

Prédiction de la réponse à l'expansion volémique

Pr Xavier MONNET

Service de réanimation médicale

Hôpital de Bicêtre

Assistance publique – Hôpitaux de Paris

Les 5 messages-clés

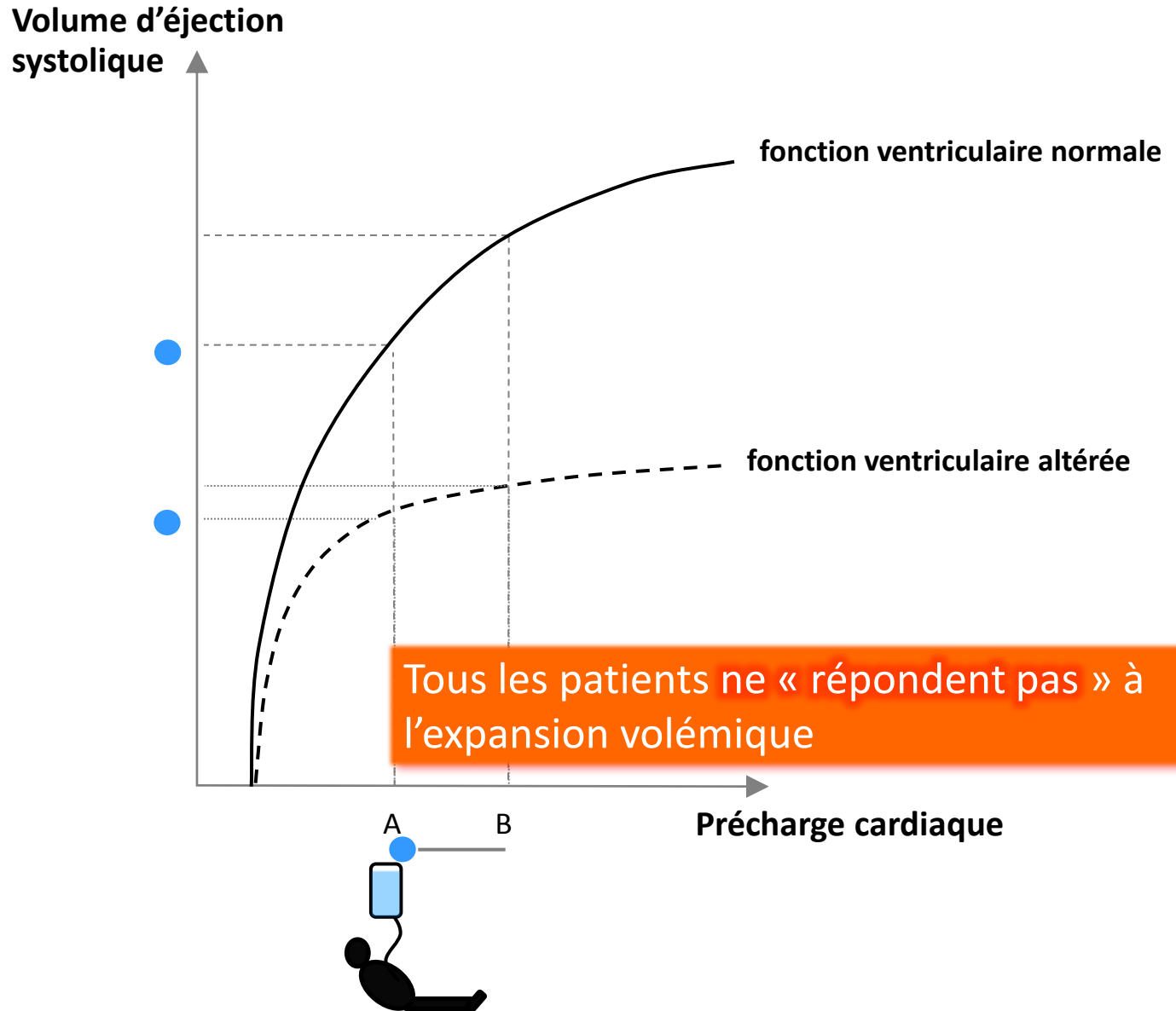
1 Tous les patients **ne répondent pas** à l'expansion volémique par une augmentation **significative** du débit cardiaque

2

3

4

5



Les 5 messages-clés

1 Tous les patients **ne répondent pas** à l'expansion volémique par une augmentation **significative** du débit cardiaque

2



Et alors?..

3

4

5

The NEW ENGLAND JOURNAL of MEDICINE

Comparison of Two Fluid-Management Strategies in Acute Lung Injury

The National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome (ARDS) Clinical Trials Network*

