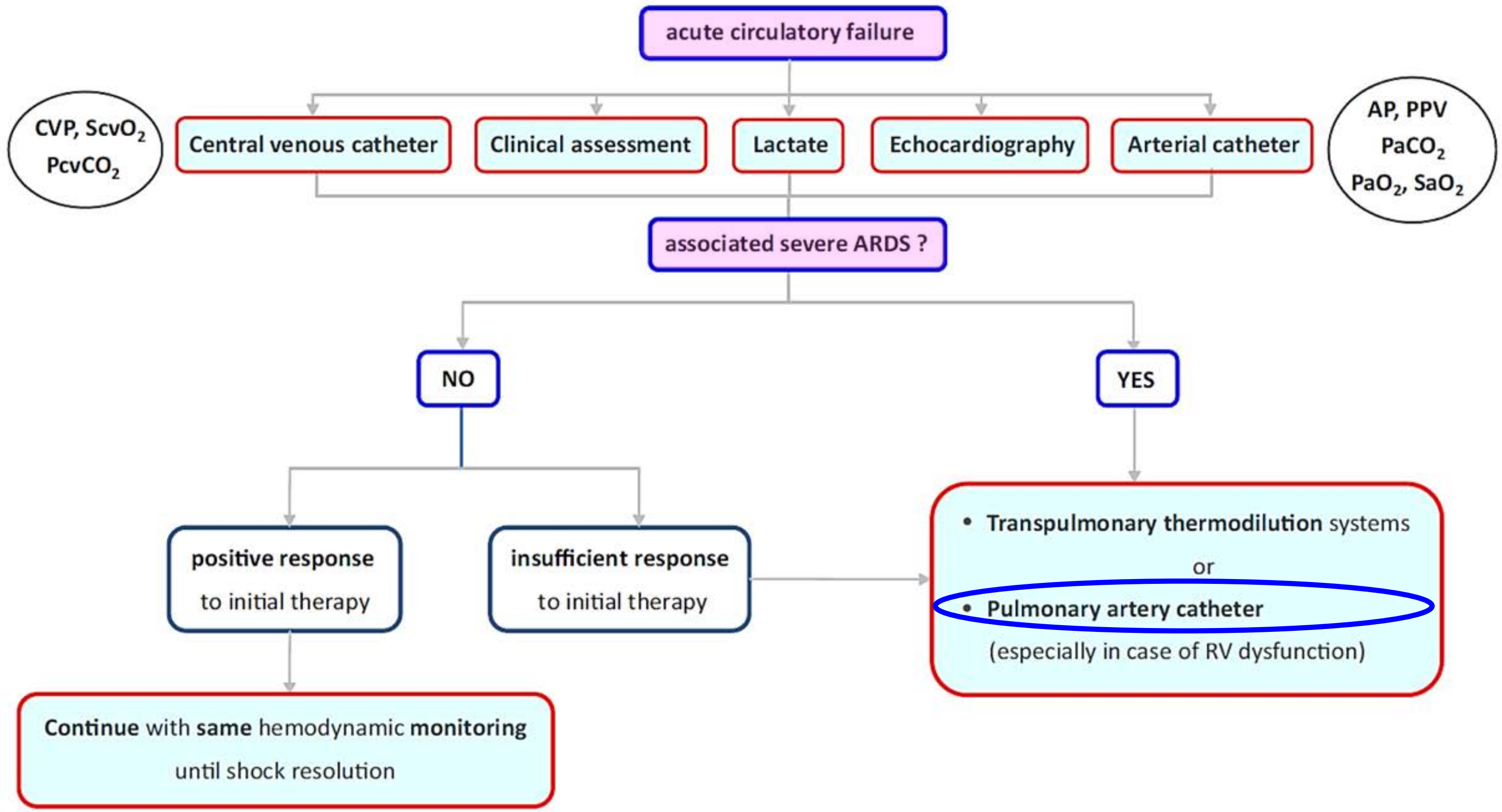

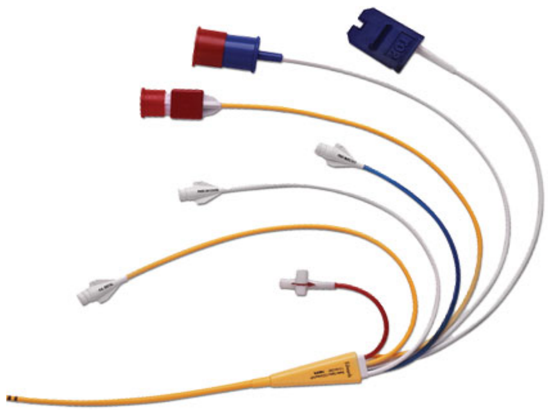

Intermittent and **semi-continuous CO**

+

Continuous SvO_2 monitoring

+

$PvCO_2$

+

Intermittent measurements of

RAP PAP PAOP

