Passive **L**eg **R**aising

Advantages and limits

Prof. Jean-Louis TEBOUL

Medical ICU

Bicetre hospital

University Paris South

France

Passive Leg Raising: the advantages

- **PLR** provides a good **prediction** of **fluid responsiveness**
- **Unlike** fluid challenge, effects of **PLR** are rapidly **reversible**
- **PLR well predicts** fluid responsiveness
  … in situations where **PPV fails** to do it

Passive Leg Raising: the advantages

- **PLR** provides a good **prediction** of **fluid responsiveness**
- **Unlike** fluid challenge, effects of **PLR** are rapidly **reversible**
- **PLR may well assess** fluid responsiveness
  … in situations where **PPV fails** to do it

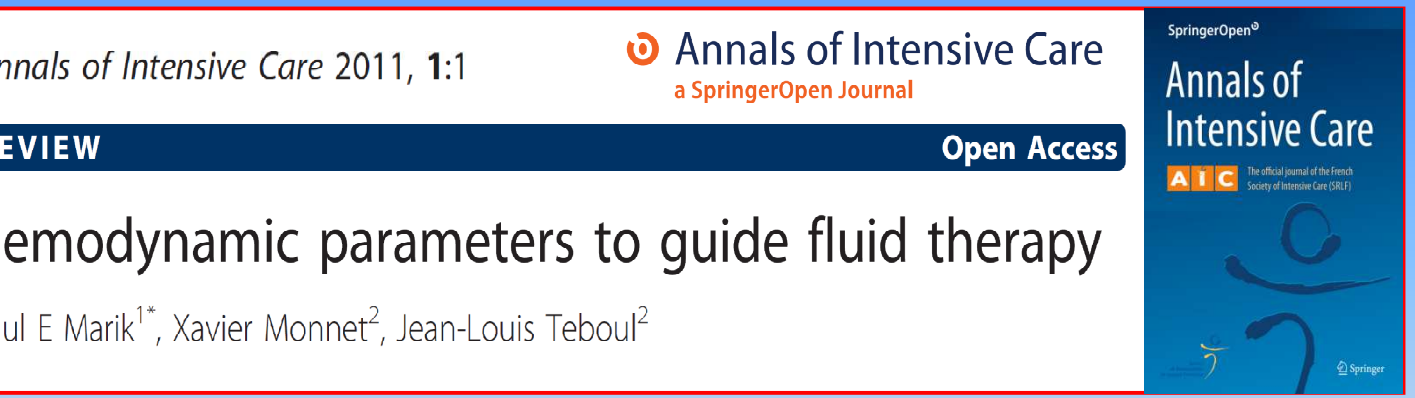
Annals of Intensive Care 2011, **1**:1

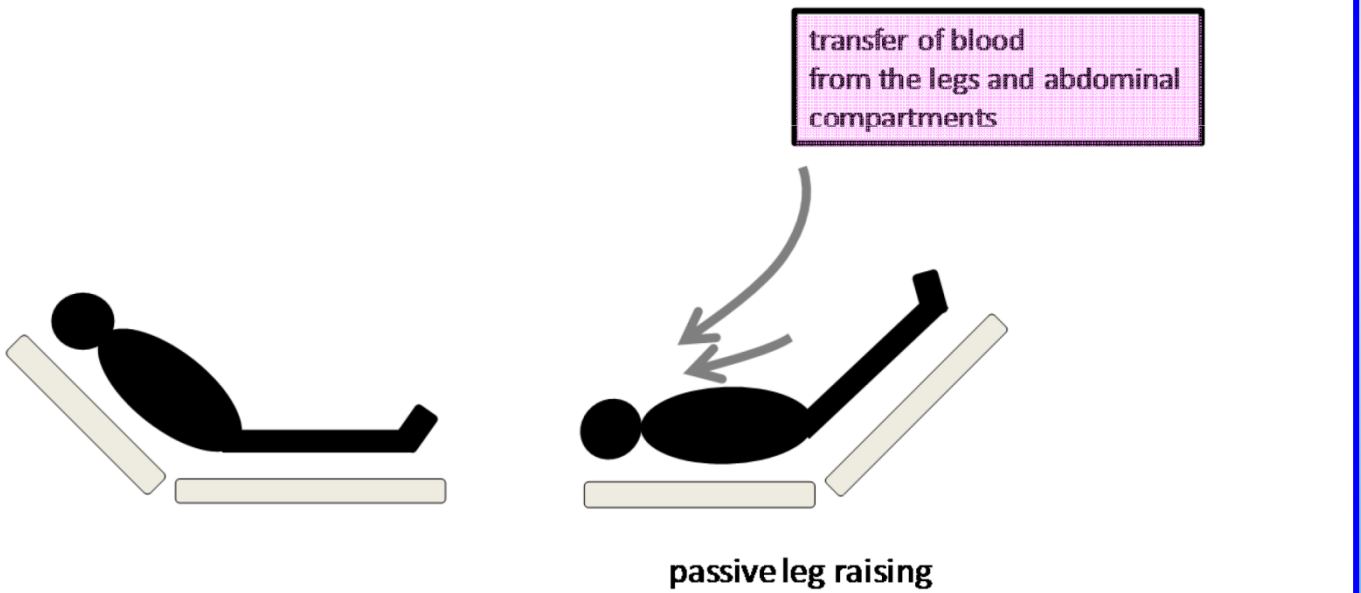
Annals of Intensive Care
a SpringerOpen Journal

REVIEW **Open Access**

Hemodynamic parameters to guide fluid therapy

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



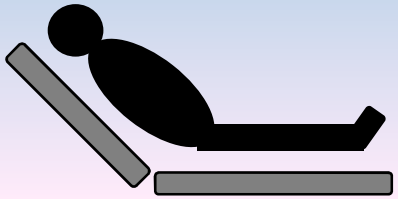


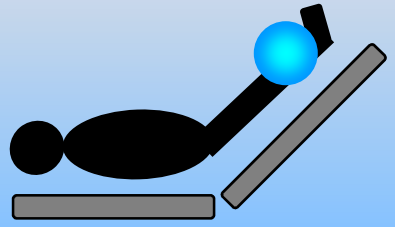
Intensive Care Med (2008) 34:659–663

CLINICAL COMMENTARY

Xavier Monnet
Jean-Louis Teboul

Passive leg raising

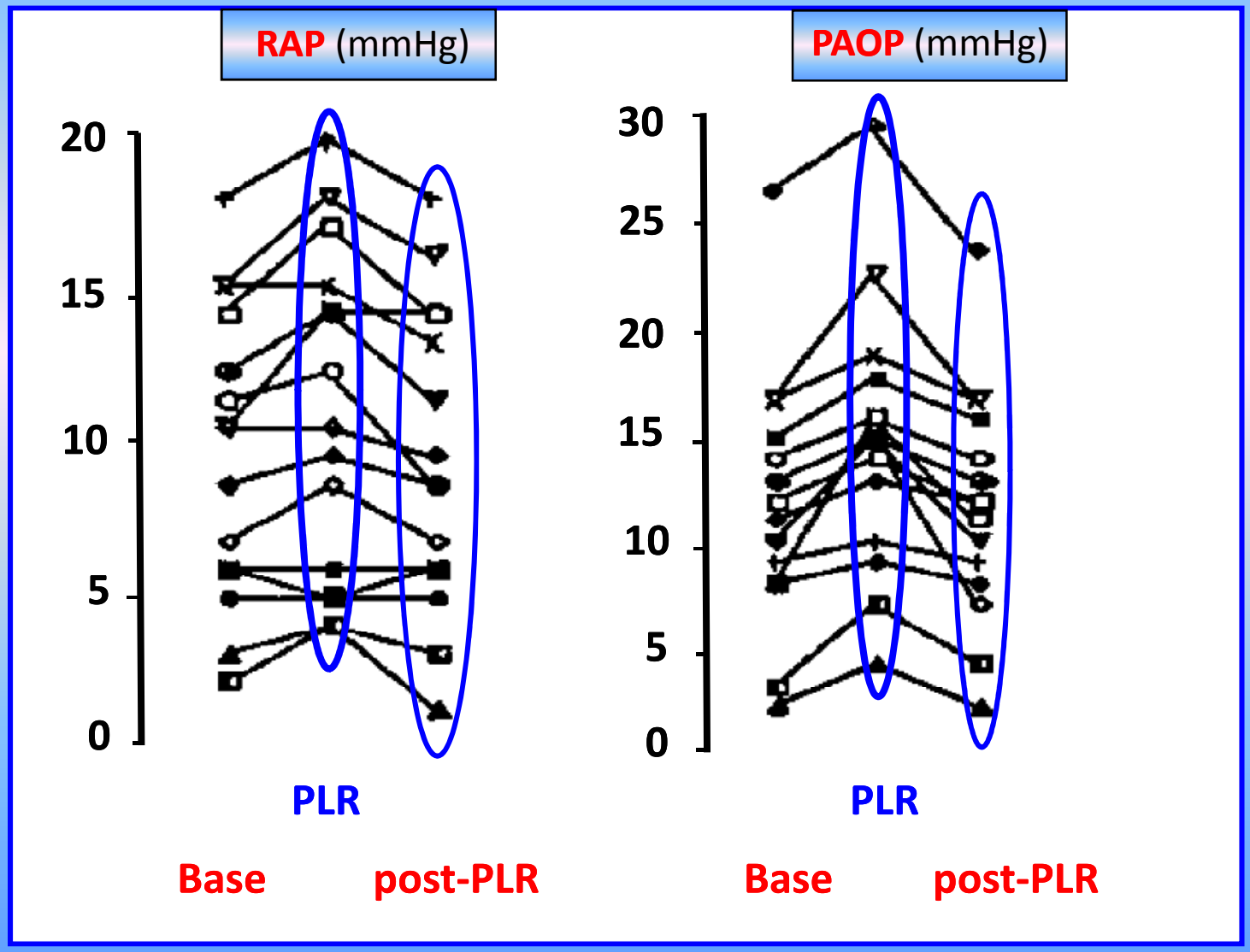




Changes in BP Induced by Passive Leg Raising Predict Response to Fluid Loading in Critically Ill Patients*

Thierry Boulain, MD; Jean-Michel Achard, MD; Jean-Louis Teboul, MD; Christian Richard, MD; Dominique Perrotin, MD; and Guy Ginies, MD