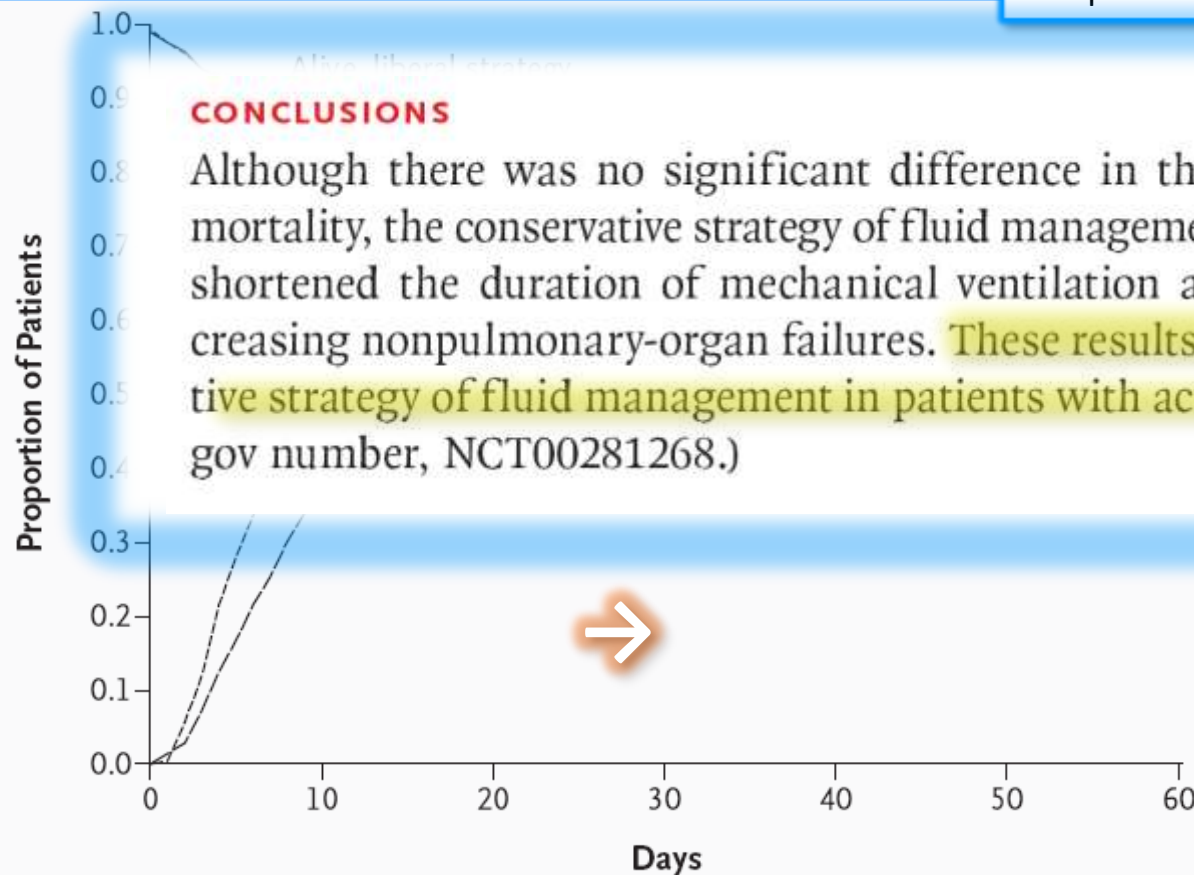
N Engl J Med 2006;354:2564-75

1,000 pts with ALI/ARDS

Comparison of conservative vs. liberal fluid strategies

CONCLUSIONS

Although there was no significant difference in the primary outcome of 60-day mortality, the conservative strategy of fluid management improved lung function and shortened the duration of mechanical ventilation and intensive care without increasing nonpulmonary-organ failures. These results support the use of a conservative strategy of fluid management in patients with acute lung injury. (ClinicalTrials.gov number, NCT00281268.)



limiter l'administration
liquidienne lors du SDRA

Sepsis in European intensive care units: Results of the SOAP study*

Jean-Louis Vincent, MD, PhD, FCCM; Yasser Sakr, MB, BCh, MSc; Charles L. Sprung, MD; V. Marco Ranieri, MD; Konrad Reinhart, MD, PhD; Herwig Gerlach, MD, PhD; Rui Moreno, MD, PhD; Jean Carlet, MD, PhD; Jean-Roger Le Gall, MD; Didier Payen, MD; on behalf of the Sepsis Occurrence in Acutely Ill Patients Investigators

Crit Care Med 2006;

Cohort study

3,147 pts with sepsis

Table 7. Multivariate, forward stepwise logistic regression analysis in sepsis patients (n = 1177), with intensive care unit mortality as the dependent factor

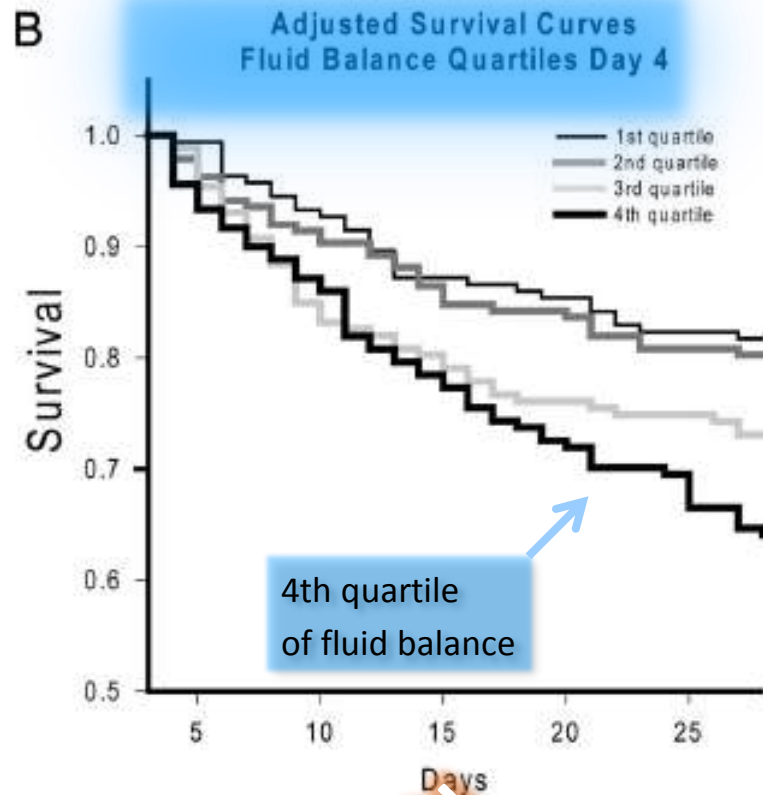
	OR (95% CI)	p Value
SAPS II score ^a (per point increase)	1.0 (1.0–1.1)	<.001
Cumulative fluid balance ^b (per liter increase)	1.1 (1.0–1.1)	.001
Age (per year increase)	1.0 (1.0–1.0)	.001
Initial SOFA score (per point increase)	1.1 (1.0–1.1)	.002
Blood stream infection	1.7 (1.2–2.4)	.004
Cirrhosis	2.4 (1.3–4.5)	.008
<i>Pseudomonas</i> infection	1.6 (1.1–2.4)	.017
Medical admission	1.4 (1.0–1.8)	.049
Female gender	1.4 (1.0–1.8)	.044

Fluid resuscitation in septic shock: A positive fluid balance and elevated central venous pressure are associated with increased mortality*

John H. Boyd, MD, FRCP(C); Jason Forbes, MD; Taka-aki Nakada, MD, PhD; Keith R. Walley, MD, FRCP(C); James A. Russell, MD, FRCP(C)

Crit Care Med 2011

778 septic shock pts from the VASST study



limiter l'administration liquidienne
lors du choc septique

Extra-vascular lung water and pulmonary vascular permeability index are independent prognostic factors in patients with acute respiratory distress syndrome or acute lung injury

Jozwiak M, Silva S, Persichini R, Anguel N, Osman D, Richard C, Teboul JL, Monnet X

Crit Care Med, in press

200 pts with ARDS

EVLW measured by PiCCO

	Odds Ratio (CI 95%)	p value
EVLWI _{max} (1 unit = 1 mL/kg)	1.07 (1.02 - 1.12)	0.007
Maximum blood lactate (1 unit = 1 mmol/L)	1.29 (1.14 - 1.46)	0.0001
Minimum PaO ₂ /FiO ₂ (1 unit = 1 mmHg)	0.98 (0.97 - 0.99)	0.006
Mean PEEP (1 unit = 1 cmH ₂ O)	0.78 (0.67 - 0.91)	0.002
SAPS II (1 unit = 1 point)	1.03 (1.01 - 1.05)	0.02
Mean cumulative fluid balance (1 unit = 1 mL)	1.0004 (1.0001 - 1.0008)	0.02

EVLWI_{max} < 21 mL/kg EVLWI_{max} ≥ 21 mL/kg

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2 L'administration liquidienne excessive est **délétère** chez les patients atteints de **sepsis** et de **SDRA**