Intensive Care Med (2016) 42:1350–1359

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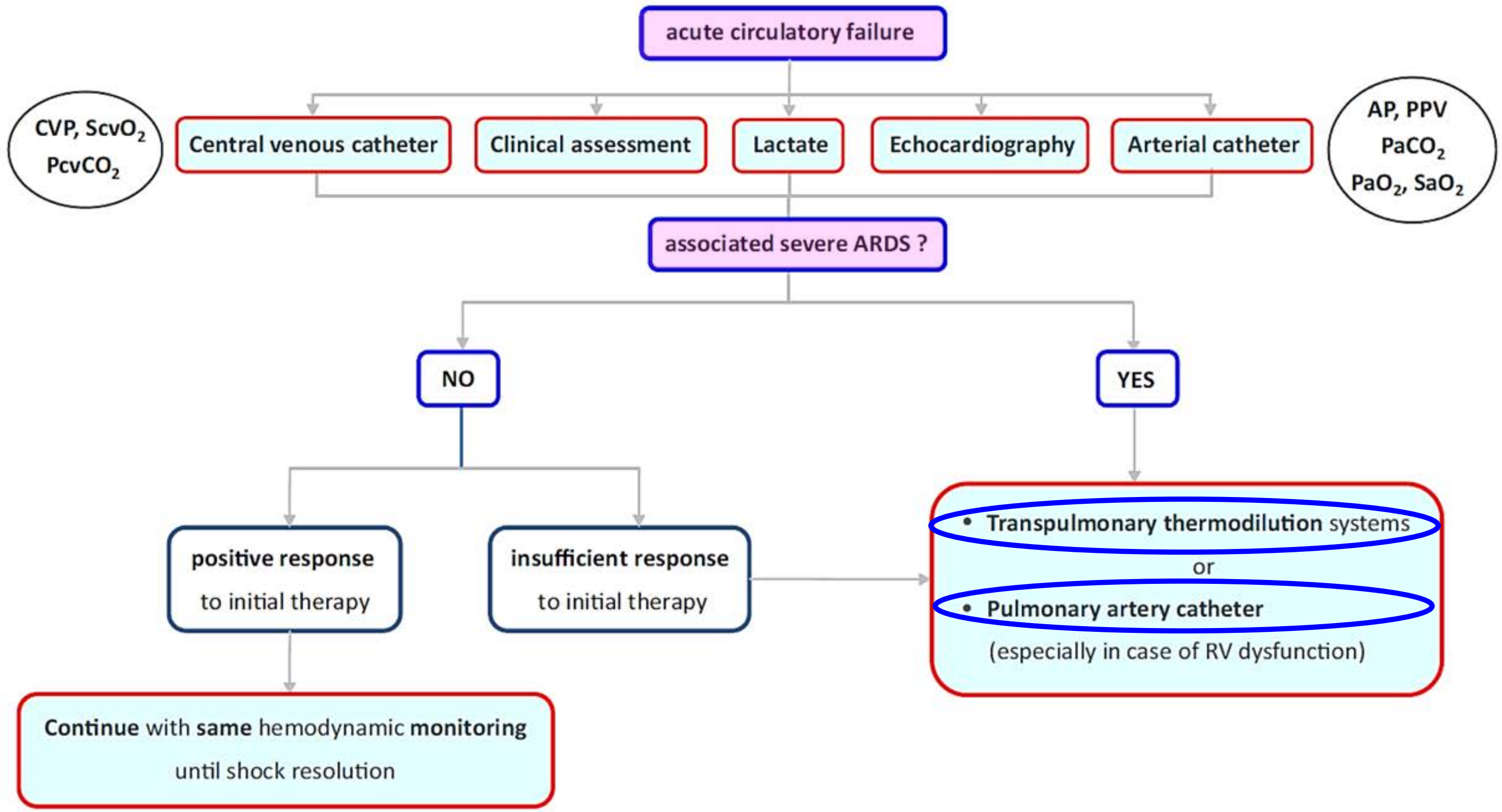
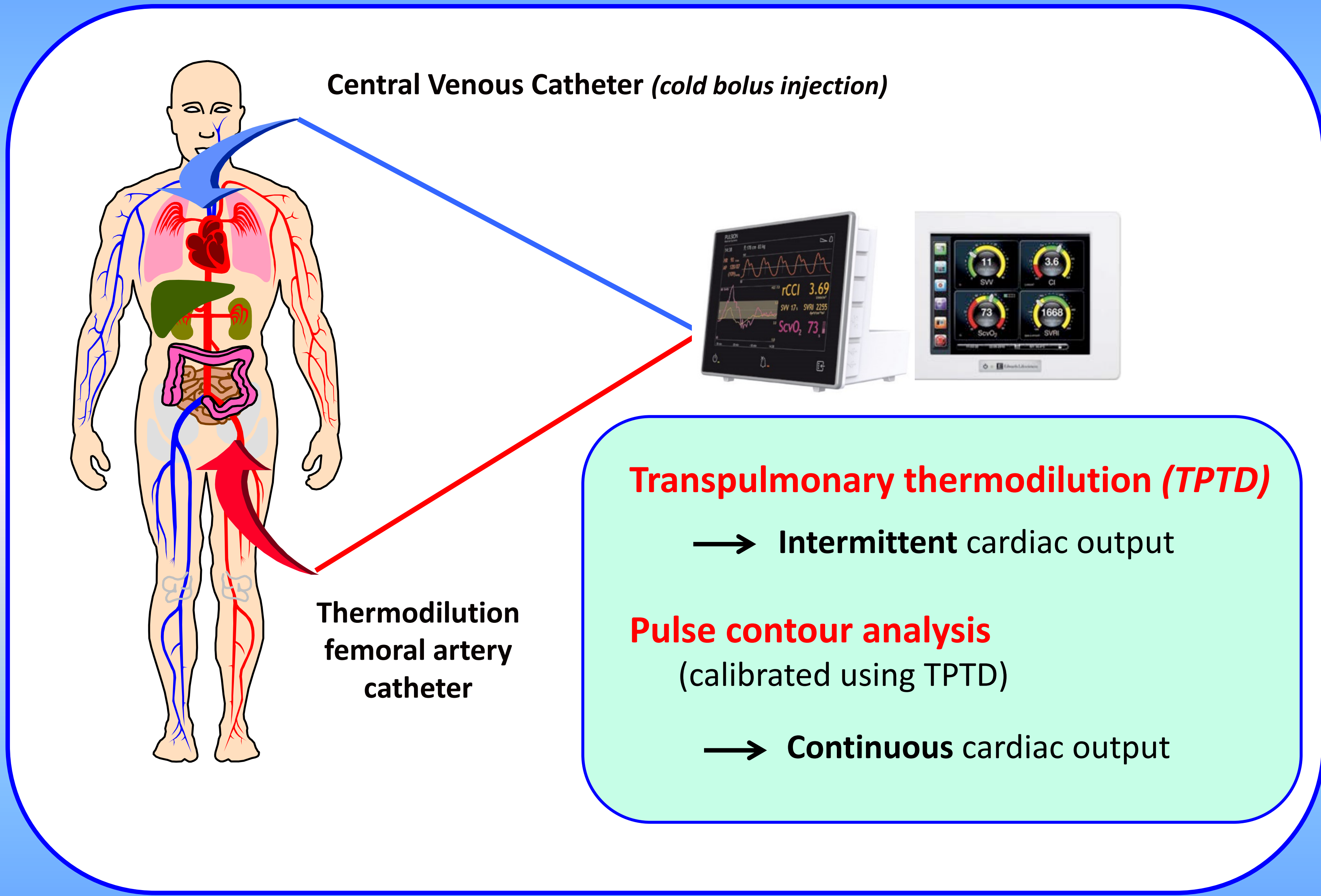
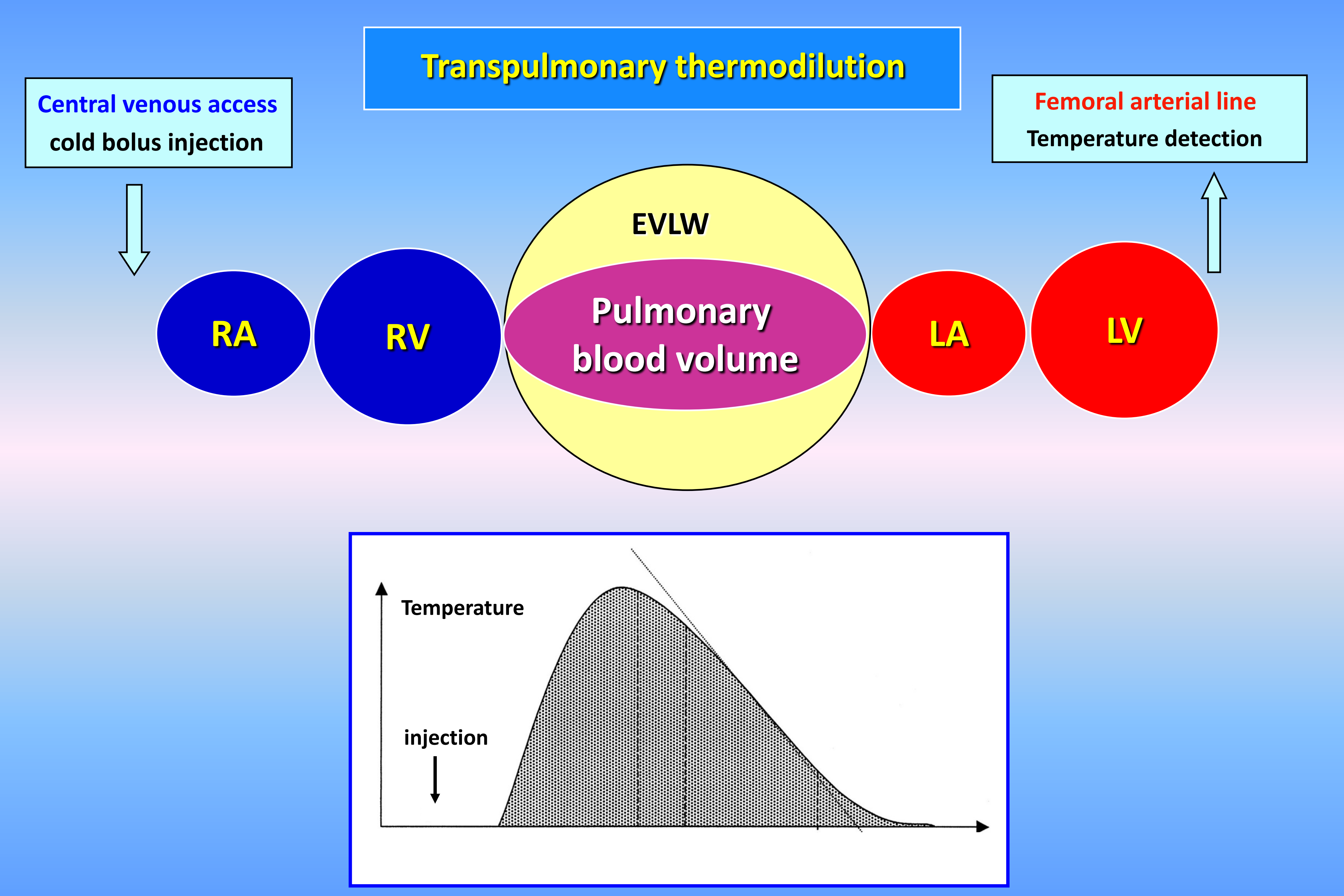