CHEST 2002; 121:1245–1252

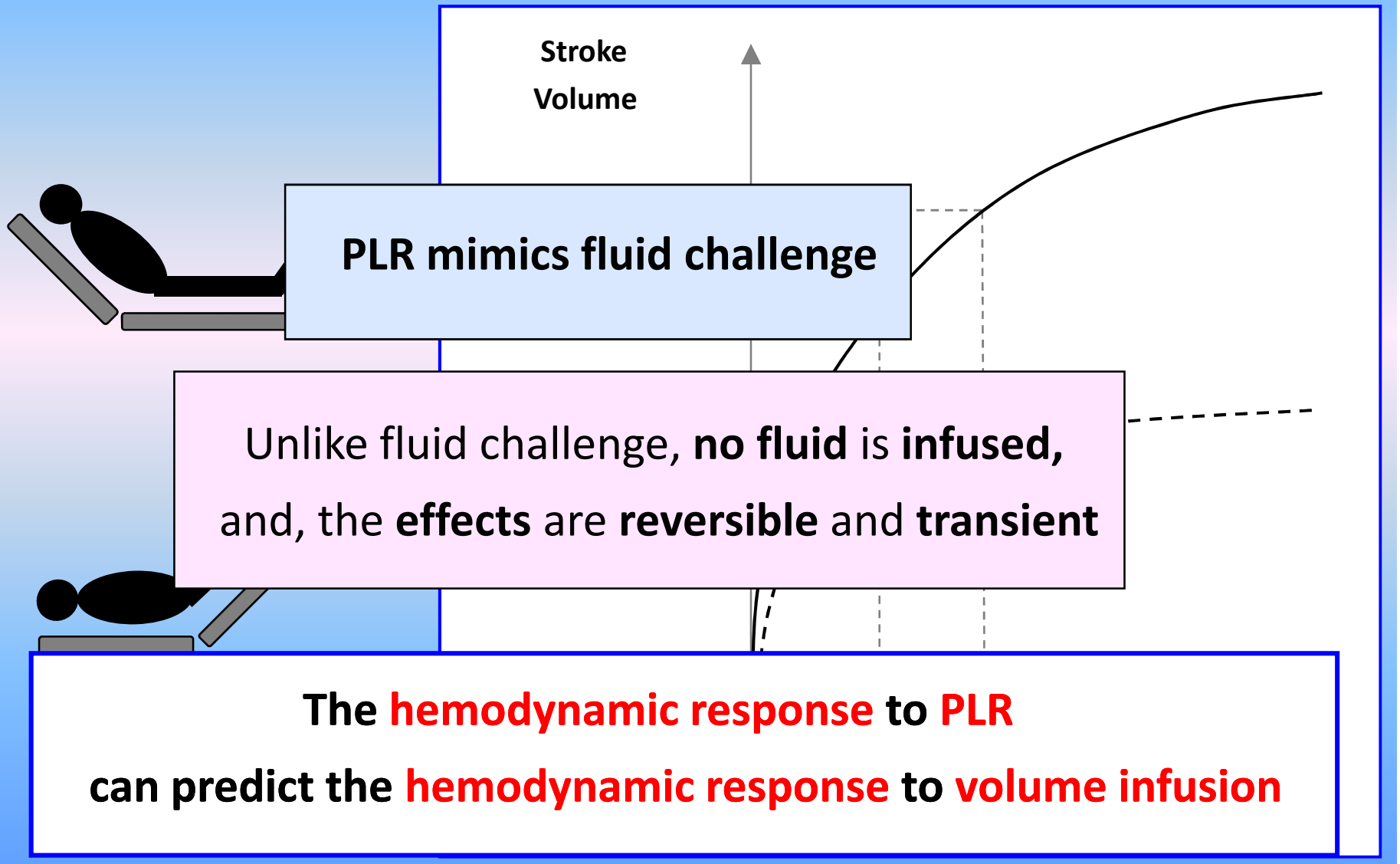


Intensive Care Med (2008) 34:659–663

CLINICAL COMMENTARY

Xavier Monnet
Jean-Louis Teboul

Passive leg raising



PLR mimics fluid challenge

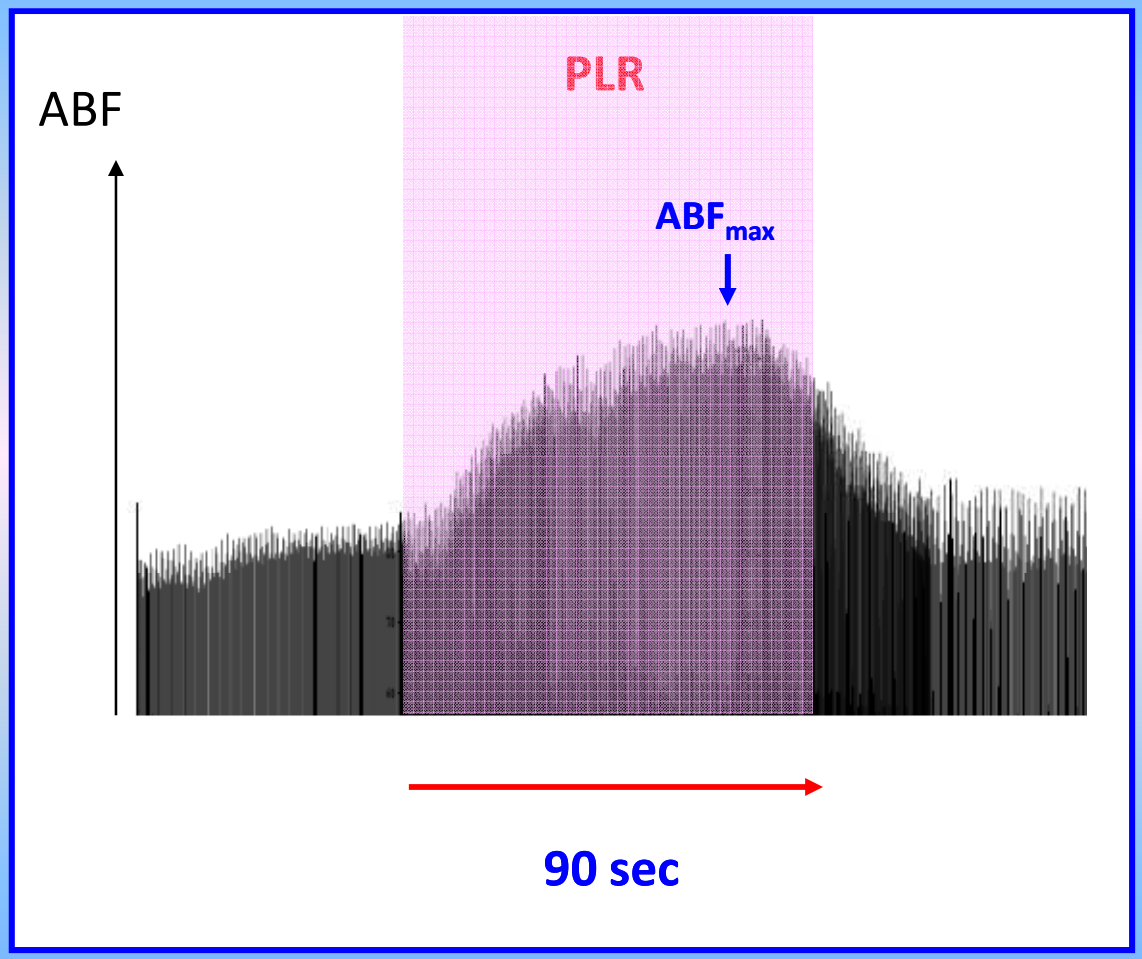
Unlike fluid challenge, **no fluid** is **infused,**

and, the **effects** are **reversible** and **transient**

The hemodynamic response to PLR

can predict the hemodynamic response to volume infusion

Transient hemodynamic effects

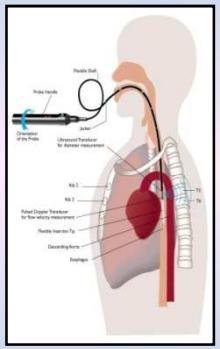


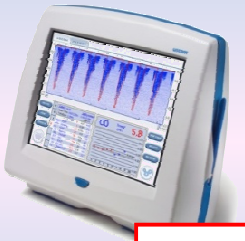
Real-time monitoring is required

The **hemodynamic response** to **PLR**

can predict the **hemodynamic response** to **fluid infusion**

Real-time CO response to PLR





Prediction of fluid responsiveness

Passive leg rai

spontaneously

pancreatitis*

Non-invasive

by

du

Intensive Care Med (2010) 36:1875–1881 ORIGINAL

Brahim Benomar
Alexandre Ouattara
Philippe Estagnasie
Alain Brusset
Pierre Squara

Fluid responsiveness predicted by noninvasive Bioreactance-based passive leg raise test

Non-invasi

predict volu

observatio

Steven W Thiel,

Predict

occlusi

Changes in stroke volu

spontaneously brea

echocardiography a

Matthieu Biais, Lionel Vidil, P

François Sztark

Intensive Care Med (2007) 33:1

Bouchra Lamia
Ana Ochagavia
Xavier Monnet
Denis Chemla
Christian Richard
Jean-Louis Teboul

Intensive Care Med

Xavier Monnet
Aurélien Bataille
Eric Magalhaes
Jérôme Barrois
Marine Le Corre
Clément Gosset
Laurent Guerin
Christian Richard
Jean-Louis Teboul

End-tidal carbon dioxide is better than arterial pressure for predicting volume responsiveness by the passive leg raising test

Passive

Michael R. Pinsky, MD, Dr hc; Jea

Can en

assess

raising

Jean-Luc Fellahi

and Jean-Luc Ha

Passive leg-raising and end-expir

better than pulse pressure variation in patients wit

respiratory system compliance

Xavier Monnet, MD, PhD; Alexandre Bleibtreu, MD; Alexis Ferre, MD; Martin Dres,
Christian Richard, MD; Jean-Louis Teboul, MD, PhD

Crit Care Med 20

Intensive Care Med (2007) 33:1133–1138 ORIGINAL

Julien Maizel
Norair Airapetian
Emmanuel Lorne
Christophe Tribouilloy
Ziad Massy
Michel Slama

Diagnosis of central hypovolemia by using passive leg raising

Changes in aortic blood

predict fluid responsive

A Lafanechère, F Pène, C Goulenot

A Cariou

nous

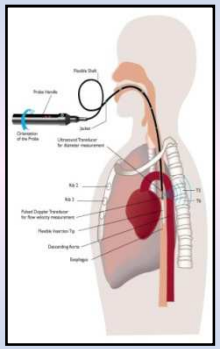
oux[1],

Critical Care 2011, 15:R216

The **hemodynamic response** to **PLR**

can predict the **hemodynamic response** to **fluid infusion**

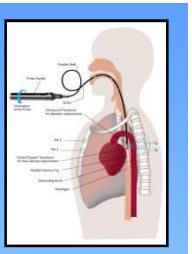
Real-time CO response to PLR



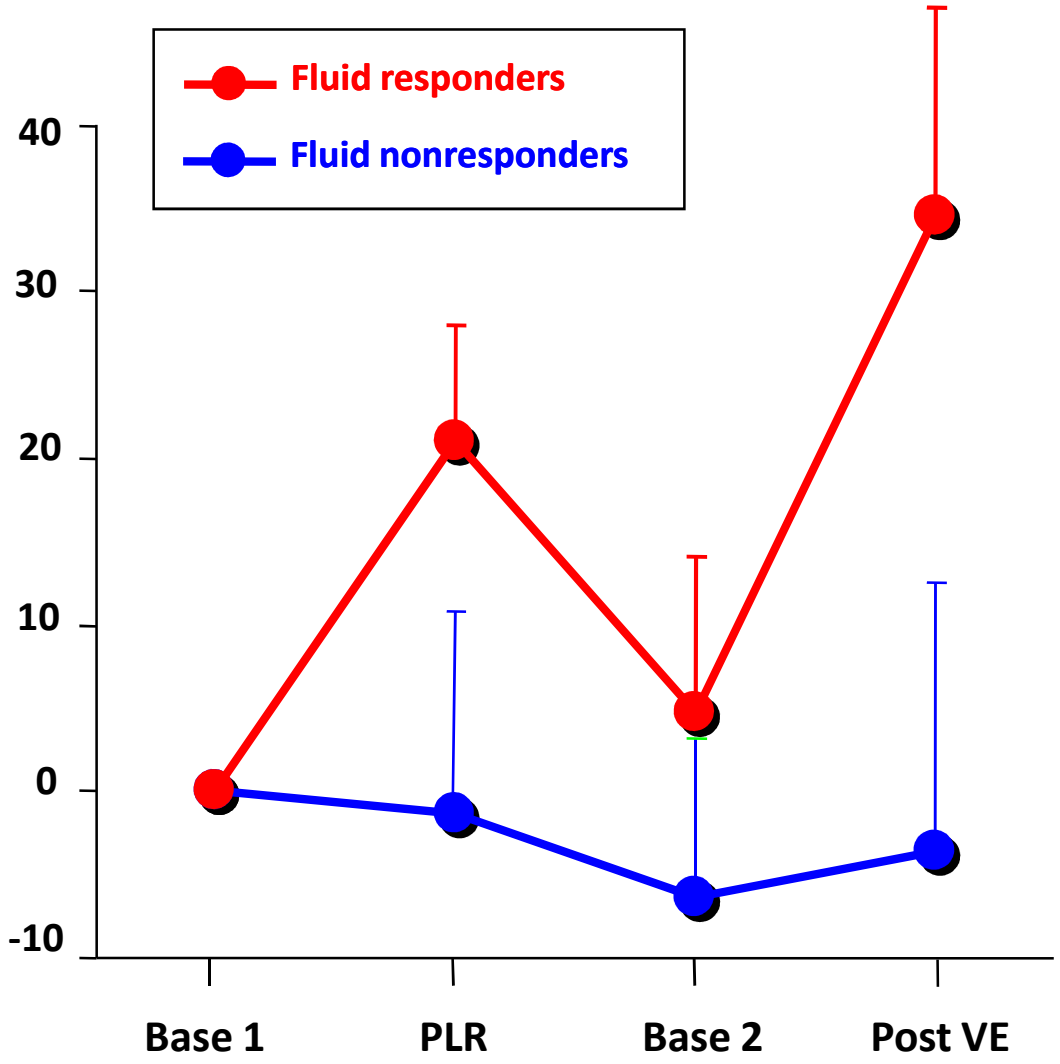
Passive leg raising predicts fluid responsiveness in the critically ill*

Xavier Monnet, MD, PhD; Mario Rienzo, MD; David Osman, MD; Nadia Anguel, MD; Christian Richard, MD; Michael R. Pinsky, MD, Dr hc; Jean-Louis Teboul, MD, PhD