3

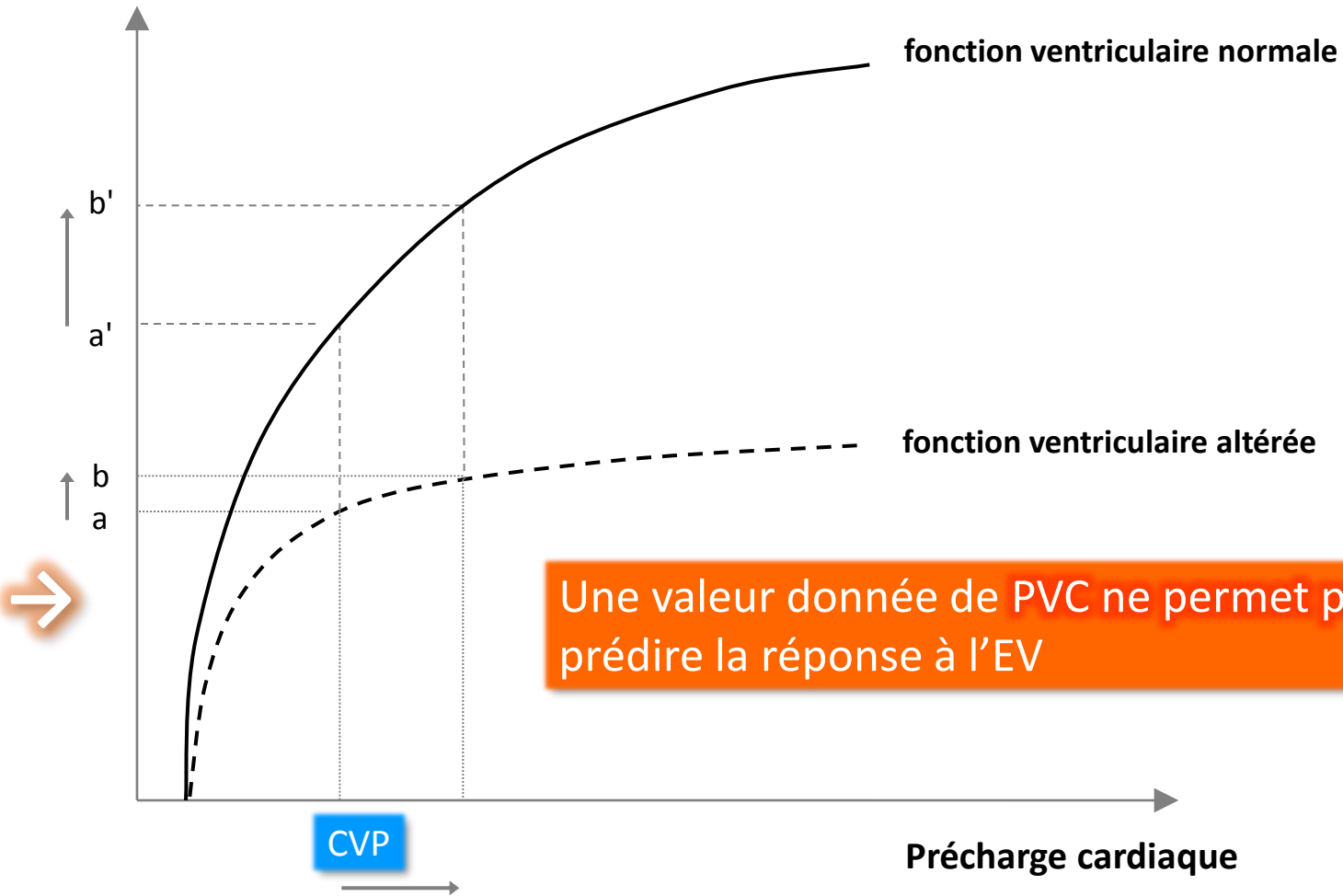


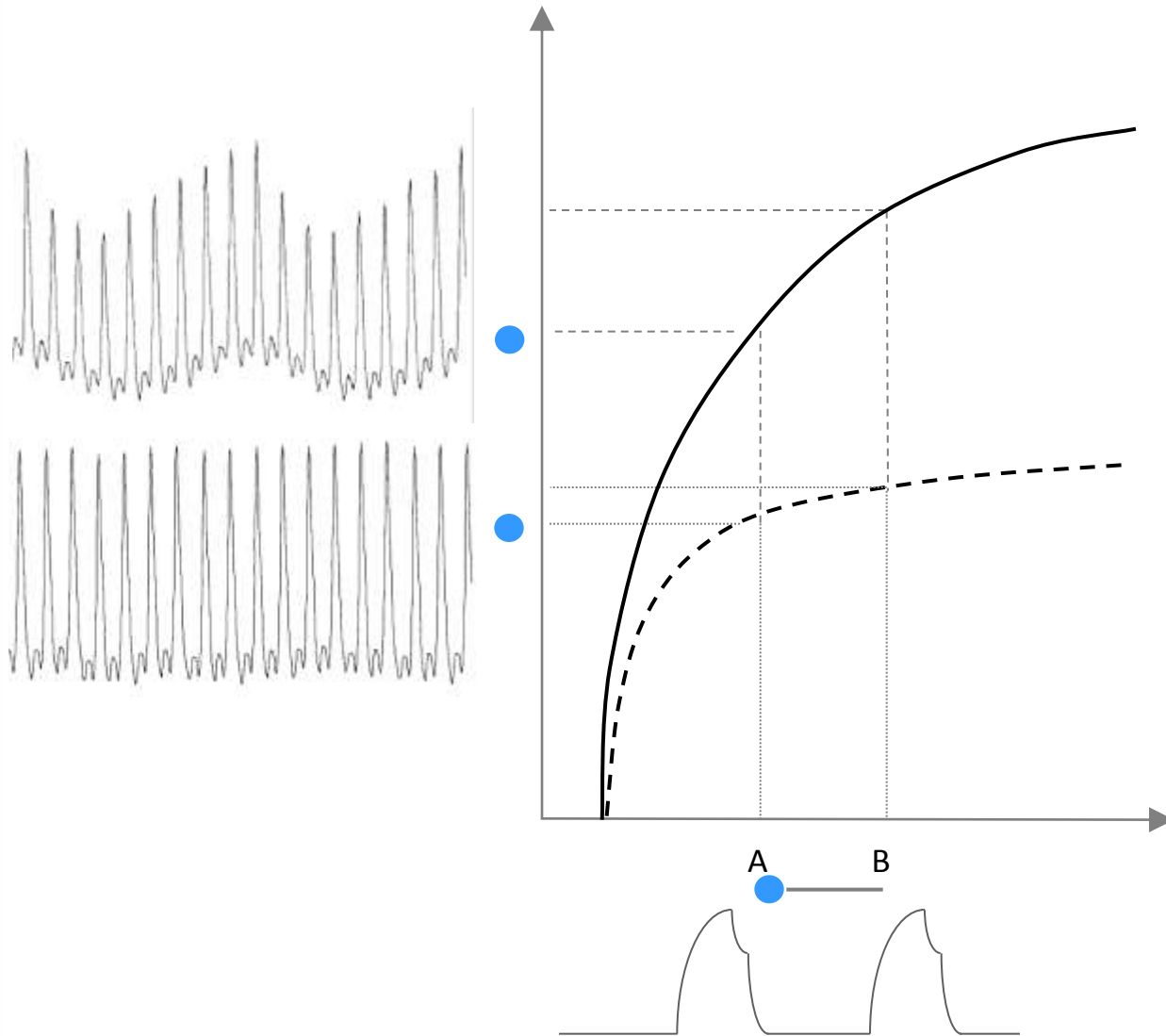
Comment prédire
la réponse à l'expansion volémique ?