Central Venous Catheter (cold bolus injection)
Thermodilution femoral artery catheter
Transpulmonary thermodilution (TPTD)
Intermittent cardiac output
Pulse contour analysis
(calibrated using TPTD)
Continuous cardiac output



Transpulmonary thermodilution
Central venous access
cold bolus injection
Femoral arterial line
Temperature detection
EVLW
RA
RV
Pulmonary
blood volume
LA
LV
Temperature
injection

Cardiac Output Monitoring Using Indicator-Dilution Techniques: Basics, Limits, and Perspectives

Daniel A. Reuter, MD, PhD,* Cecil Huang, MD, PhD,† Thomas Edrich, MD, PhD,†
Stanton K. Shernan, MD,† and Holger K. Eltzschig, MD, PhD†‡§

Anesth Analg 2010;110:799–811

Table 2. Comparisons of Transcardiopulmonary Thermodilution Versus Pulmonary Artery Thermodilution Cardiac Output

	Study variables				Measures of agreement		
Investigators (y)	**Patient population**	**Ages**	***N***	***n***	***r***	**Bias**	**Precision**
Della Rocca et al. 2002[128]	Liver transplant	24–66	62	186	0.93	+1.9%	11%
Friesecke et al. 2009[129]	Severe heart failure	ni	29	325	ni	10.3%	27.3%
Goedje et al. 1999[87]	Cardiac surgery	41–81	24	216	0.93	+4.9%	11%
Holm et al. 2001[85]	Burns	19–78	23	109	0.97	+8.0%	7.3%
Kuntscher 2002[86]	Burns	21–61	14	113	0.81	ni	ni
McLuckie et al. 1996[84]	Pediatrics	1–8	10	60	ni	+4.3%	4.8%
Segal 2002[81]	Intensive care unit	27–79	20	190	0.91	+4.1%	10%
von Spiegel et al. 1996[80]	Cardiology	0.5–25	21	48	0.97	−4.7%	12%
Wiesenack et al. 2001[130]	Cardiac surgery	43–73	18	36	0.96	+7.4%	7.6%
Zöllner et al. 1999[67]	ARDS	19–75	18	160	0.91	−0.33%	12%

What is the precision

of the transpulmonary

thermodilution method?

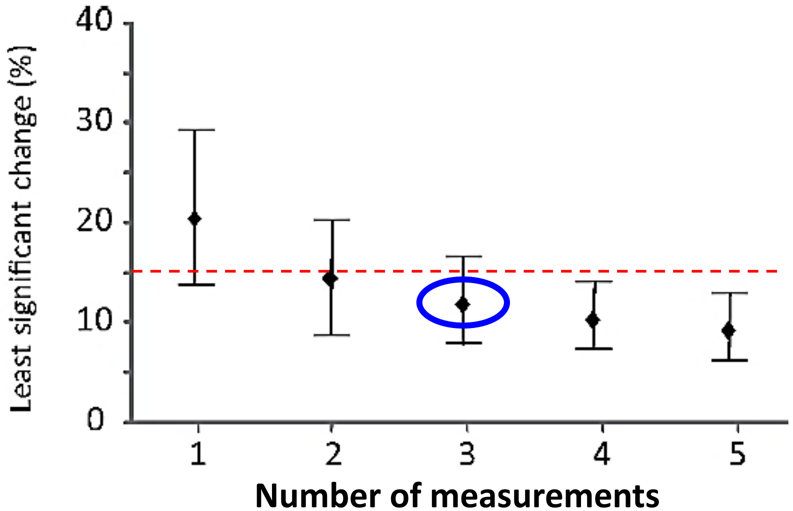
Precision of the transpulmonary thermodilution measurements

Xavier Monnet[1,2*], Romain Persichini[1,2], Mariem Ktari[1,2], Mathieu Jozwiak[1,2], Christian Richard[1,2] and Jean-Louis Teboul[1,2]

Critical Care 2011, **15**:R204

What are the **number** of cold bolus injections that are necessary for achieving **an acceptable level of precision** for measuring **cardiac output** ?

CO



For assessing a 15% change in CO one needs averaging three measurements

Transpulmonary thermodilution

systems are not just

CO monitoring systems

REVIEW

Transpulmonary thermodilution: advantages and limits

Xavier Monnet[1,2,3*] and Jean-Louis Teboul[1,2]