Crit Care Med 2006; 34:1402–1407



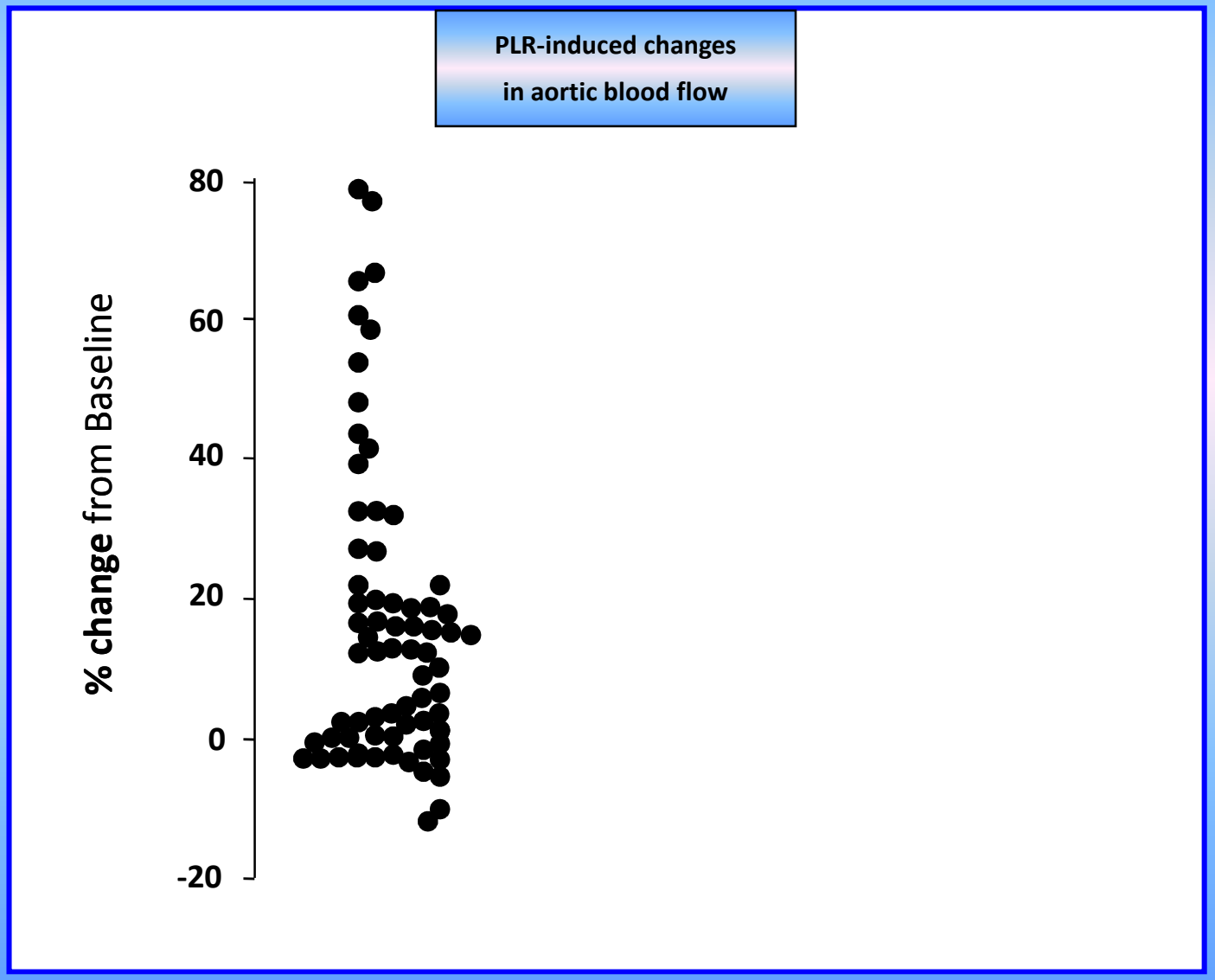
Changes in aortic blood flow (%)



Passive leg raising predicts fluid responsiveness in the critically ill*

Xavier Monnet, MD, PhD; Mario Rienzo, MD; David Osman, MD; Nadia Anguel, MD; Christian Richard, MD; Michael R. Pinsky, MD, Dr hc; Jean-Louis Teboul, MD, PhD

Crit Care Med 2006; 34:1402–1407



Passive leg raising predicts fluid responsiveness in the critically ill*

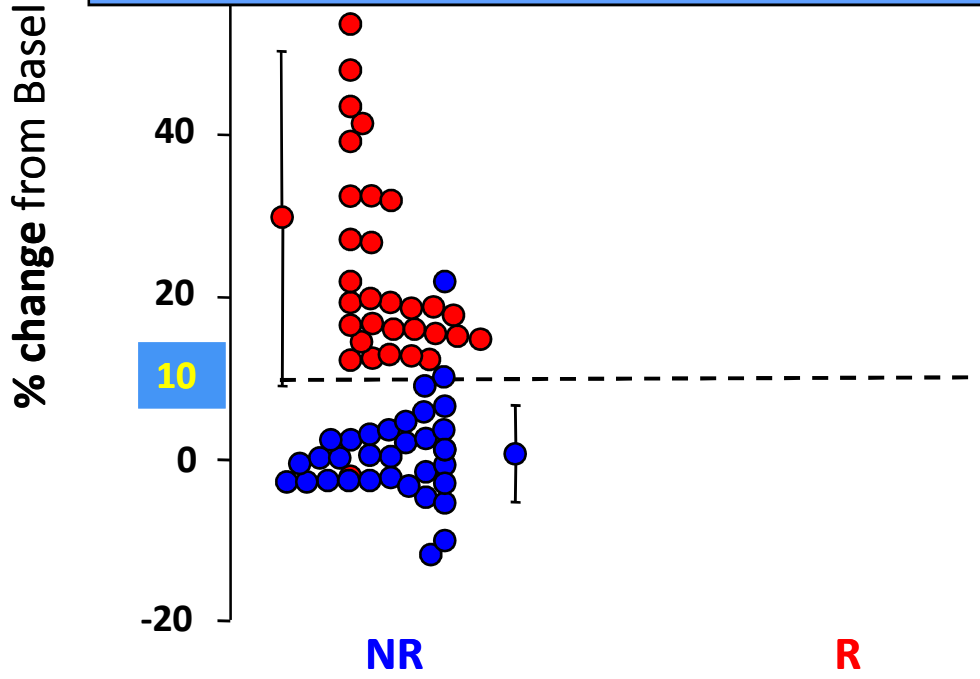
Xavier Monnet, MD, PhD; Mario Rienzo, MD; David Osman, MD; Nadia Anguel, MD; Christian Richard, MD; Michael R. Pinsky, MD, Dr hc; Jean-Louis Teboul, MD, PhD

Crit Care Med 2006; 34:1402–1407

PLR-induced change in **aortic blood flow**

good **prediction**

of **volume responsiveness**



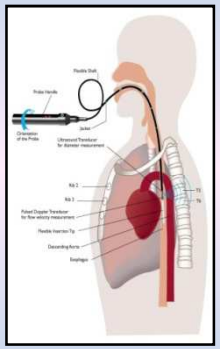
sensitivity: **97%**

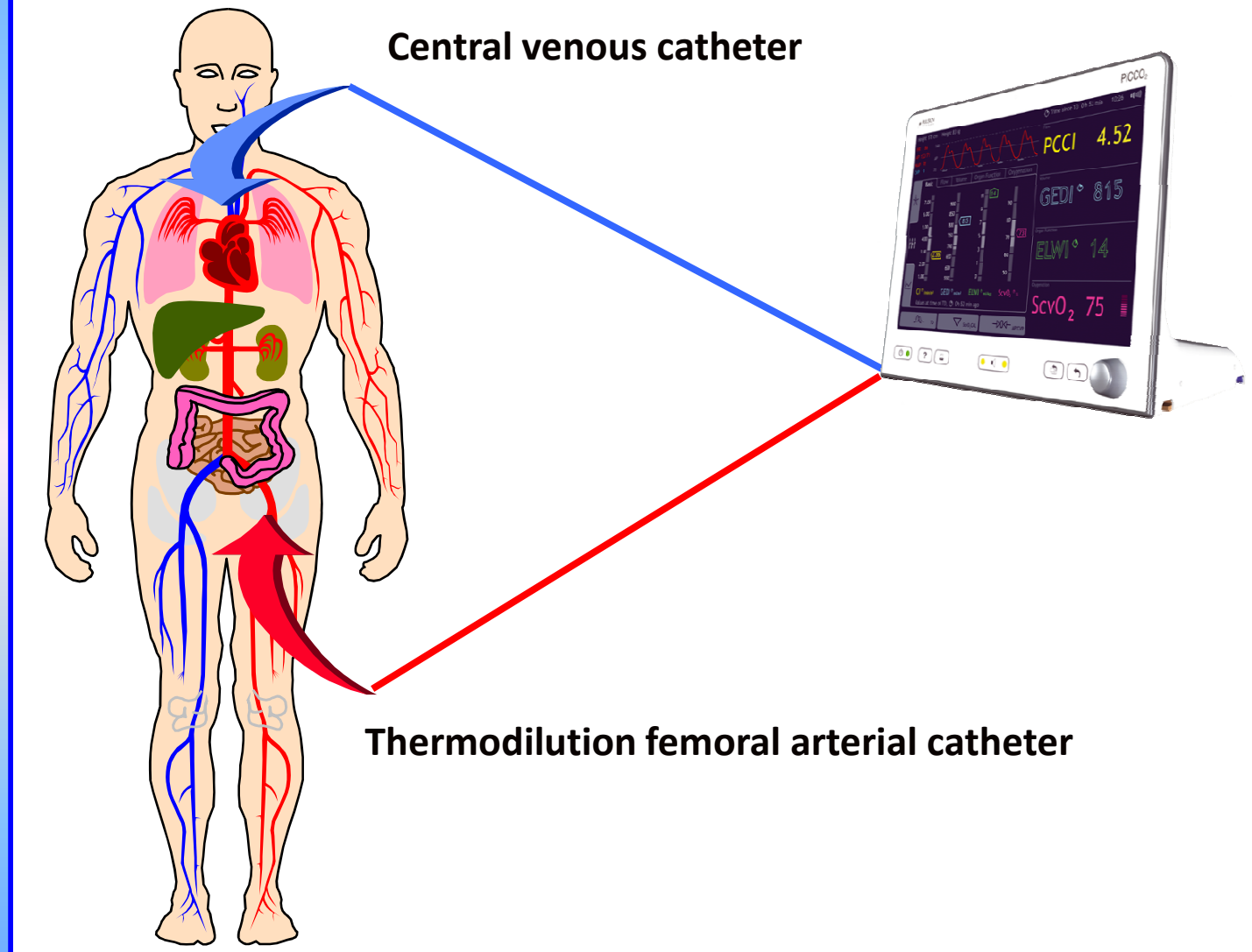
specificity: **94%**

The **hemodynamic response** to **PLR**

can predict the **hemodynamic response** to **fluid infusion**

Real-time CO response to PLR



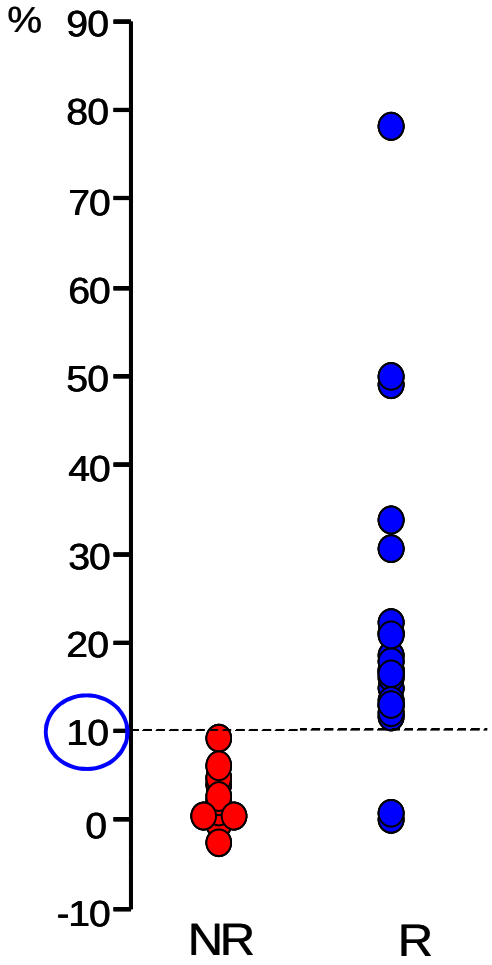

Central venous catheter
PCCI 4.52
GEDI 815
ELWI 14
ScvO2 75
Thermodilution femoral arterial catheter

Predicting volume responsiveness by using the end-expiratory occlusion in mechanically ventilated intensive care unit patients

Xavier Monnet, MD, PhD; David Osman, MD; Christophe Ridel, MD; Bouchra Lamia, MD; Christian Richard, MD; Jean-Louis Teboul, MD, PhD

Crit Care Med 2009; 37:951–956

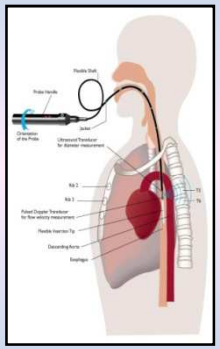
PLR-induced **changes** in **Pulse Contour CO (%)**