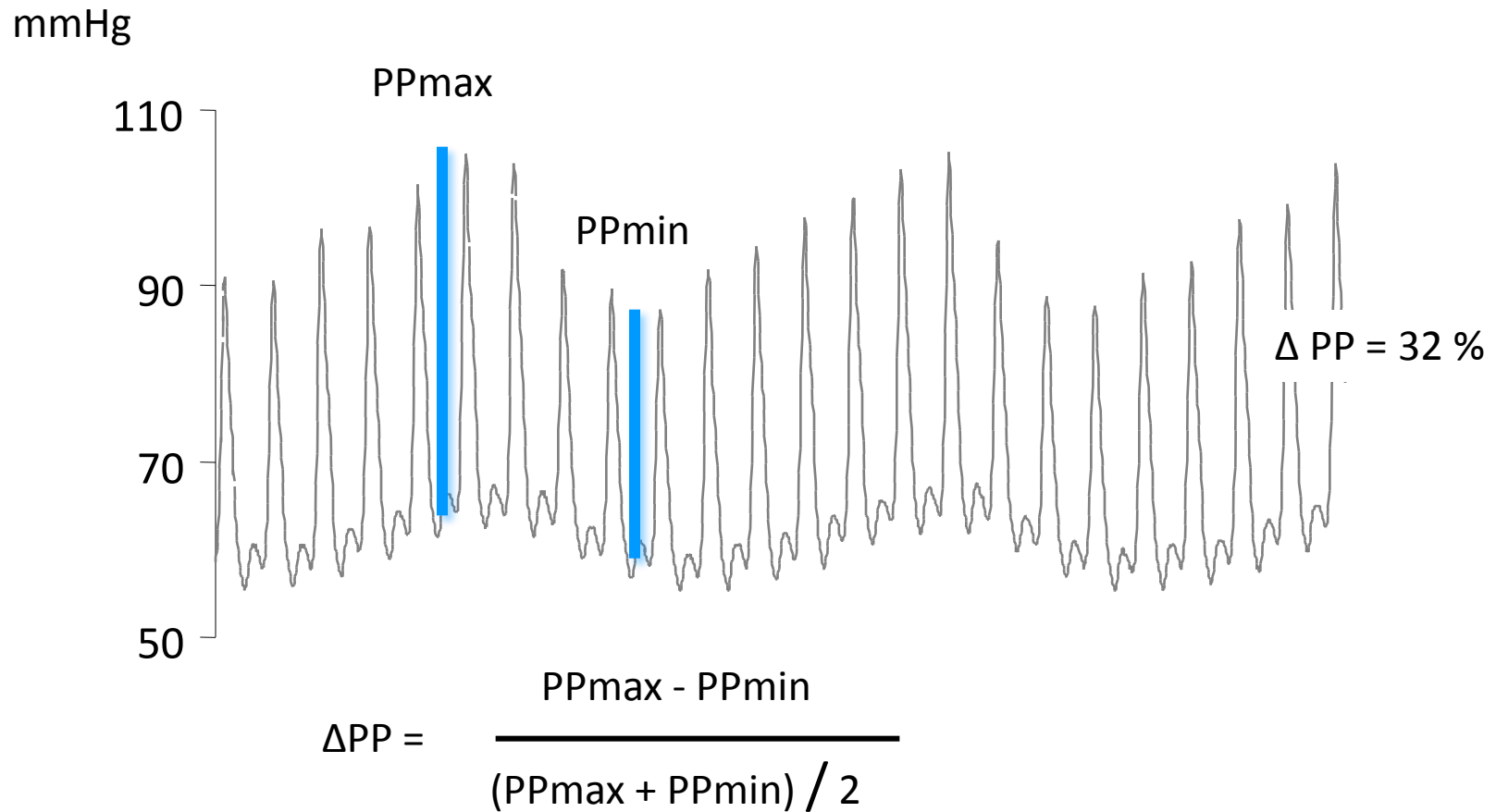
4

5

Volume d'éjection
systolique







Dynamic changes in arterial waveform derived variables and fluid responsiveness in mechanically ventilated patients: A systematic review of the literature*

Paul E. Marik, MD, FCCM; Rodrigo Cavallazzi, MD; Tajender Vasu, MD; Amyr Hirani, MD