Critical Care (2017) 21:147

GEDV

a measure of global cardiac preload

Is **Global End-Diastolic Volume**

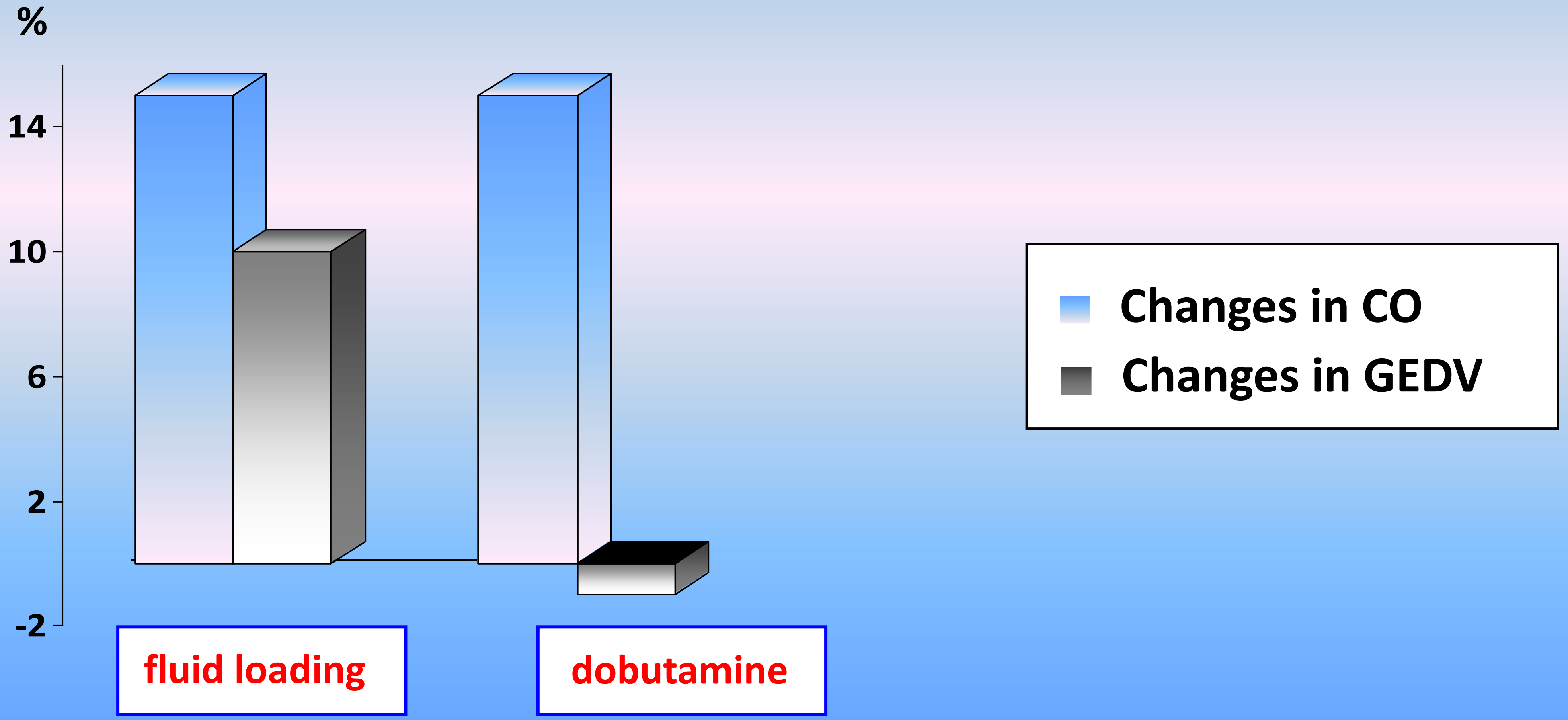
really a marker of **preload**?

Global End-Diastolic Volume as an Indicator of Cardiac Preload in Patients With Septic Shock*

Frédéric Michard, MD, PhD; Sami Alaya, MD; Véronique Zarka, MD; Mabrouk Bahloul, MD; Christian Richard, MD; and Jean-Louis Teboul, MD, PhD

CHEST 2003; 124:1900–1908

GEDV behaves as a marker of preload



REVIEW

Transpulmonary thermodilution: advantages and limits

Xavier Monnet[1,2,3*] and Jean-Louis Teboul[1,2]

Critical Care (2017) 21:147

CFI and GEF

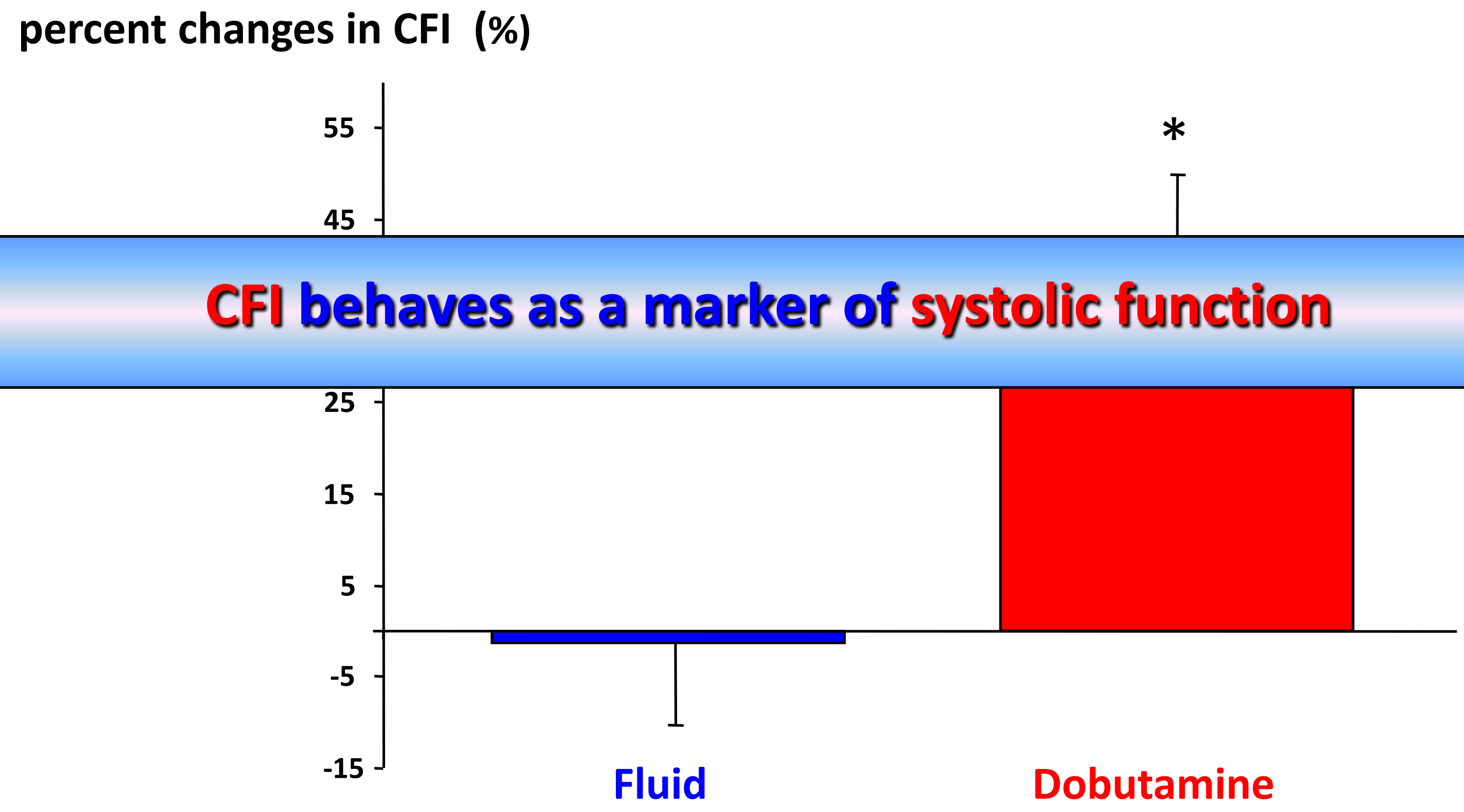
markers of

global systolic function

Cardiac function index provided by transpulmonary thermodilution behaves as an indicator of left ventricular systolic function

Julien Jabot, MD; Xavier Monnet, MD, PhD; Lamia Bouchra, MD, PhD; Denis Chemla, MD, PhD; Christian Richard, MD; Jean-Louis Teboul, MD, PhD