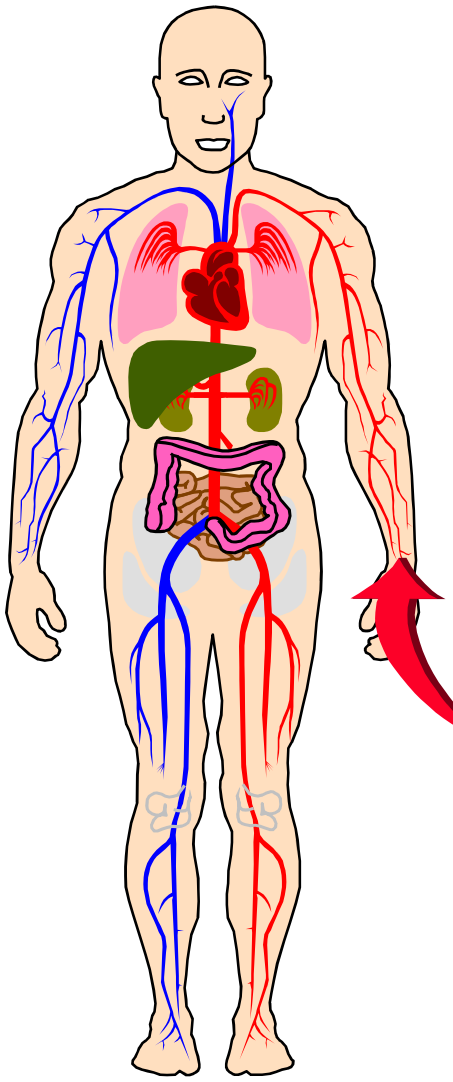


The **hemodynamic response** to **PLR**

can predict the **hemodynamic response** to **fluid infusion**

Real-time CO response to PLR



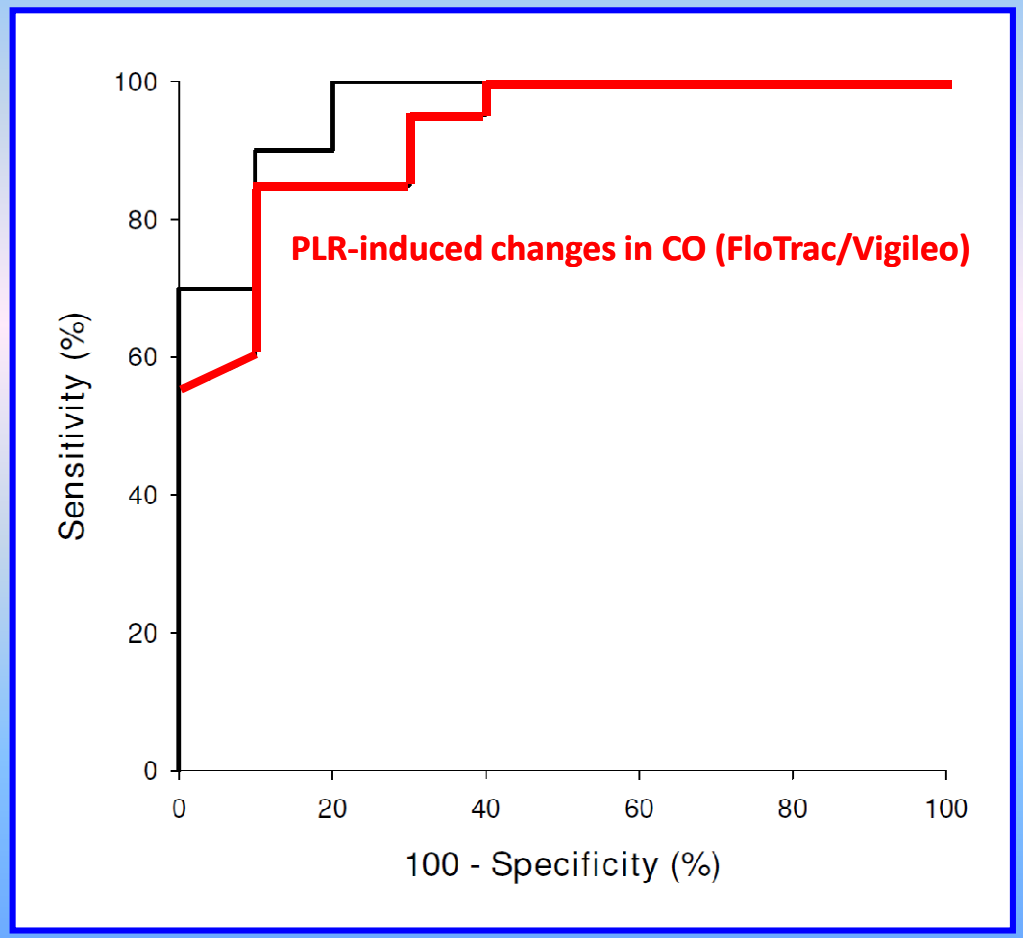


radial arterial catheter

Changes in stroke volume induced by passive leg raising in spontaneously breathing patients: comparison between echocardiography and Vigileo™/FloTrac™ device

Matthieu Biais, Lionel Vidil, Philippe Sarrabay, Vincent Cottenceau, Philippe Revel and François Sztark

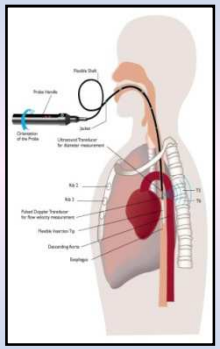
Critical Care 2009, **13**:R195



The **hemodynamic response** to **PLR**

can predict the **hemodynamic response** to **fluid infusion**

Real-time CO response to PLR

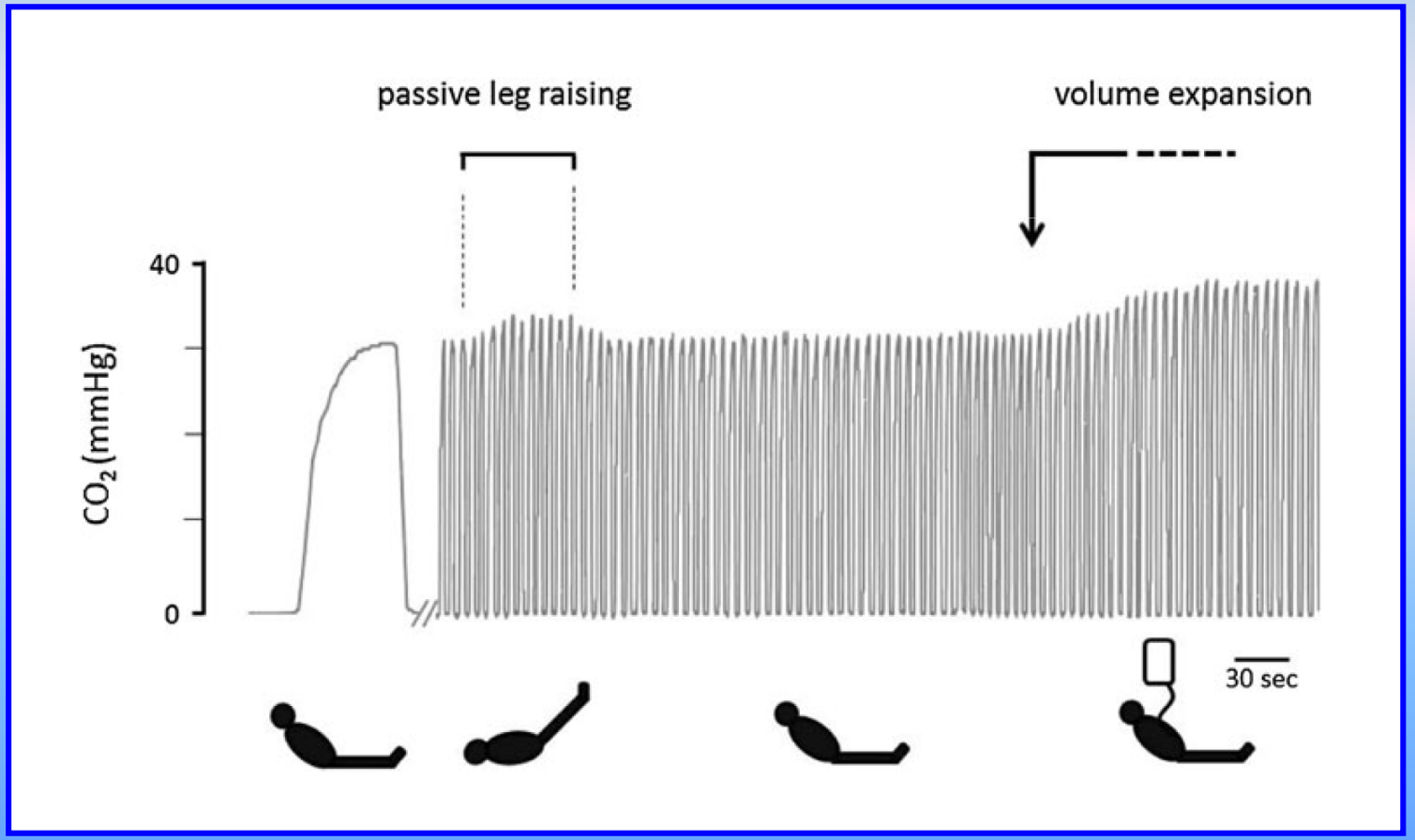


Intensive Care Med 2012

ORIGINAL

Xavier Monnet
Aurélien Bataille
Eric Magalhaes
Jérôme Barrois
Marine Le Corre
Clément Gosset
Laurent Guerin
Christian Richard
Jean-Louis Teboul

End-tidal carbon dioxide is better than arterial pressure for predicting volume responsiveness by the passive leg raising test

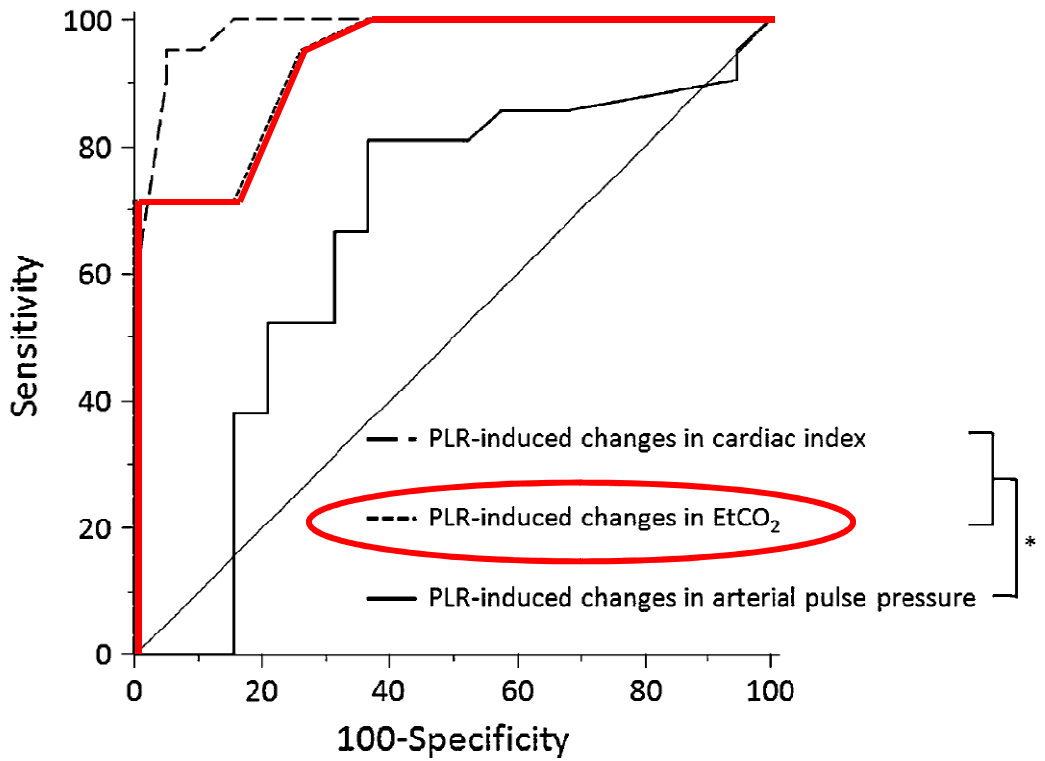


Intensive Care Med 2012

ORIGINAL

Xavier Monnet
Aurélien Bataille
Eric Magalhaes
Jérôme Barrois
Marine Le Corre
Clément Gosset
Laurent Guerin
Christian Richard
Jean-Louis Teboul

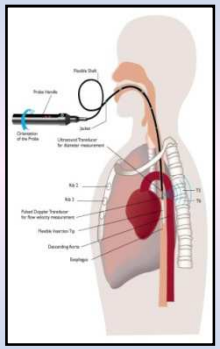
End-tidal carbon dioxide is better than arterial pressure for predicting volume responsiveness by the passive leg raising test



The **hemodynamic response** to **PLR**

can predict the **hemodynamic response** to **fluid infusion**

Real-time CO response to PLR

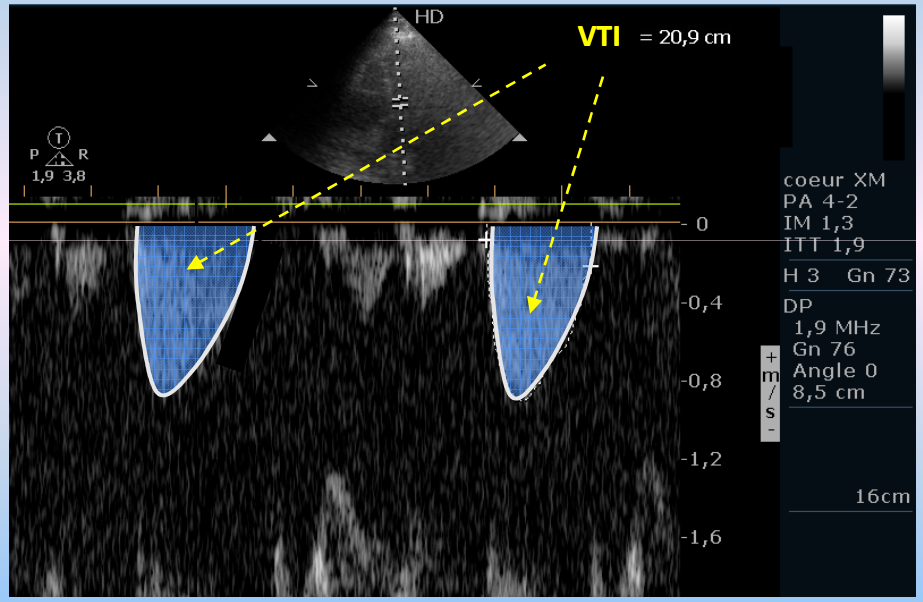


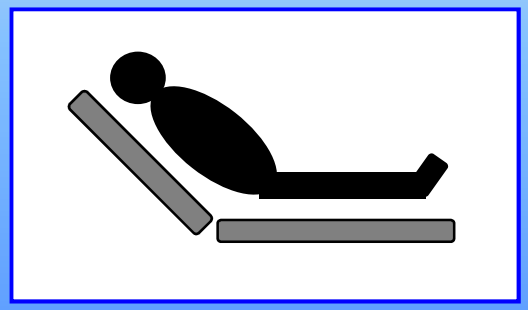
Intensive Care Med (2007) 33:1125–1132

ORIGINAL

Bouchra Lamia
Ana Ochagavia
Xavier Monnet
Denis Chemla
Christian Richard
Jean-Louis Teboul