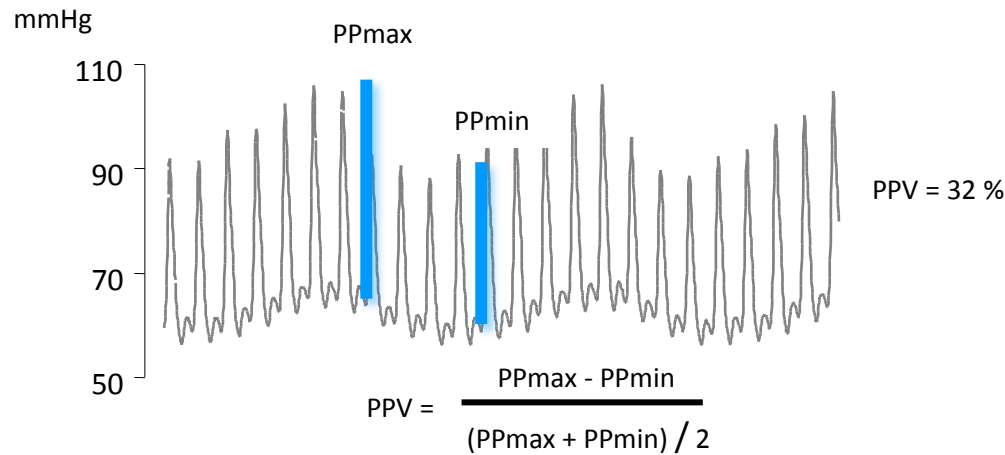
Meta-analysis

29 studies

685 patients

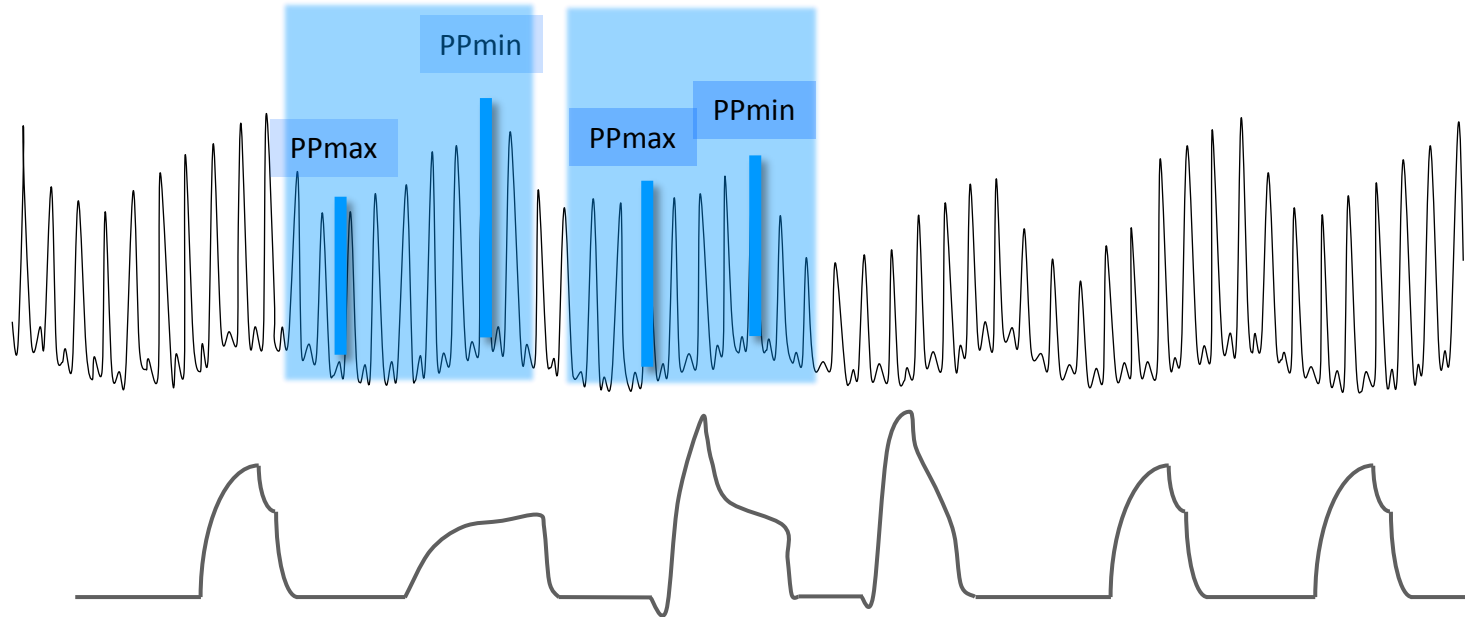
Author	Year	n	Patient	Dynamic Variable		
				SPV	PPV	SVV
Tavernier (31)	1998	15	ICU-sepsis	Y	N	N
Michard (32)	1999	14	ICU-ARDS	N	Y	N
Michard (33)	2000	40	ICU-sepsis	Y	Y	N
Berkenstadt (34)	2001	15	Neurosurg ^a	N	N	Y
Reuter (35)	2002	20	Post C.Surg	Y	N	Y
Reuter (36)	2002	20	Post C.Surg	N	N	Y
Reuter (37)	2003	12	Post C.Surg-a	N	N	Y
		14	Post C.Surg-b			
Bendjelid (38)	2004	16	Post C.Surg	Y	Y	N
Rex (39)	2004	14	Post C.Surg	N	N	Y
Kramer (40)	2004	21	Post C.Surg	Y	Y	N
Marx (41)	2004	10	ICU-sepsis	N	N	Y
Hofer (42)	2005	35	Post C.Surg	N	Y	Y
Preisman (43)	2005	18	Post C.Surg	Y	Y	Y
De Backer (44) ^d	2005	27	ICU-mixed	N	Y	N
Wiesenack (45)	2005	20	C.Surg ^a	N	Y	Y
Feissel (46)	2005	20	ICU-sepsis	N	Y	N
Solus-Biguenet (47)	2006	8	Hepatic surgery	N	Y	N
Charron (48)	2006	21	ICU-mixed	N	Y	N
Natalini (49)	2006	22	ICU-mixed	Y	Y	N
Wyffels (50)	2007	32	Post C.Surg	N	Y	N
Feissel (51)	2007	23	ICU-sepsis	N	Y	N
Lee (52)	2007	20	Neurosurg ^a	N	Y	N
Cannesson (53)	2007	25	C.Surg ^a	N	Y	N
Cannesson (54)	2008	25	C.Surg ^a	N	Y	N
Auler (55)	2008	59	Post C.Surg	N	Y	N
Belloni (56)	2008	19	C.Surg ^a	Y	Y	Y
Cannesson (57)	2008	25	C.Surg ^a	N	Y	N
Hofer (58)	2008	40	Post CABG	N	Y	Y
Biasis (59)	2008	35	Liver transplant	N	Y	Y

A large base of evidence

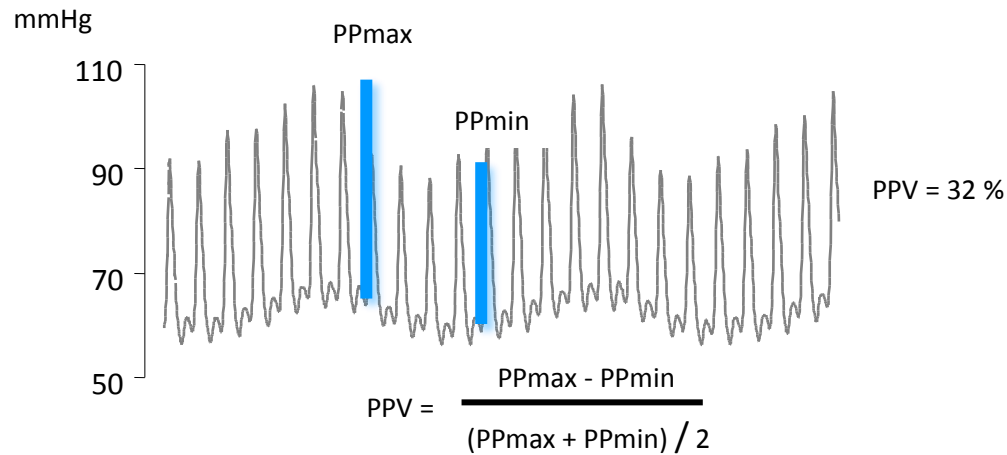


Ne peuvent être utilisées en cas de :