Crit Care Med 2009; 37:2913–2918

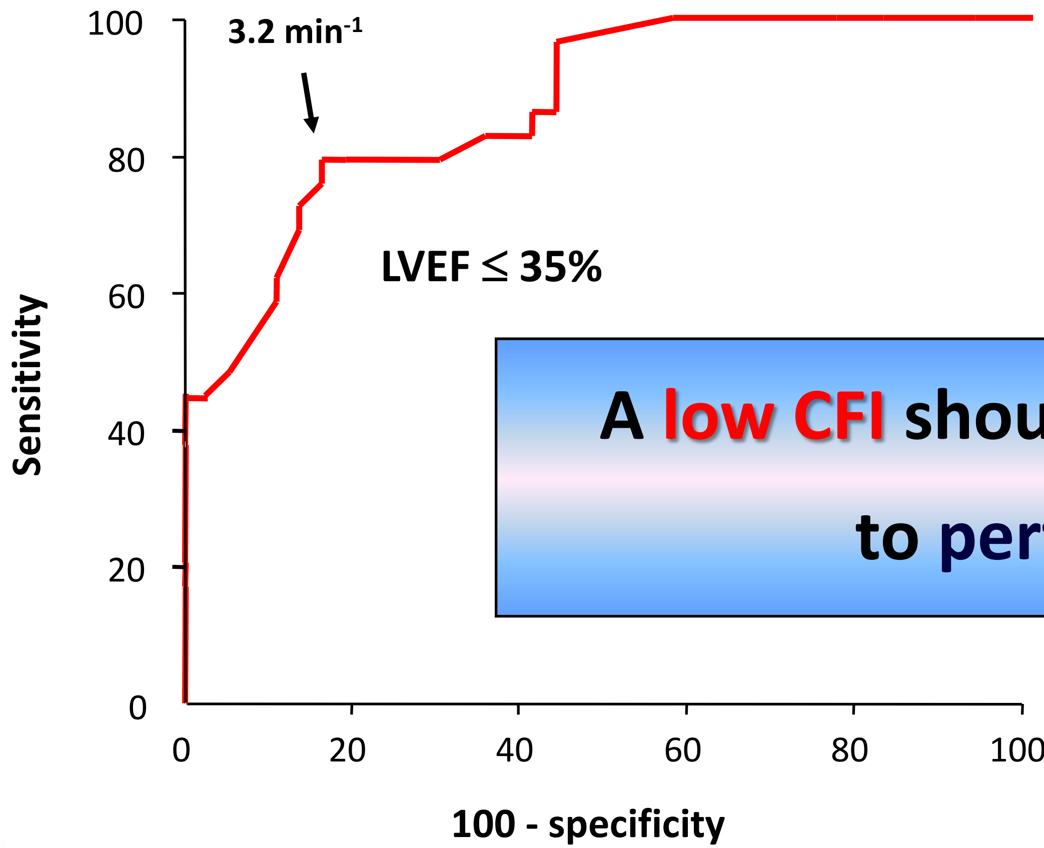


CFI behaves as a marker of systolic function

Cardiac function index provided by transpulmonary thermodilution behaves as an indicator of left ventricular systolic function

Julien Jabot, MD; Xavier Monnet, MD, PhD; Lamia Bouchra, MD, PhD; Denis Chemla, MD, PhD; Christian Richard, MD; Jean-Louis Teboul, MD, PhD

Crit Care Med 2009; 37:2913–2918



A low CFI should incite the clinician to perform an echo

REVIEW

Transpulmonary thermodilution: advantages and limits

Xavier Monnet[1,2,3*] and Jean-Louis Teboul[1,2]

Critical Care (2017) 21:147

Extravascular lung water

a quantitative measure of **lung edema**

RESEARCH Open Access

Extravascular lung water levels are associated with mortality: a systematic review and meta-analysis

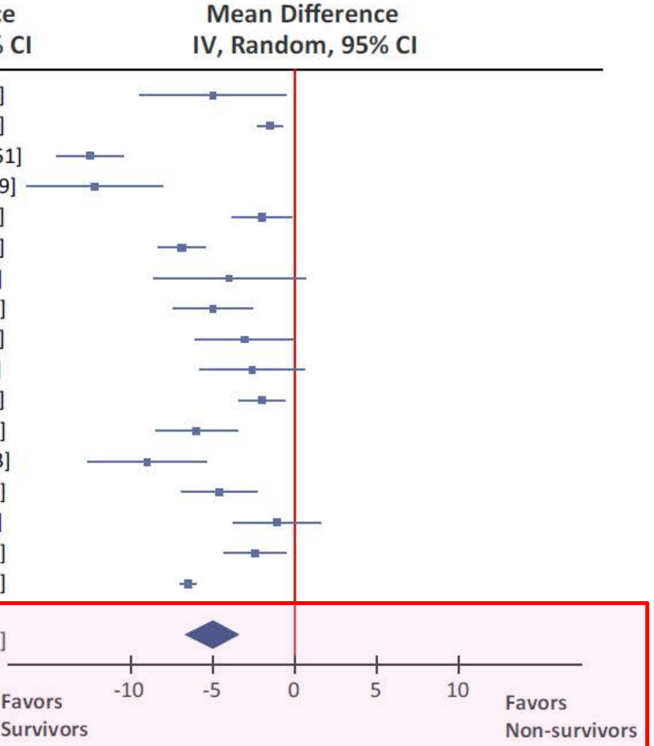
Francesco Gavelli[1,2†], Rui Shi[1,3*†], Jean-Louis Teboul[1,3], Danila Azzolina[4], Pablo Mercado[5], Mathieu Jozwiak[6,7], Michelle S. Chew[8], Wolfgang Huber[9], Mikhail Y. Kirov[10], Vsevolod V. Kuzkov[10], Tobias Lahmer[9], Manu L. N. G. Malbrain[11,12], Jihad Mallat[13,14], Samir G. Sakka[15], Takashi Tagami[16], Tài Pham[1,17] and Xavier Monnet[1,3]

Critical Care *(2022) 26:202*

Study ID	Survivors Mean	Survivors SD	Survivors Total	Non-survivors Mean	Non-survivors SD	Non-survivors Total	Weight	Mean Difference IV, Random, 95% CI
Brown 2013[33]	12	5	41	17	9	18	4.5%	-5.00 [-9.43, -0.57]
Chew 2012[31]	9.1	1.3	36	10.6	1.2	15	6.9%	-1.50 [-2.24, -0.76]
Chung 2008[28]	8.5	1.7	16	21	3.8	17	6.3%	-12.50 [-14.49, -10.51]
Chung 2010[29]	12.2	5.8	34	24.4	10.6	33	4.7%	-12.20 [-16.31, -8.09]
Cordemans 2012[13]	11.7	4.3	58	13.7	5.9	65	6.4%	-2.00 [-3.81, -0.19]
Craig 2010[30]	10.6	2.4	32	17.5	2	12	6.6%	-6.90 [-8.30, -5.50]
Huber 2020[36]	10	4	33	14	9	16	4.4%	-4.00 [-8.62, 0.62]
Jozwiak 2013[8]	19	7	92	24	10	108	6.0%	-5.00 [-7.37, -2.63]
Kuzkov 2006[7]	8	3	16	11.07	6.24	22	5.6%	-3.07 [-6.06, -0.08]
Ma 2019[35]	11.2	3.4	23	13.8	6.1	18	5.5%	-2.60 [-5.74, 0.54]
Mallat 2012[32]	14.5	1.6	32	16.5	3	23	6.7%	-2.00 [-3.35, -0.65]
Martin 2005[27]	8	3.7	17	14	3.1	12	6.0%	-6.00 [-8.48, -3.52]
Phillips 2008[11]	11.6	1.9	12	20.6	4.6	7	5.1%	-9.00 [-12.57, -5.43]
Shi 2021[37]	18.7	5.2	47	23.3	7.7	73	6.1%	-4.60 [-6.91, -2.29]
Tagami 2014[14]	20.7	7.3	133	21.8	9.2	59	5.8%	-1.10 [-3.76, 1.56]
Wang 2016[12]	12	4.4	45	14.4	5.3	60	6.4%	-2.40 [-4.26, -0.54]
Zhao 2015[34]	13	0.5	13	19.5	0.5	8	7.0%	-6.50 [-6.94, -6.06]
Total (95% CI)			680			566	100.0%	-4.97 [-6.54, -3.41]