Echocardiographic prediction of volume responsiveness in critically ill patients with spontaneously breathing activity





Intensive Care Med (2007) 33:1125–1132
DOI 10.1007/s00134-007-0646-7

ORIGINAL

Bouchra Lamia
Ana Ochagavia
Xavier Monnet
Denis Chemla
Christian Richard
Jean-Louis Teboul

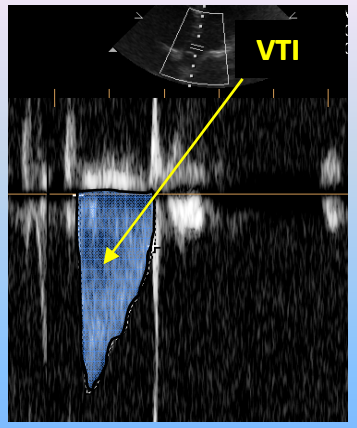
Echocardiographic prediction of volume responsiveness in critically ill patients with spontaneously breathing activity

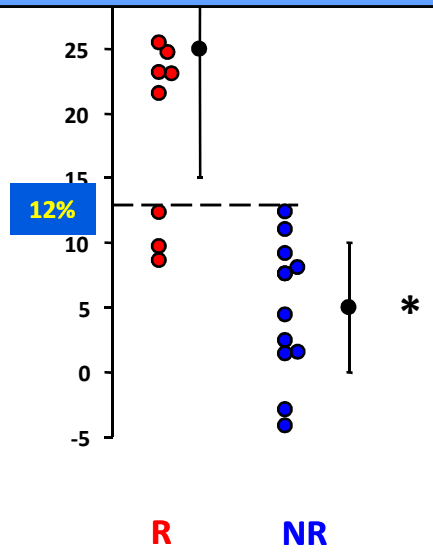
24 pts with circu
TTE before and a

PLR-induced change in **Velocity-Time Integral**

good **prediction**

of **volume responsiveness**

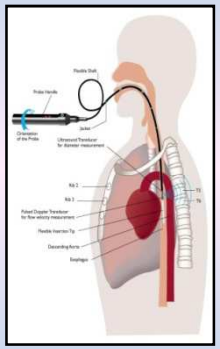


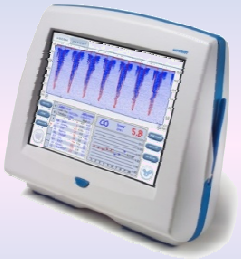


The **hemodynamic response** to **PLR**

can predict the **hemodynamic response** to **fluid infusion**

Real-time CO response to PLR

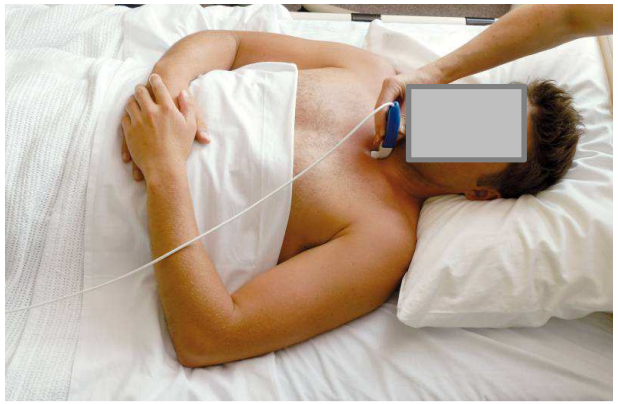




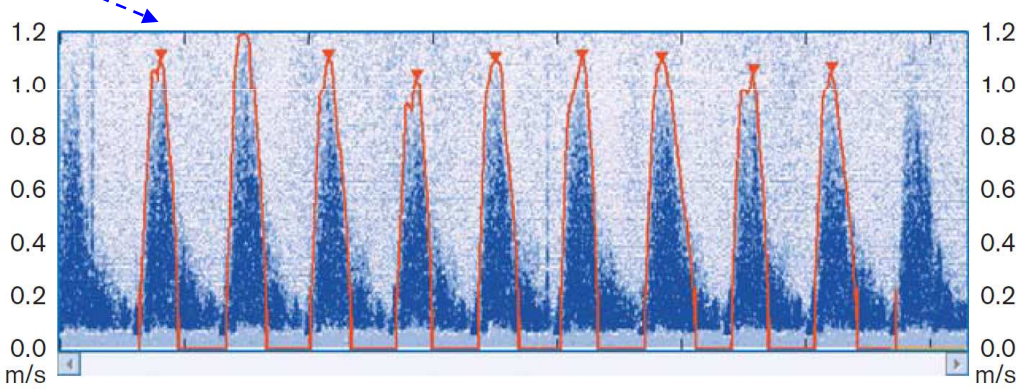
USCOM

Two access windows for measuring CO

- **the suprasternal notch for the aortic valve**
  (simple probe positioning, image quick to acquire)



Nonimaging transthoracic probe and **continuous-wave Doppler ultrasound** to obtain a beat-to-beat flow profile that can provide a **real-time velocity time integral (VTI)**



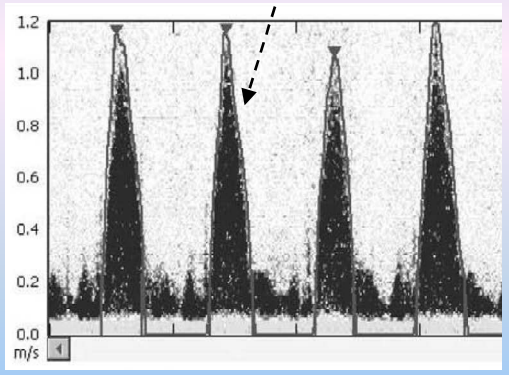
The cross-sectional area of a vessel is **predicted** by a **height- and weight-based nomogram** incorporated in the USCOM software

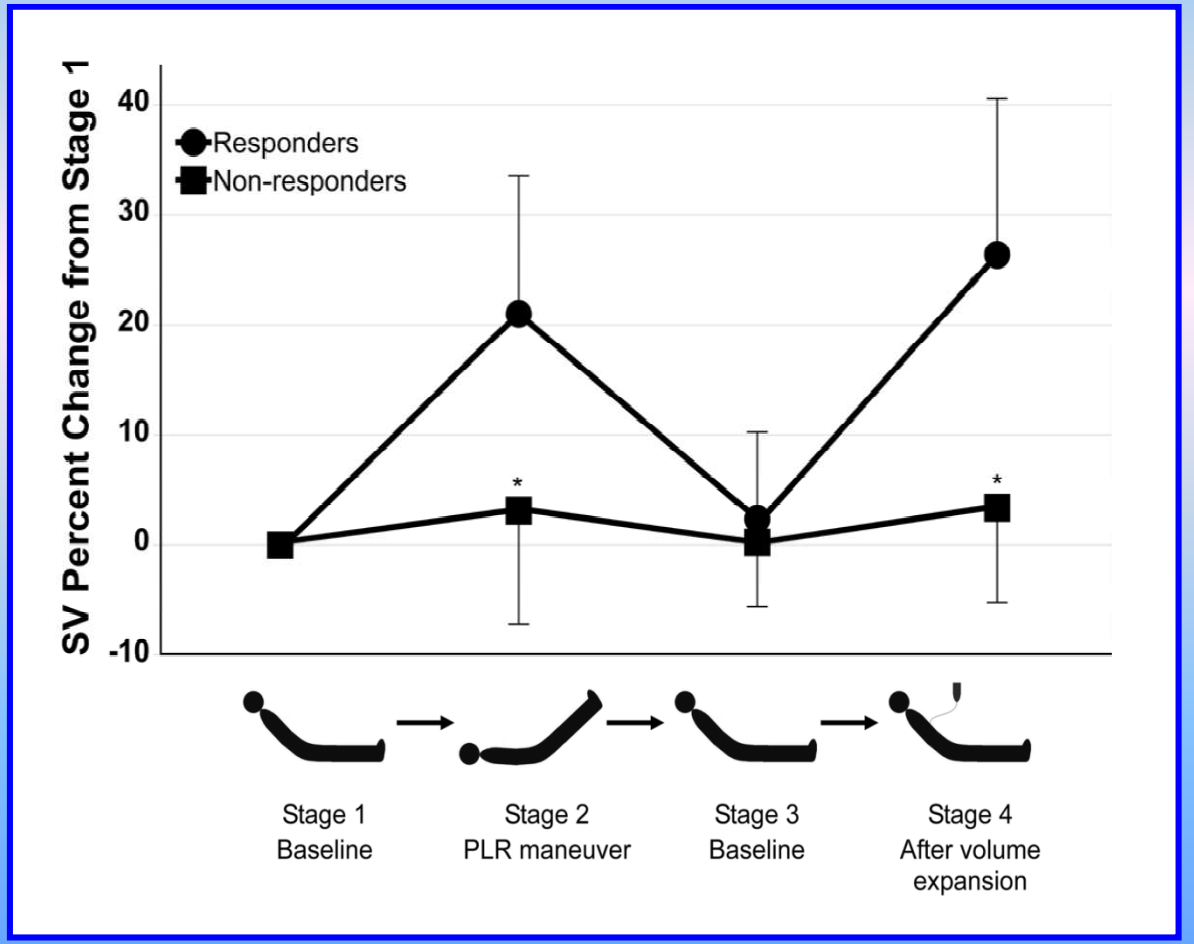
Non-invasive stroke volume measurement and passive leg raising predict volume responsiveness in medical ICU patients: an observational cohort study

Steven W Thiel, Marin H Kollef and Warren Isakow

Critical Care 2009, **13**:R111

VTI

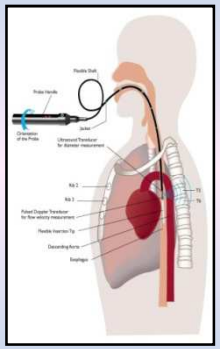


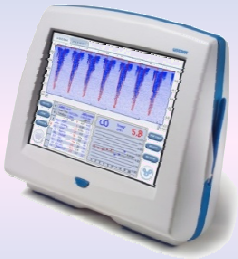


The **hemodynamic response** to **PLR**

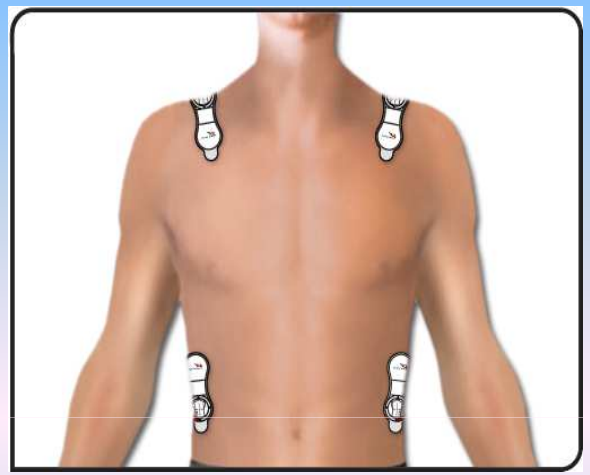
can predict the **hemodynamic response** to **fluid infusion**