activité respiratoire spontanée

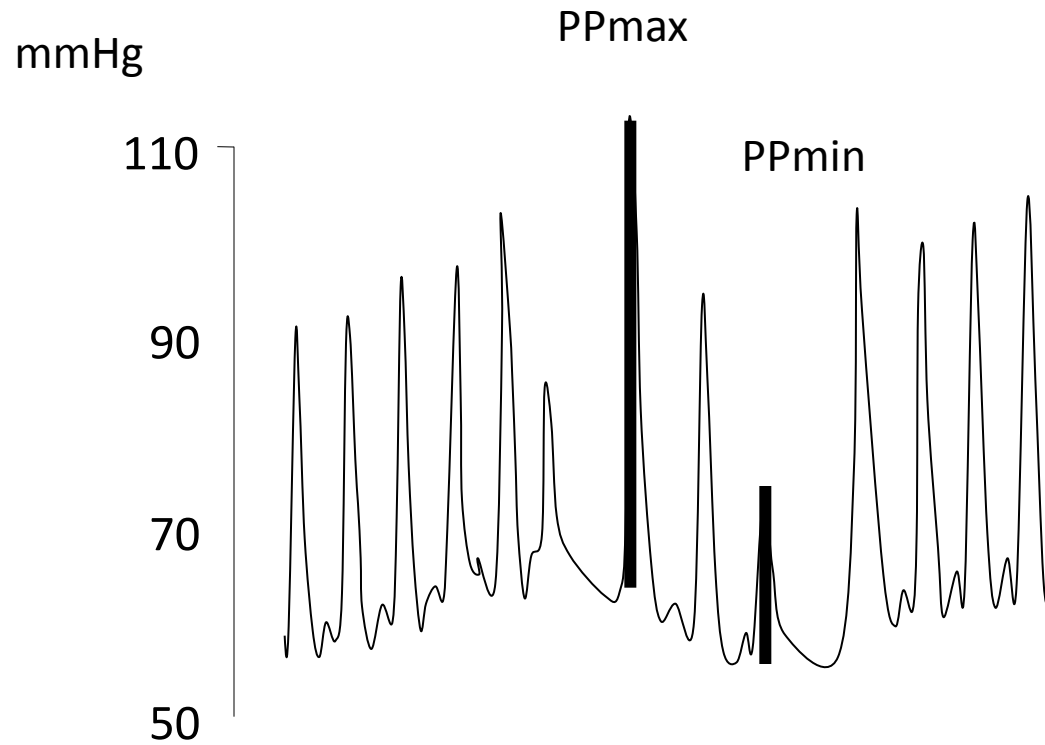


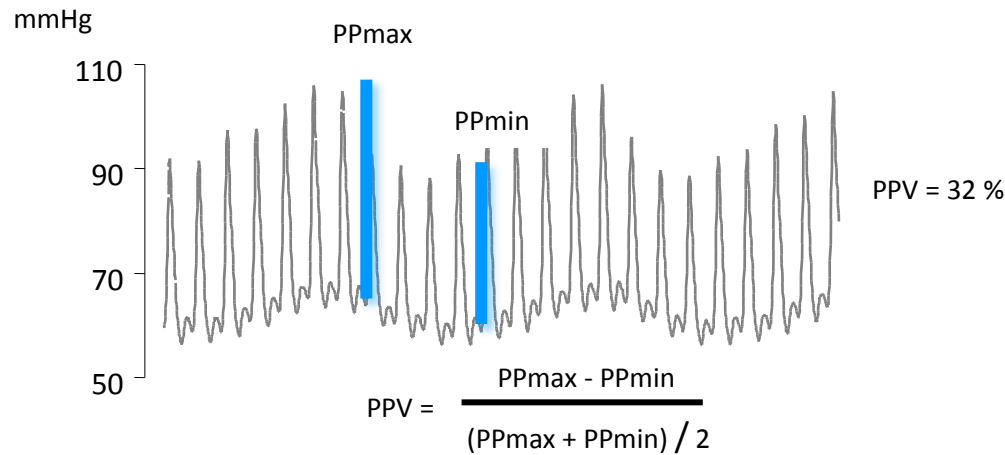
The inhomogeneity of the variations in intrathoracic pressure induced by ventilation precludes to use PPV as a predictor of fluid responsiveness



Ne peuvent être utilisées en cas de :

activité respiratoire spontanée





Ne peuvent être utilisés en cas de :

activité respiratoire spontanée

arythmies cardiaques

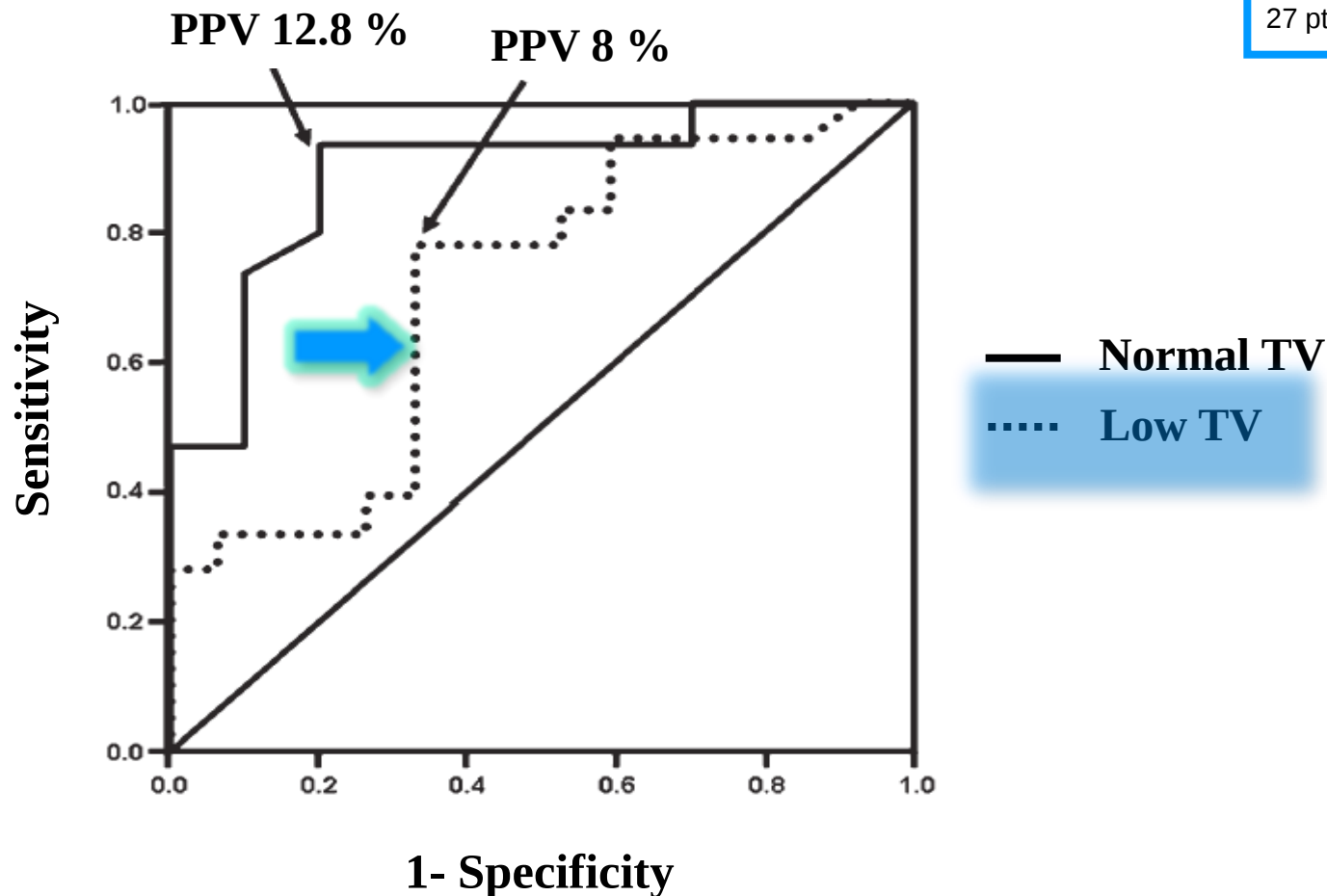
Intensive Care Med (2005) 31:517-523
DOI 10.1007/s00134-005-2586-4

ORIGINAL

Daniel De Backer
Sarah Heenen
Michael Piagnerelli
Marc Koch
Jean-Louis Vincent

Pulse pressure variations to predict fluid responsiveness: influence of tidal volume

26 pts with $V_t < 7$ mL/kg
9 pts with $V_t 7-8$ mL/kg
27 pts with $V_t > 8$ mL/kg