Heterogeneity: $Tau^2 = 9.13$; $Chi^2 = 258.55$, df = 16 ($P < 0.00001$); $I^2 = 94\%$

Test for overall effect: Z = 6.22 ($P < 0.00001$)



REVIEW

Transpulmonary thermodilution: advantages and limits

Xavier Monnet[1,2,3*] and Jean-Louis Teboul[1,2]

Critical Care (2017) 21:147

Pulmonary vascular permeability index

(PVPI)

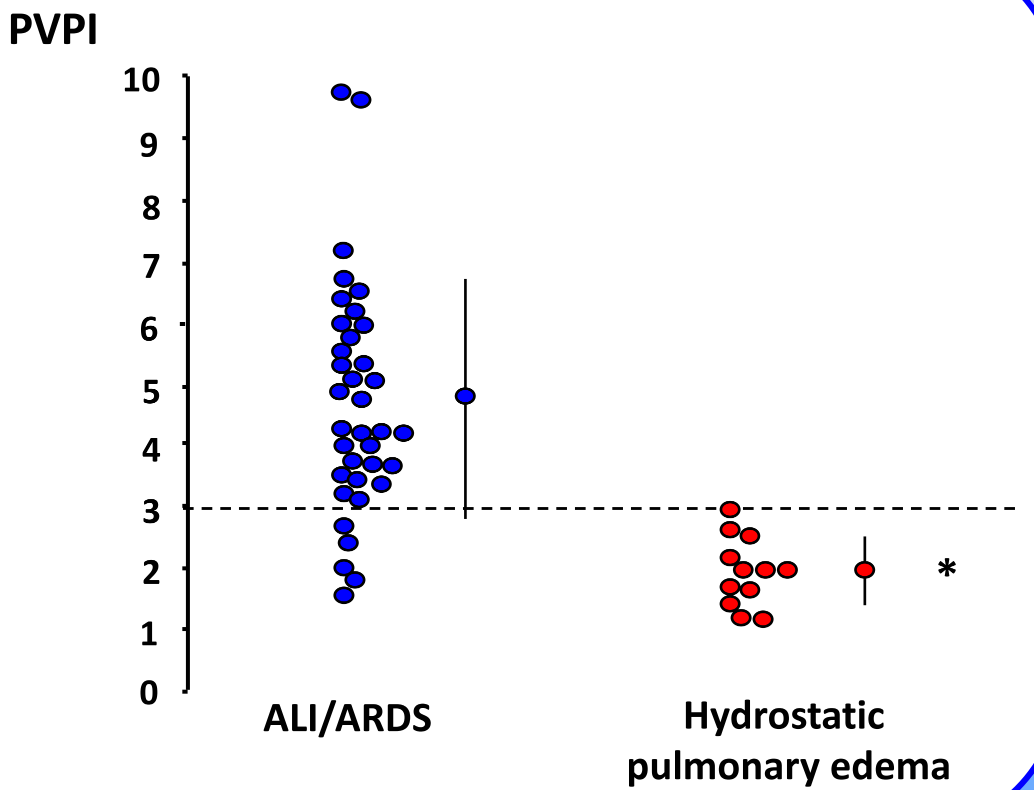
measure of **lung capillary leak**

Intensive Care Med (2007) 33:448–453

ORIGINAL

Xavier Monnet
Nadia Anguel
David Osman
Olfa Hamzaoui
Christian Richard
Jean-Louis Teboul

Assessing pulmonary permeability by transpulmonary thermodilution allows differentiation of hydrostatic pulmonary edema from ALI/ARDS



cut-off value = 3

Se = 85 %

Sp = 100 %

Intensive Care Med (2007) 33:448–453

ORIGINAL

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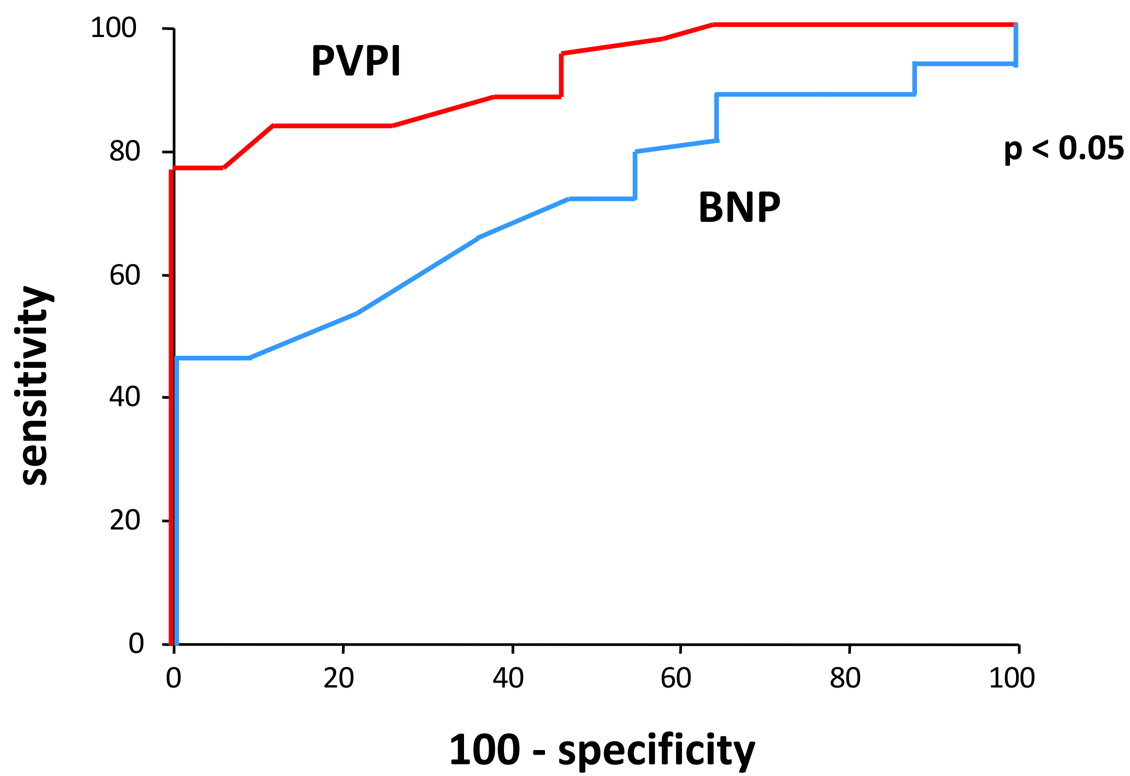


Extravascular Lung Water is an Independent Prognostic Factor in Patients with Acute Respiratory Distress Syndrome*

Mathieu Jozwiak, MD; Serena Silva, MD; Romain Persichini, MD; Nadia Anguel, MD; David Osman, MD; Christian Richard, MD; Jean-Louis Teboul, MD, PhD; Xavier Monnet, MD, PhD

Crit Care Med 2013; 41:472–480

PVPI is an **independent** predictor of **mortality** in ARDS patients

200 pts

D_{28} mortality: 54%

Mean PEEP	0.78	(0.67 – 0.91)	0.002
Minimal PaO_2 / FiO_2	0.98	(0.97 - 0.99)	0.0009
SAPS II	1.03	(1.01 - 1.05)	0.008
$PVPI_{max}$	**1.07**	**(1.02 - 1.12)**	**0.03**
Mean fluid balance	1.0004	(1.0000 – 1.0007)	0.03