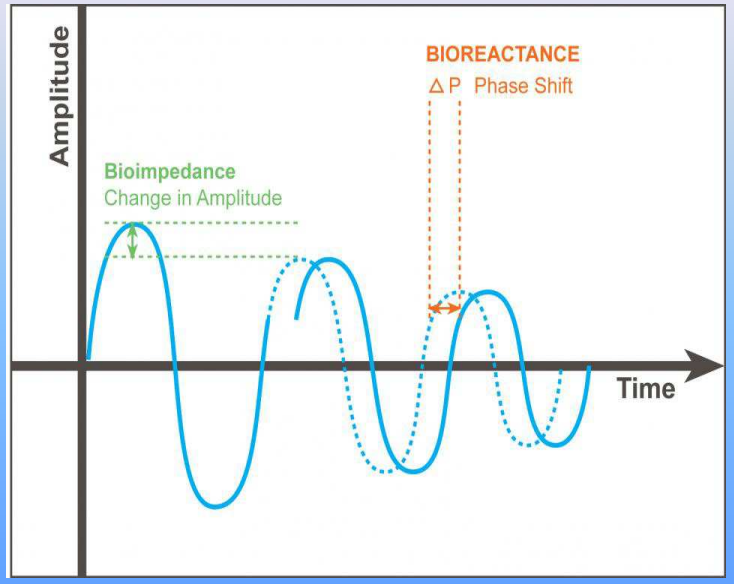
Real-time CO response to PLR





Bioreactance

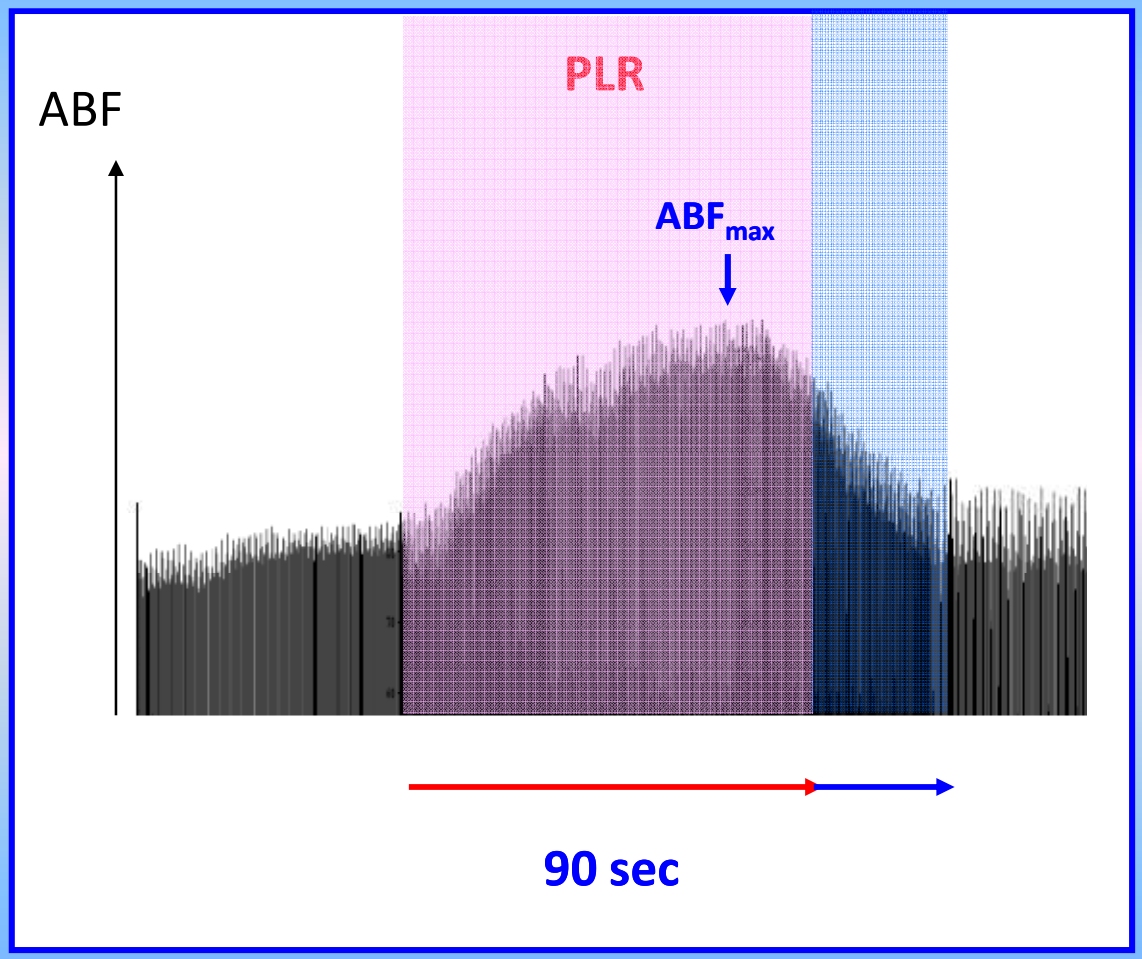




Passive Leg Raising: the advantages

- **PLR** provides a good **prediction** of **fluid responsiveness**
- **Unlike** fluid challenge, effects of **PLR** are rapidly **reversible**
- **PLR may well assess** fluid responsiveness
  … in situations where **PPV fails** to do it

reversible hemodynamic effects

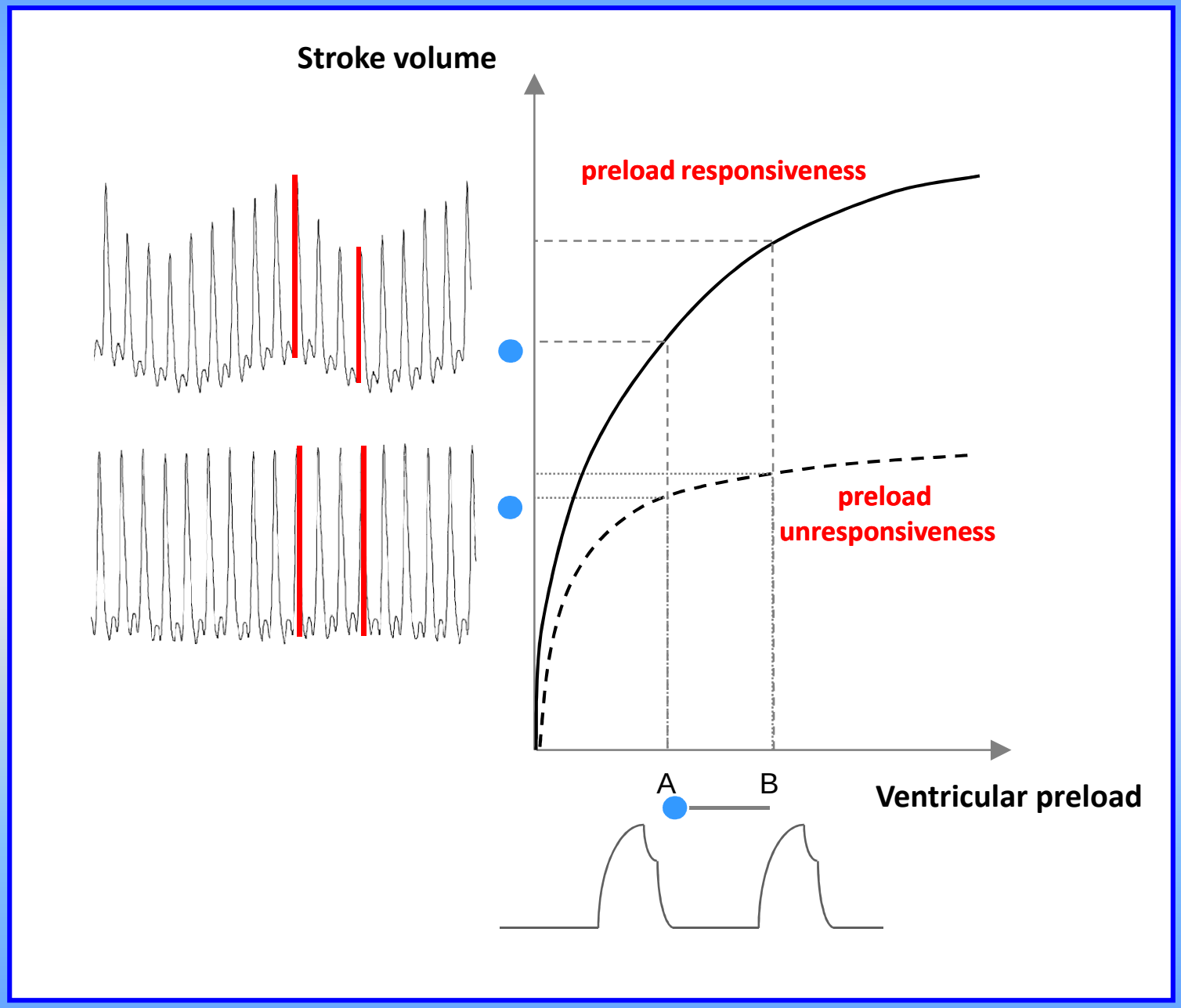


No risk of pulmonary edema

Passive Leg Raising: the advantages

- **PLR** provides a good **prediction** of **fluid responsiveness**
- **Unlike** fluid challenge, effects of **PLR** are rapidly **reversible**
- **PLR** may **well assess** fluid responsiveness

  … in situations where **PPV fails** to do it


Stroke volume
preload responsiveness
preload
unresponsiveness
A
B
Ventricular preload

Clinical Use of Respiratory Changes in Arterial Pulse Pressure to Monitor the Hemodynamic Effects of PEEP

FRÉDÉRIC MICHARD, DENIS CHEMLA, CHRISTIAN RICHARD, MARC WYSOCKI, MICHAEL R. PINSKY, YVES LECARPENTIER, and JEAN-LOUIS TEBOUL

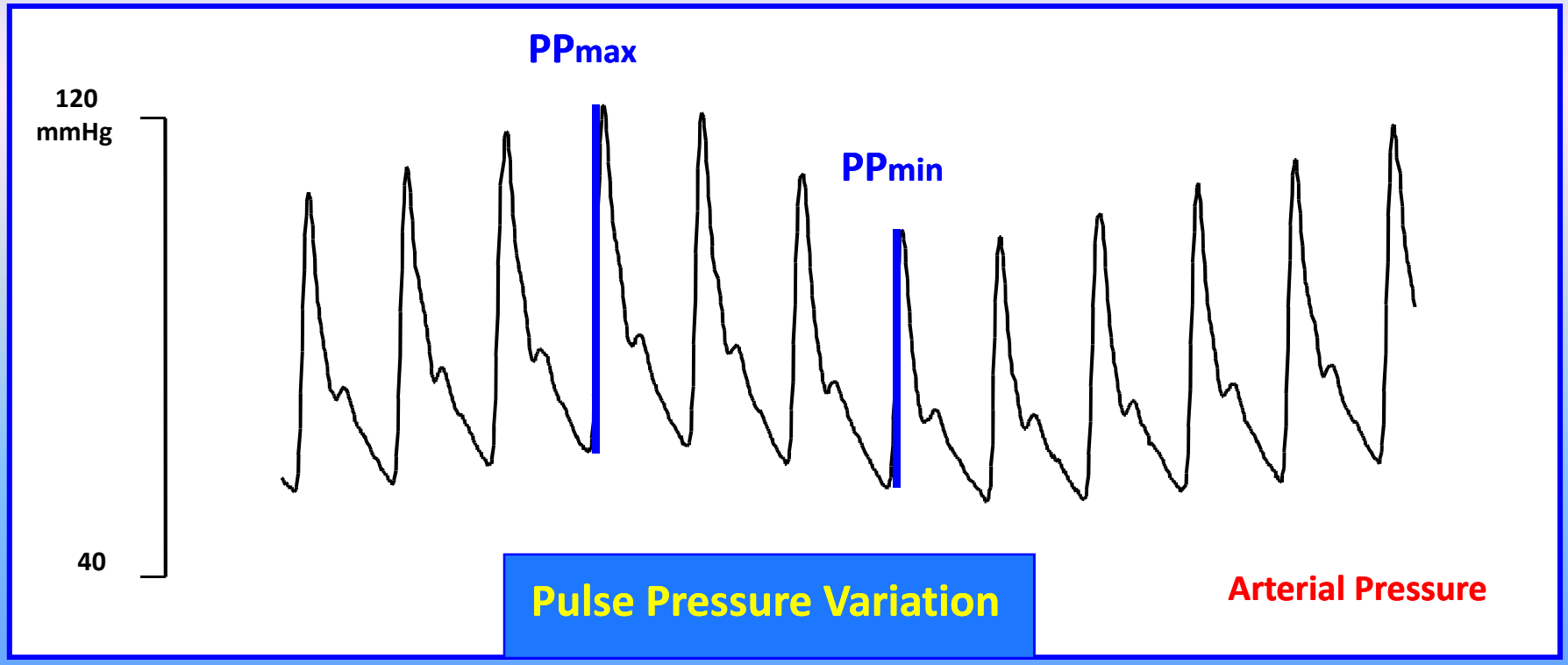
AM J RESPIR CRIT CARE MED 1999;159:935–939

Relation between Respiratory Changes in Arterial Pulse Pressure and Fluid Responsiveness in Septic Patients with Acute Circulatory Failure

FRÉDÉRIC MICHARD, SANDRINE BOUSSAT, DENIS CHEMLA, NADIA ANGUEL, ALAIN MERCAT, YVES LECARPENTIER, CHRISTIAN RICHARD, MICHAEL R. PINSKY, and JEAN-LOUIS TEBOUL

Am J Respir Crit Care Med 2000,162:134–138

$$PPV = \frac{PP_{max} - PP_{min}}{(PP_{max} + PP_{min}) / 2}$$



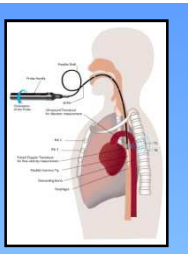
Passive Leg Raising: The advantages

- **PLR** provides a good **prediction** of **fluid responsiveness**
- **Unlike** fluid challenge, effects of **PLR** are rapidly **reversible**
- **PLR** may **well assess** fluid responsiveness
  … in situations where **PPV fails** to do it
    - **Spontaneous Breathing** activity