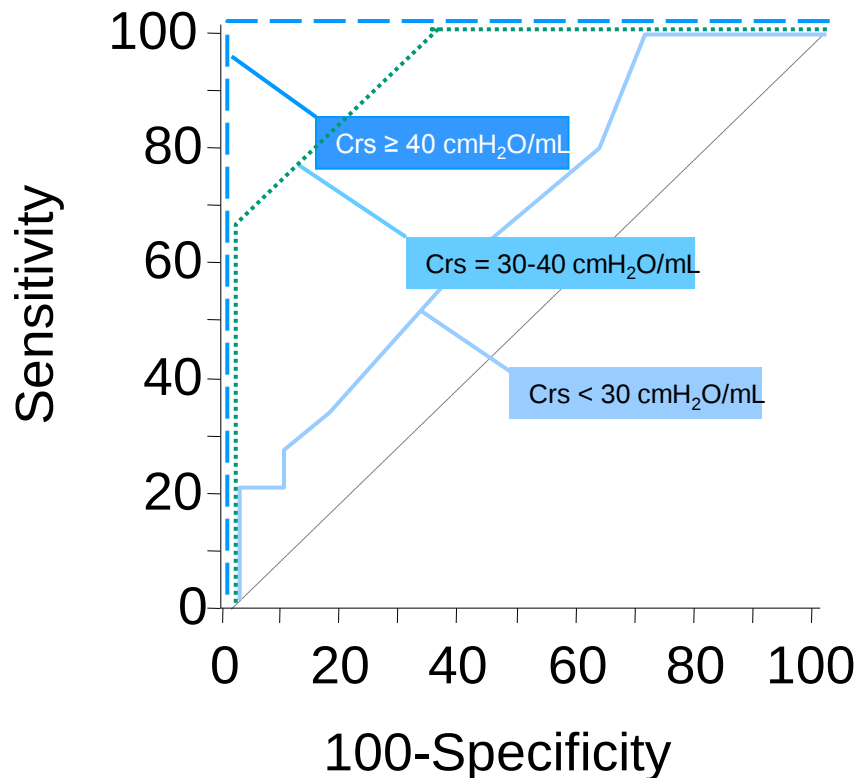


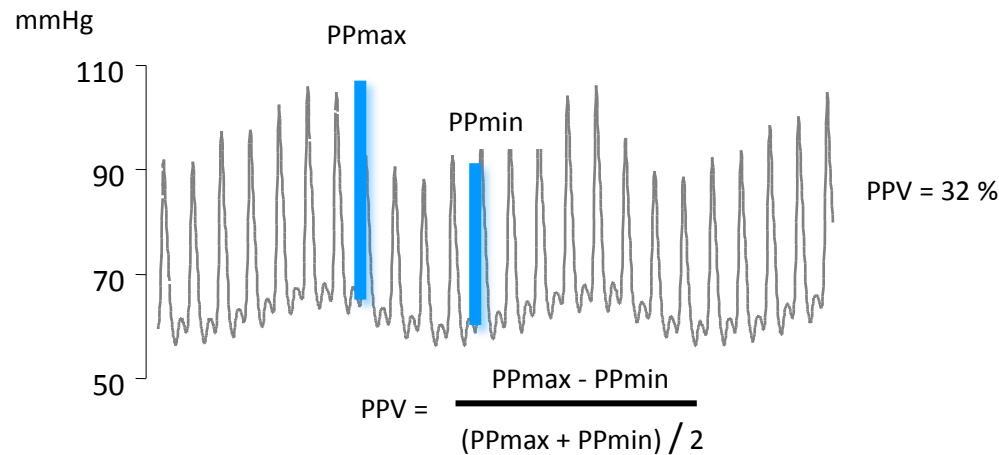
Passive leg-raising and end-expiratory occlusion tests perform better than pulse pressure variation in patients with low respiratory system compliance

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

39 septic shock patients
19 ARDS and 20 non ARDS patients



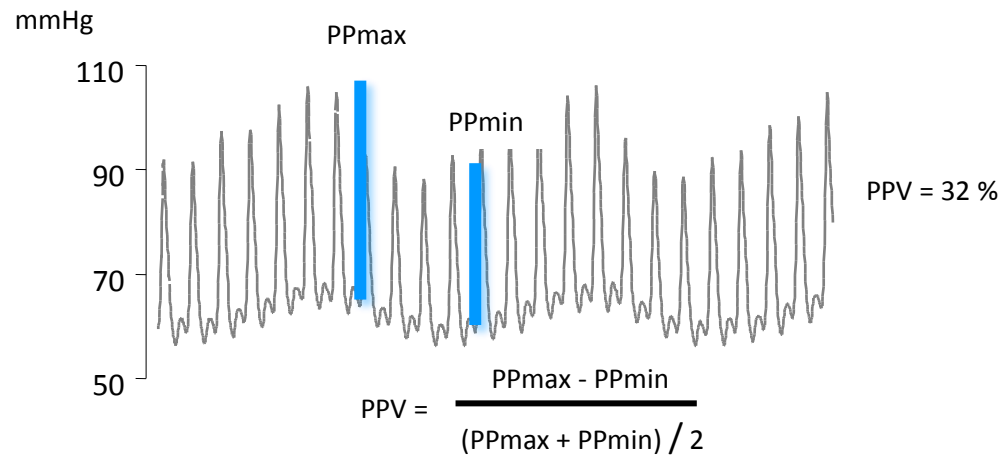


Ne peuvent être utilisés en cas de :

activité respiratoire spontanée

arythmies cardiaques

SDRA avec faible VT / compliance pulmonaire



Ne peuvent être utilisés en cas de :

activité respiratoire spontanée

arythmies cardiaques

SDRA avec faible VT / compliance pulmonaire

3 situations fréquentes
en réanimation

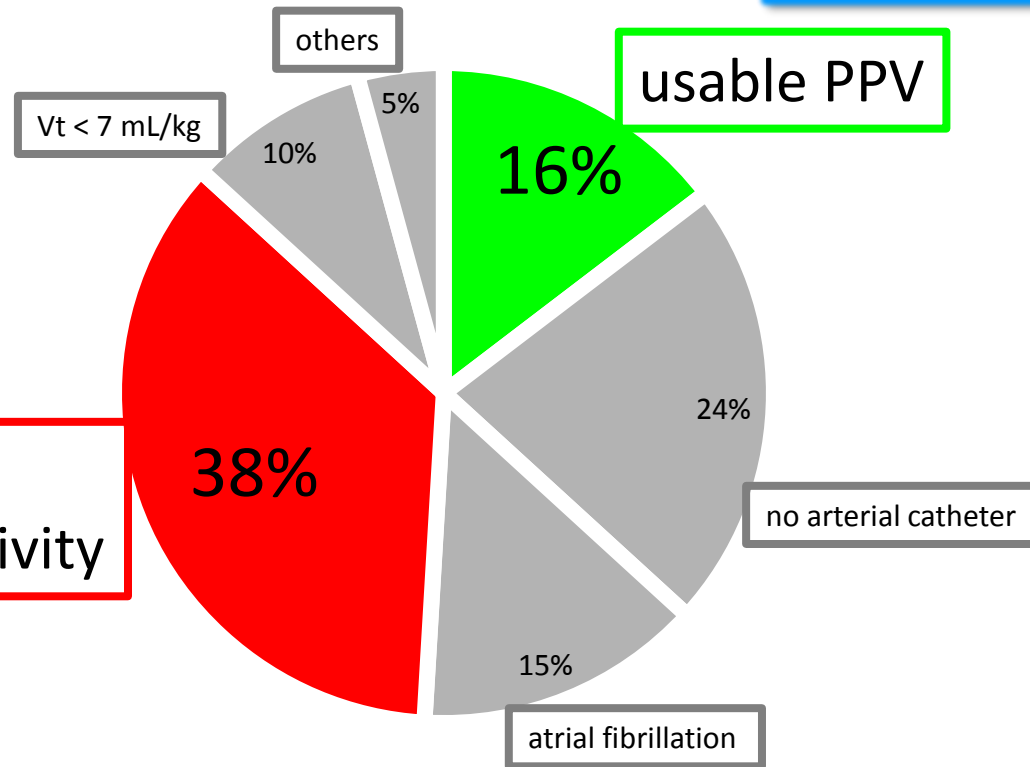
Pulse pressure cannot be used in a large majority of ICU patients for predicting fluid responsiveness

Jozwiak M, Teboul JL, Richard C, Monnet X

In preparation

200 volume expansions

Validity of PPV as a marker of fluid responsiveness



Les 5 messages-clés

- 1 Tous les patients **ne répondent pas** à l'expansion volémique par une augmentation **significative** du débit cardiaque
- 2 L'administration liquidienne excessive est **délétère** chez les patients atteints de **sepsis** et de **SDRA**
- 3 La variabilité respiratoire des signaux hémodynamiques ne peut être utilisée en cas **d'arythmie**, de **ventilation spontanée** et de **SDRA**

4



Quelles alternatives ?