REVIEW

Transpulmonary thermodilution: advantages and limits

Xavier Monnet[1,2,3*] and Jean-Louis Teboul[1,2]

Critical Care (2017) 21:147

SVV and PPV

for guiding

fluid administration

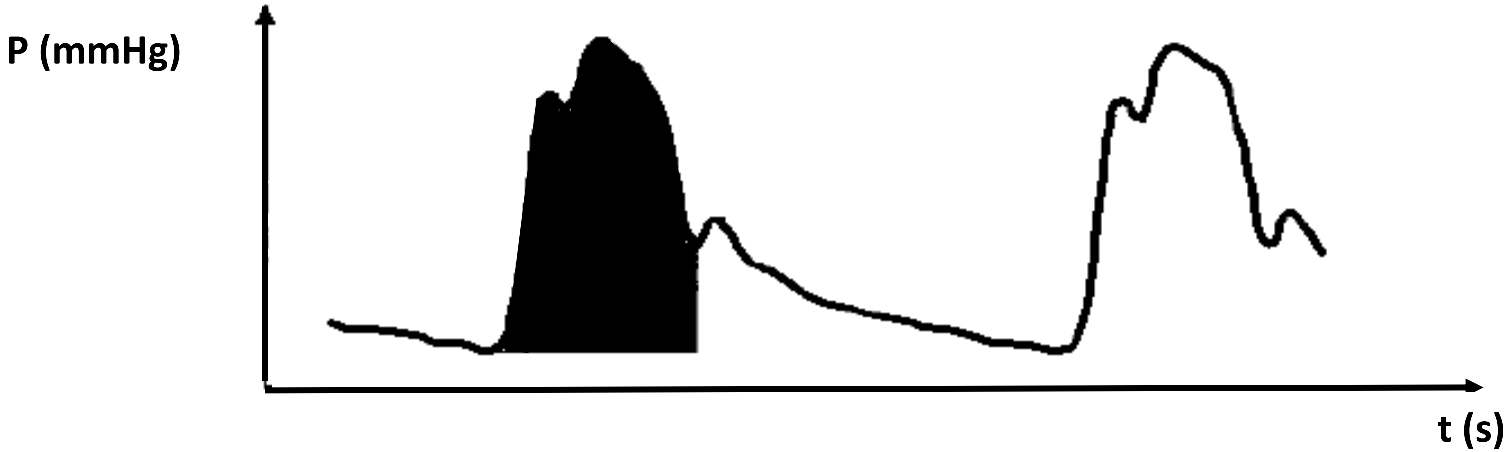
REVIEW

Transpulmonary thermodilution: advantages and limits

Xavier Monnet[1,2,3*] and Jean-Louis Teboul[1,2]

Critical Care (2017) 21:147

Continuous cardiac output



$$PCCO = cal \cdot HR \cdot \int_{systole} \left(P(t)/SVR + C(p) \cdot dP/dt \right) dt$$

- cal: **Patient-specific calibration factor** (determined with thermodilution)
- $\int_{systole} P(t)/SVR$: **area of pressure curve**
- $C(p)$: **compliance**
- dP/dt: **shape of pressure curve**

One frequently asked question

How **often** do we need to **recalibrate**?

Effects of changes in vascular tone on the agreement between pulse contour and transpulmonary thermodilution cardiac output measurements within an up to 6-hour calibration-free period*

Olfa Hamzaoui, MD; Xavier Monnet, MD, PhD; Christian Richard, MD; David Osman, MD; Denis Chemla, MD, PhD; Jean-Louis Teboul, MD, PhD

Crit Care Med 2008; 36:434–440

Intervals of Time (Elapsed fro…				Bias ± SD	Percentage Error
With…					27
Betw…					26
Betw…					32
Betw…					37
Between 3 and 4 hrs	45	.65	<.001	0.03 ± 0.63	35
Between 4 and 5 hrs	47	.62	<.001	0.14 ± 0.63	35
Between 5 and 6 hrs	51	.62	<.001	0.13 ± 0.66	36

We recommend to **recalibrate**

if the **preceding calibration**

was performed **more than one hour before**

REVIEW

How can assessing hemodynamics help to assess volume status?

Daniel De Backer[1*], Nadia Aissaoui[2], Maurizio Cecconi[3,4], Michelle S. Chew[5], André Denault[6,7], Ludhmila Hajjar[8], Glenn Hernandez[9], Antonio Messina[3,4], Sheila Nainan Myatra[10], Marlies Ostermann[11], Michael R. Pinsky[12], Jean-Louis Teboul[13], Philippe Vignon[14], Jean-Louis Vincent[15] and Xavier Monnet[13]

Intensive Care Med (2022) 48:1482–1494

Another **advantage** of **transpulmonary thermodilution** devices is the calibrated estimation of CO with **pulse contour analysis** which is **perfect** for performing tests of **fluid responsiveness,** like the **passive leg raising** (PLR) or the **end-expiratory occlusion** test

Intensive Care Med (2016) 42:1935–1947

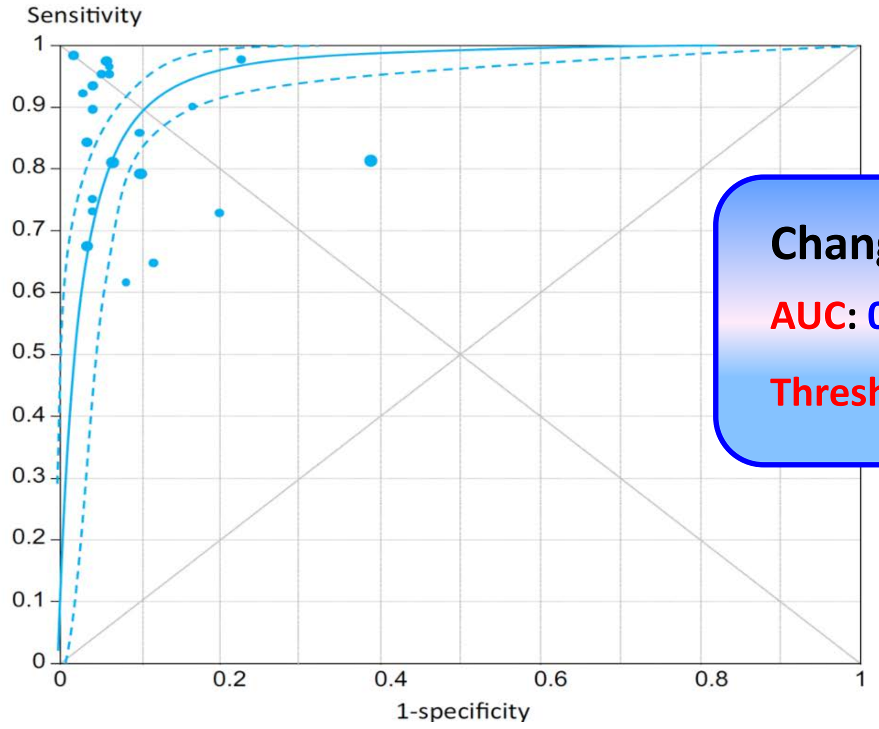
ORIGINAL

Xavier Monnet
Paul Marik
Jean-Louis Teboul

Passive leg raising for predicting fluid responsiveness: a systematic review and meta-analysis