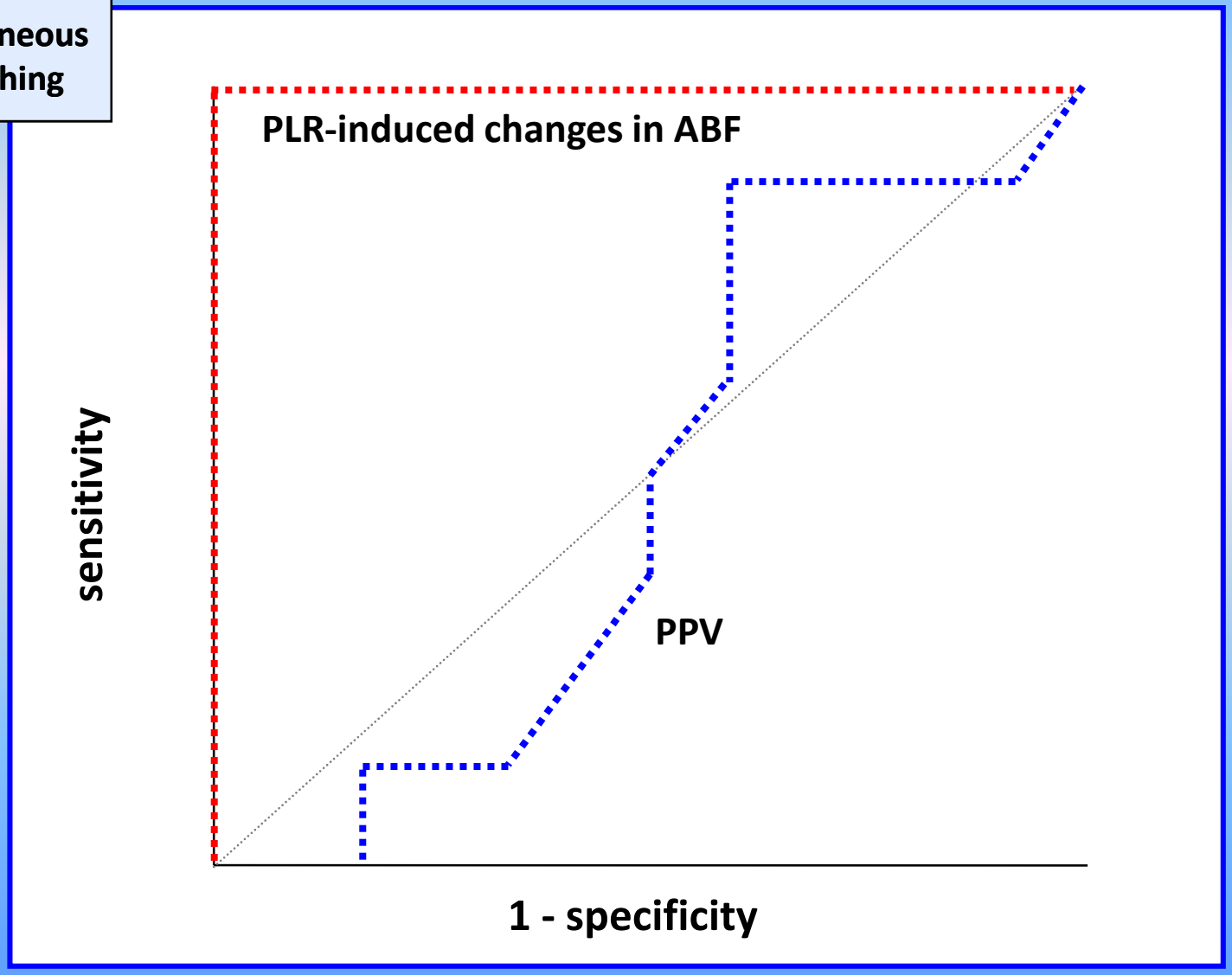
Passive leg raising predicts fluid responsiveness in the critically ill*

Xavier Monnet, MD, PhD; Mario Rienzo, MD; David Osman, MD; Nadia Anguel, MD; Christian Richard, MD; Michael R. Pinsky, MD, Dr hc; Jean-Louis Teboul, MD, PhD

Crit Care Med 2006; 34:1402–1407



Pts with **spontaneous breathing**



Passive Leg Raising: The advantages

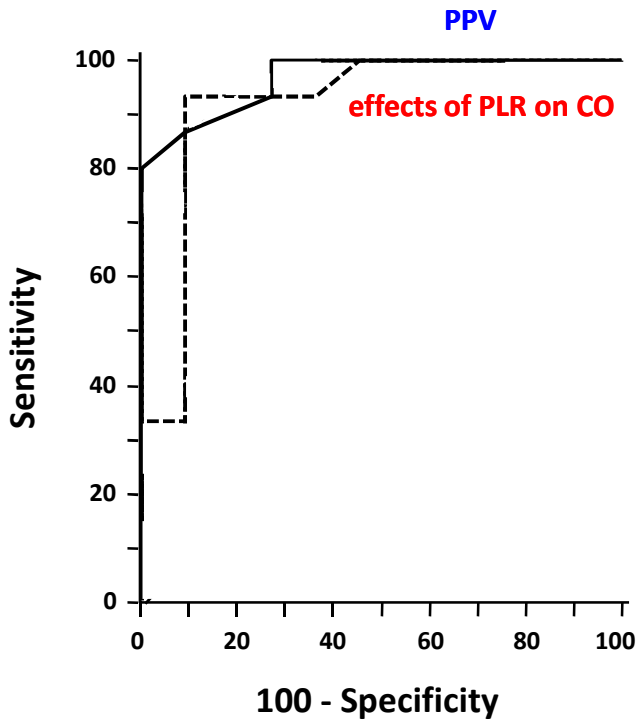
- **PLR** provides a good **prediction** of **fluid responsiveness**
- **Unlike** fluid challenge, effects of **PLR** are rapidly **reversible**
- **PLR** may **well assess** fluid responsiveness
  … in situations where **PPV fails** to do it
    - Spontaneous Breathing activity
    - **Low** lung **compliance**

Passive leg-raising and end-expiratory occlusion tests perform better than pulse pressure variation in patients with low respiratory system compliance

Xavier Monnet, MD, PhD; Alexandre Bleibtreu, MD; Alexis Ferre, MD; Martin Dres, MD; Rim Gharbi, MD; Christian Richard, MD; Jean-Louis Teboul, MD, PhD

Crit Care Med 2012; 40:152–157

Lung compliance ≥ 30 mL/cmH_2O



Passive Leg Raising: the “limits”

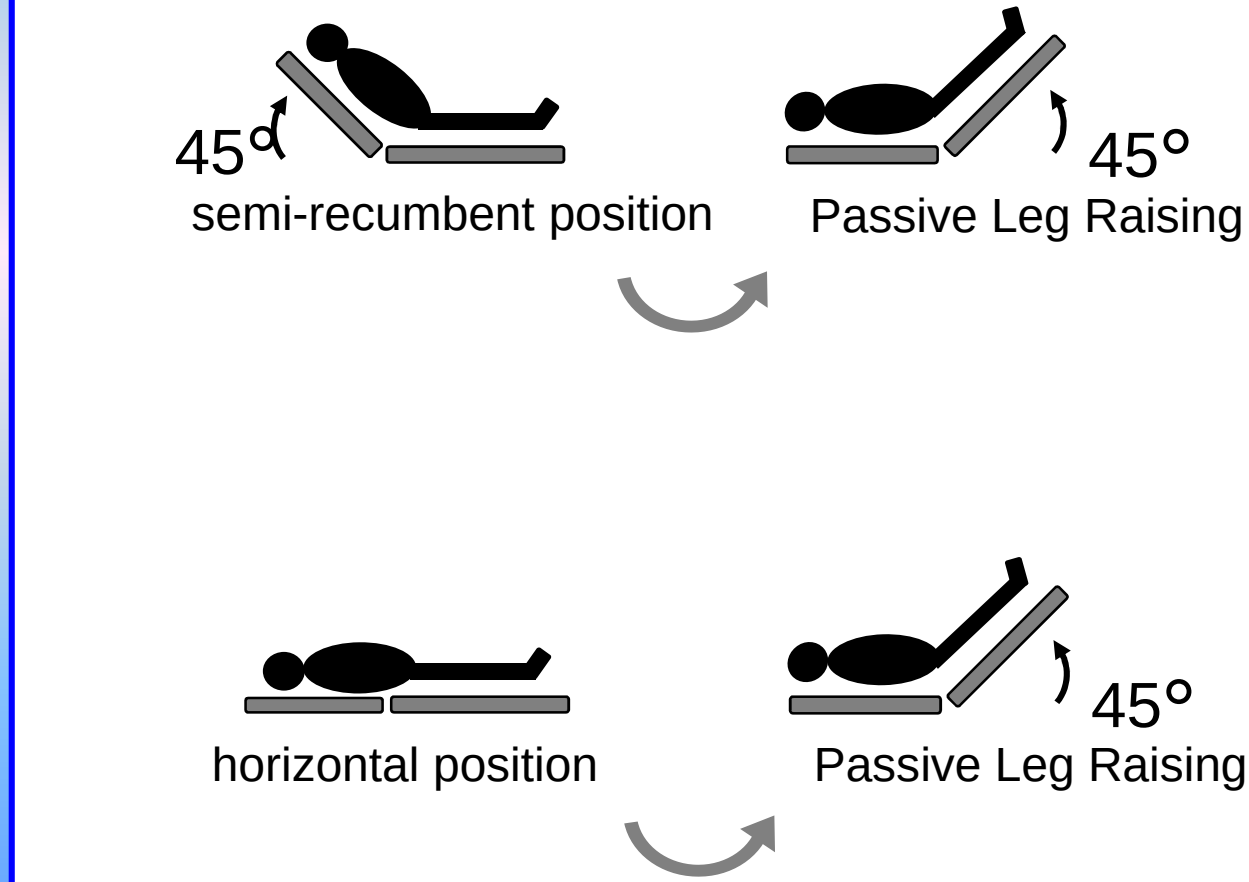
- **PLR** should **not** start from a **horizontal** patient’s position but from a **semi-recumbent** position

Intensive Care Med (2009) 35:85–90

ORIGINAL

Julien Jabot
Jean-Louis Teboul
Christian Richard
Xavier Monnet

Passive leg raising for predicting fluid responsiveness: importance of the postural change

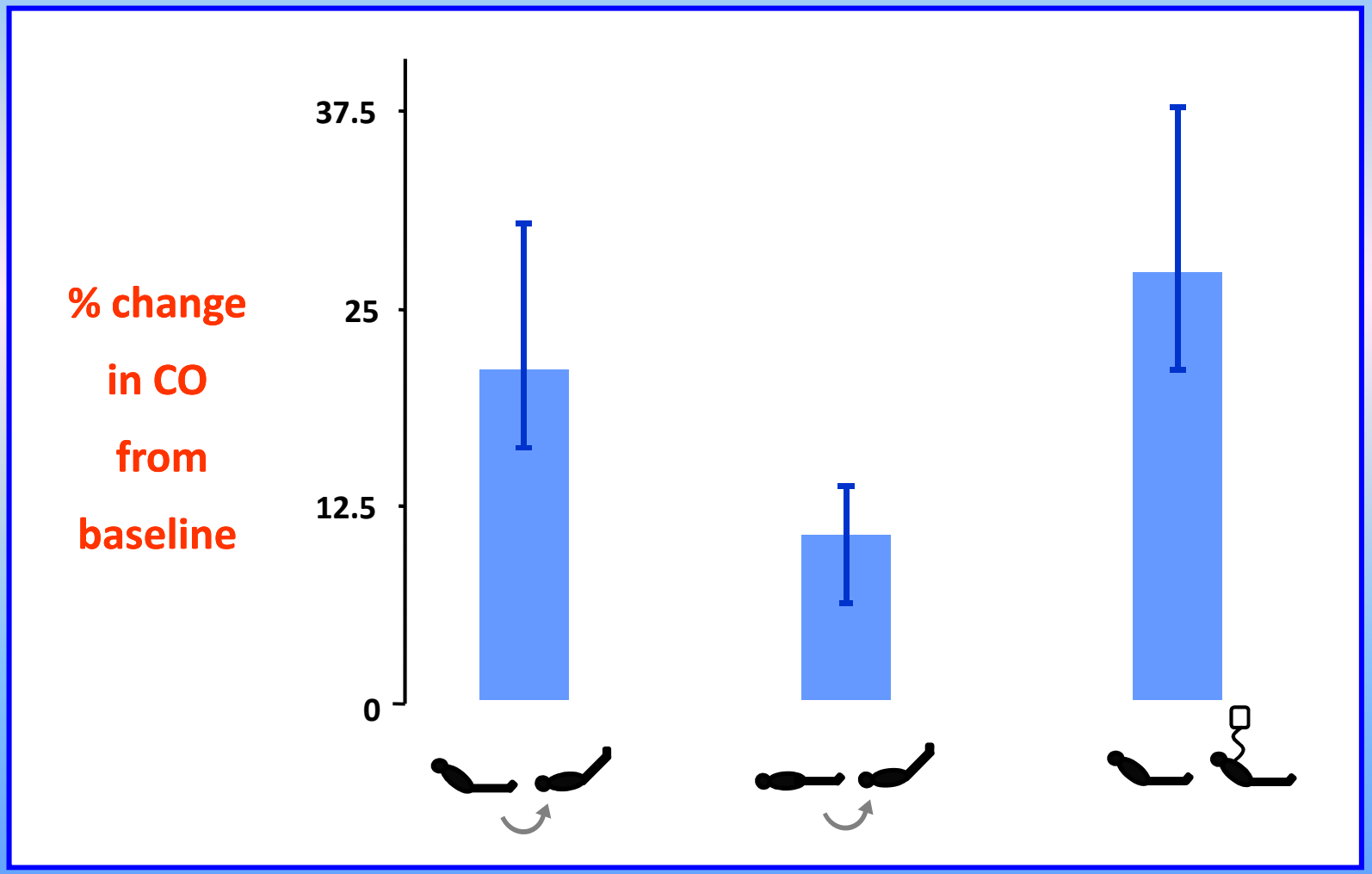


Intensive Care Med (2009) 35:85–90

ORIGINAL

Julien Jabot
Jean-Louis Teboul
Christian Richard
Xavier Monnet

Passive leg raising for predicting fluid responsiveness: importance of the postural change



Intensive Care Med (2009) 35:85–90

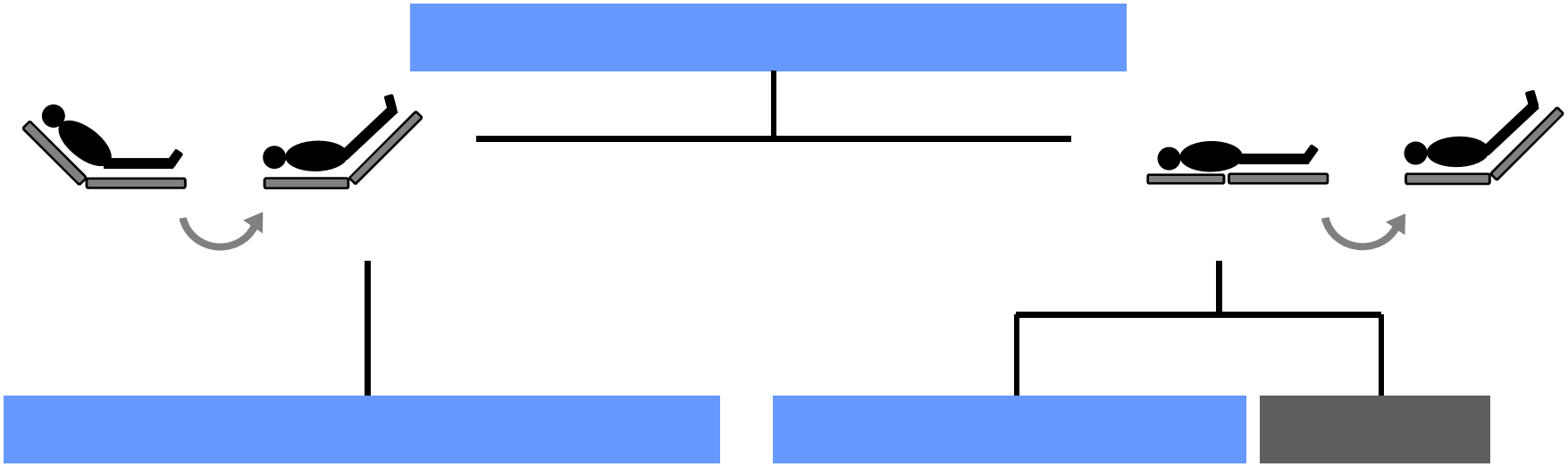
ORIGINAL

Julien Jabot
Jean-Louis Teboul
Christian Richard
Xavier Monnet

Passive leg raising for predicting fluid responsiveness: importance of the postural change

35 patients

(all responders to fluid administration)



35 pts correctly classified as responders

20 pts correctly classified as responders

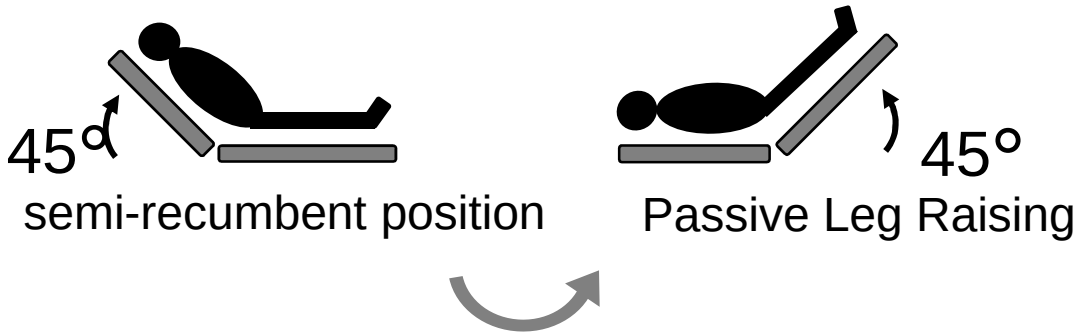
15 pts classified as nonresponders

Intensive Care Med (2009) 35:85–90

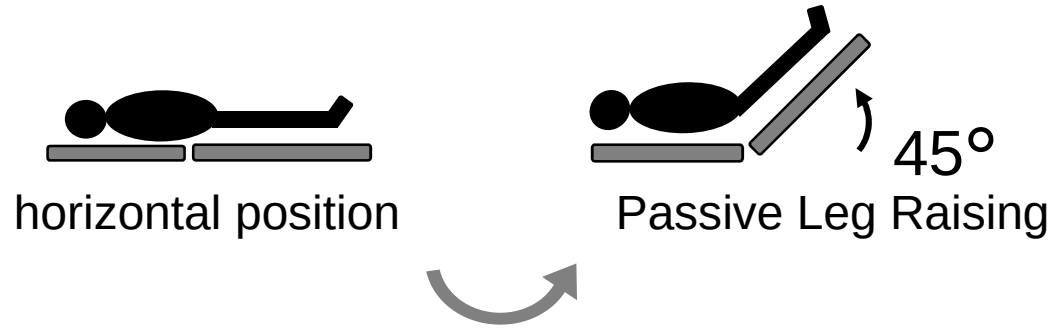
ORIGINAL

Julien Jabot
Jean-Louis Teboul
Christian Richard
Xavier Monnet

Passive leg raising for predicting fluid responsiveness: importance of the postural change



rather than



Passive Leg Raising: the "limits"

- **PLR** should **not** start from a **horizontal** patient's position but from a **semi-recumbent** position

- The hemodynamic **response** to **PLR should not** be monitored with **arterial pressure** but **with CO** measurements

Intensive Care Med (2010) 36:1475–1483

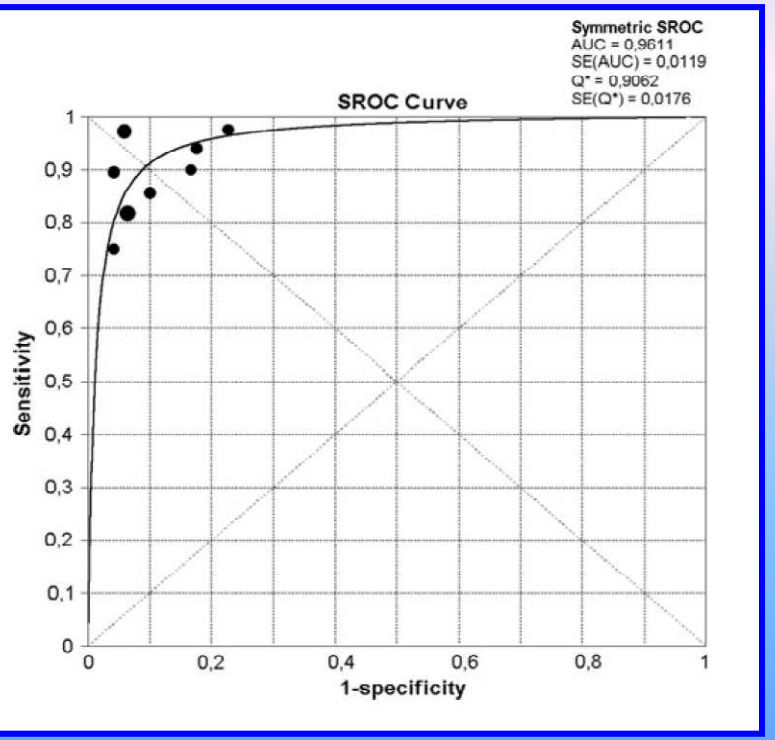
REVIEW

Fabio Cavallaro
Claudio Sandroni
Cristina Marano
Giuseppe La Torre
Alice Mannocci
Chiara De Waure
Giuseppe Bello
Riccardo Maviglia
Massimo Antonelli

Diagnostic accuracy of passive leg raising for prediction of fluid responsiveness in adults: systematic review and meta-analysis of clinical studies

PLR-induced changes in CO

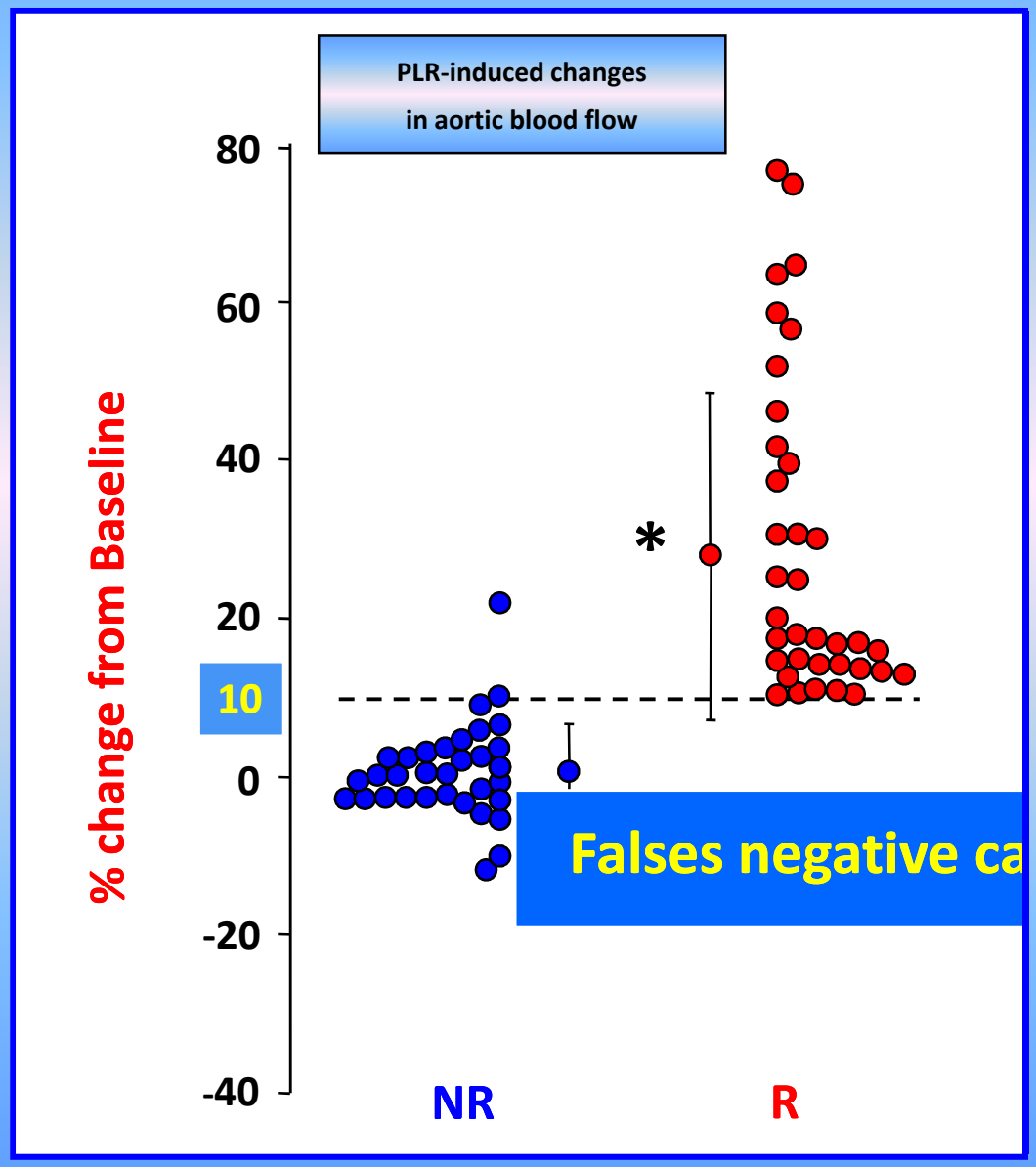
Study name	sample size	AUC
Monnet CCM 2006	71	0.96
Lafanéchère CC 2006	22	0.95
Lamia ICM 2007	24	0.96
Maizel ICM 2007	34	0.89
Monnet CCM 2009	34	0.94
Thiel CC 2009	102	0.89
Biais CC 2009	30	0.96
Preau CCM 2010	34	0.94
	351	0.95



Passive leg raising predicts fluid responsiveness in the critically ill*

Xavier Monnet, MD, PhD; Mario Rienzo, MD; David Osman, MD; Nadia Anguel, MD; Christian Richard, MD; Michael R. Pinsky, MD, Dr hc; Jean-Louis Teboul, MD, PhD

Crit Care Med 2006; 34:1402–1407



Conclusion

- **PLR** provides a good **prediction** of **fluid responsiveness**
- **Unlike** fluid challenge, effects of **PLR** are rapidly **reversible**
- **PLR** may **well assess** fluid responsiveness
  … in situations where **PPV fails** to do it
- In the **ER**, the **response to PLR** is better assessed with **non-invasive CO** measurements than AP measurements

Thank you