***21* clinical studies**

***995* pts**



Changes in CO

AUC: 0.95 ± 0.01

Threshold: 10%

REVIEW

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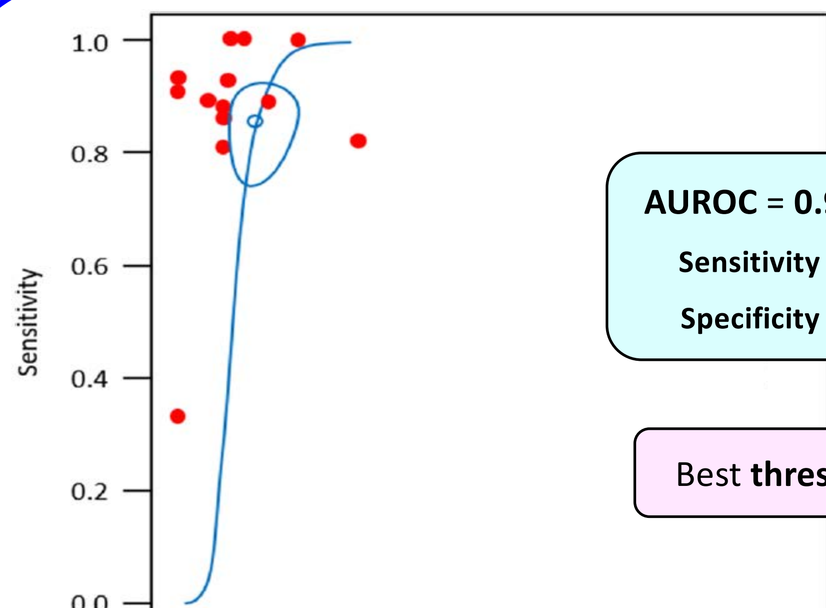
Ann. Intensive Care (2020) 10:65 Annals of Intensive Care
RESEARCH **Open Access**

The end-expiratory occlusion test for detecting preload responsiveness: a systematic review and meta-analysis

Francesco Gavelli[1,2,3*], Rui Shi[1,2], Jean-Louis Teboul[1,2], Danila Azzolina[4] and Xavier Monnet[1,2]



AUROC = **0.91** [0.86-0.94]

Sensitivity = **0.85** [0.77-0.91]

Specificity = **0.88** [0.83-0.91]

Best **threshold** = **5.1** ± 0.2%

A **real-time** and **precise** CO monitoring device is **required**

Transpulmonary thermodilution systems

Useful for guiding fluid management

especially in patients with shock and ARDS

Fluid infusion benefit/risk ratio

- **PPV** and **SVV**
- **Pulse contour CO** response to PLR or EEO

} prediction of **fluid responsiveness**

- **EVLW** and **PVPI** for assessing **lung tolerance** to fluid infusion

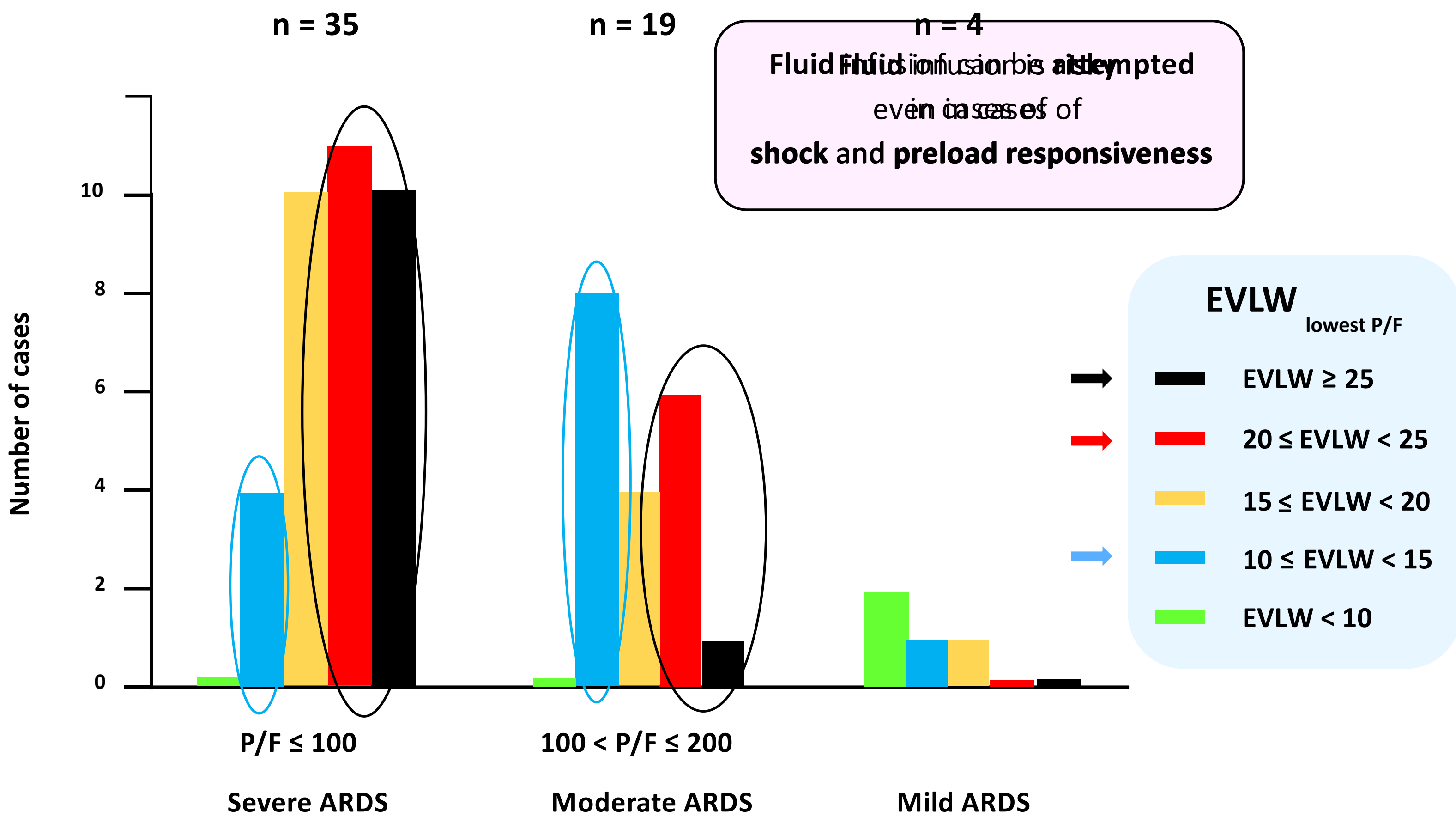
⟹ **decision**

- **to start**
- **to continue** **fluid infusion**
- **to stop**

COVID-19 ARDS is characterized by higher extravascular lung water than non-COVID-19 ARDS: the PiCCOVID study

Rui Shi[1], Christopher Lai[1], Jean-Louis Teboul[1], Martin Dres[3,4], Francesca Moretto[1], Nello De Vita[5], Tài Pham[1,2], Vincent Bonny[3,4], Julien Mayaux[3,4], Rosanna Vaschetto[5], Alexandra Beurton[3,4] and Xavier Monnet[1*]

Crit Care *(2021) 25:186*



Conclusions

- **Echocardiography** should be performed **asap** in shock states as it is the **best** tool to assess **cardiac function** and it is **non invasive**
- But it is **not** a **monitoring** technique
- It should be performed in **combination** with other **hemodynamic** measurements, especially in **complex** shock states or in cases of associated **severe ARDS**, where more **invasive** technologies are often **necessary** to better **assess hemodynamics** and **monitor** the **response** to **therapy**

Merci