5

Chez un patient avec une insuffisance circulatoire



réponse à l'expansion
volémique

?

Arrhythmies, SDRA, ventilation spontanée ?

non

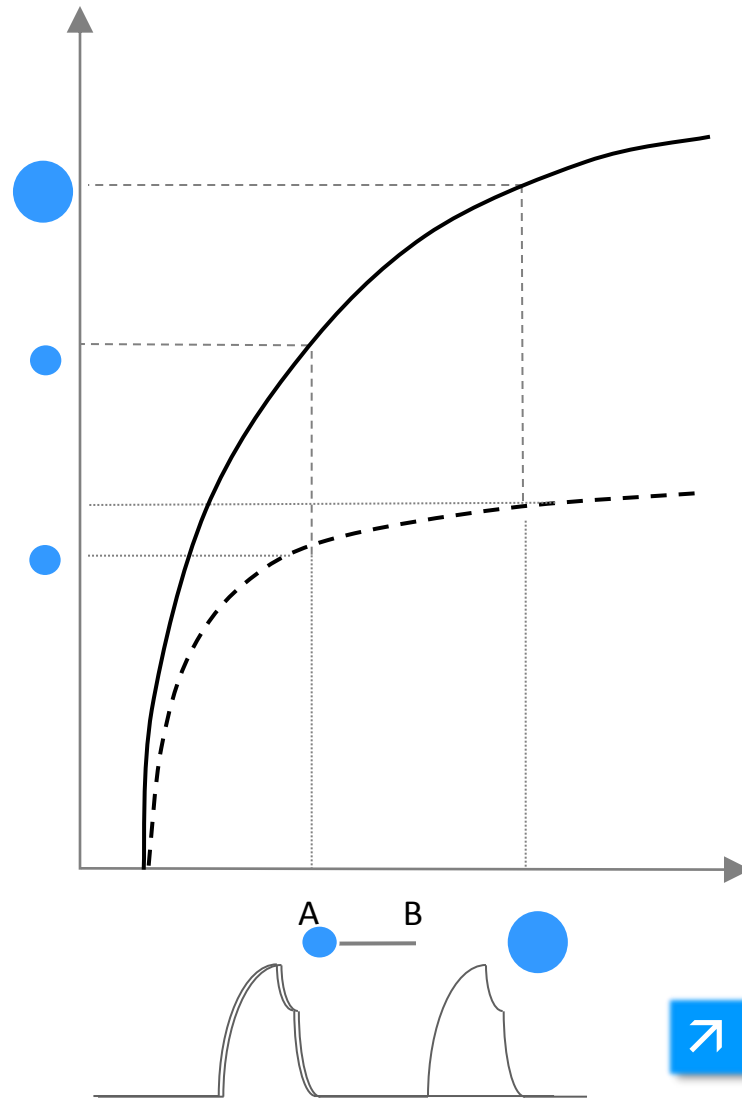
VVP, VVE...

oui

?

~ 80% des
patients

Test d'occlusion télé-expiratoire



↗ retour veineux systémique

Test d'occlusion télé-expiratoire

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

34 patients with acute circulatory failure monitored by PiCCO device

Arterial pressure
(mm Hg)

100

30

Airway pressure
(cm H₂O)

40

0

Test d'occlusion télé-expiratoire



Plus facile avec une mesure continue du débit cardiaque

Test d'occlusion télé-expiratoire

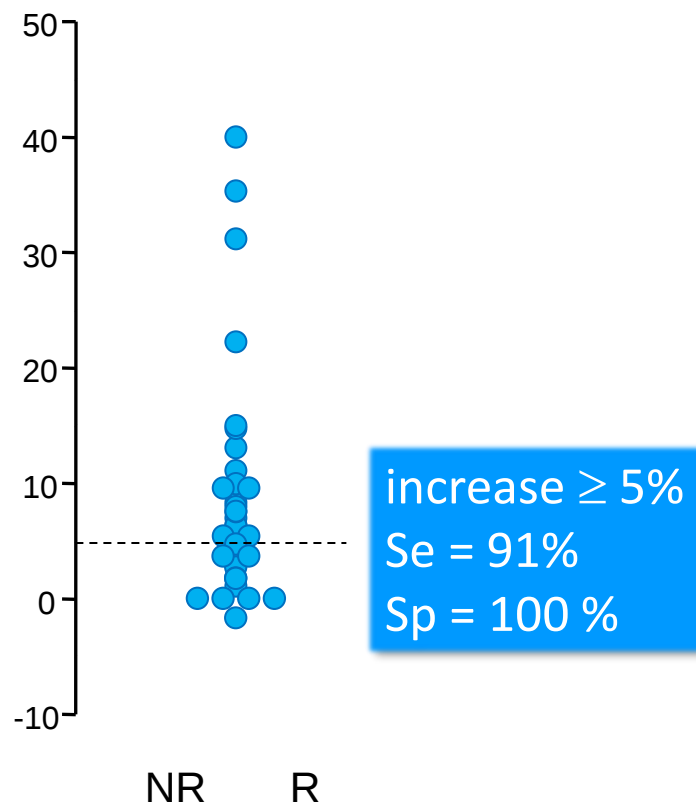
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34 patients with acute circulatory failure monitored by PICCO device

Crit Care Med 2009

Effects of end-expiratory pause on **continuous** cardiac index



Test d'occlusion télé-expiratoire

limites

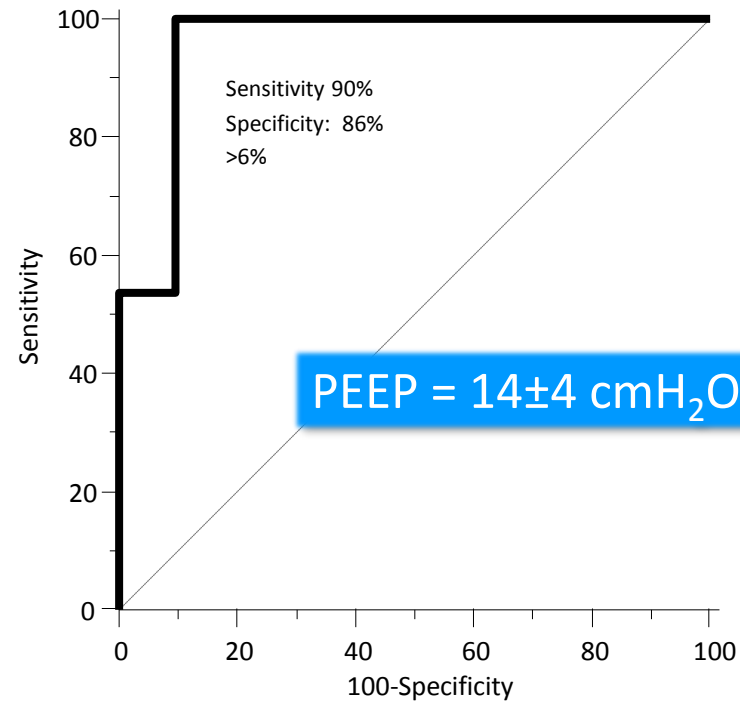
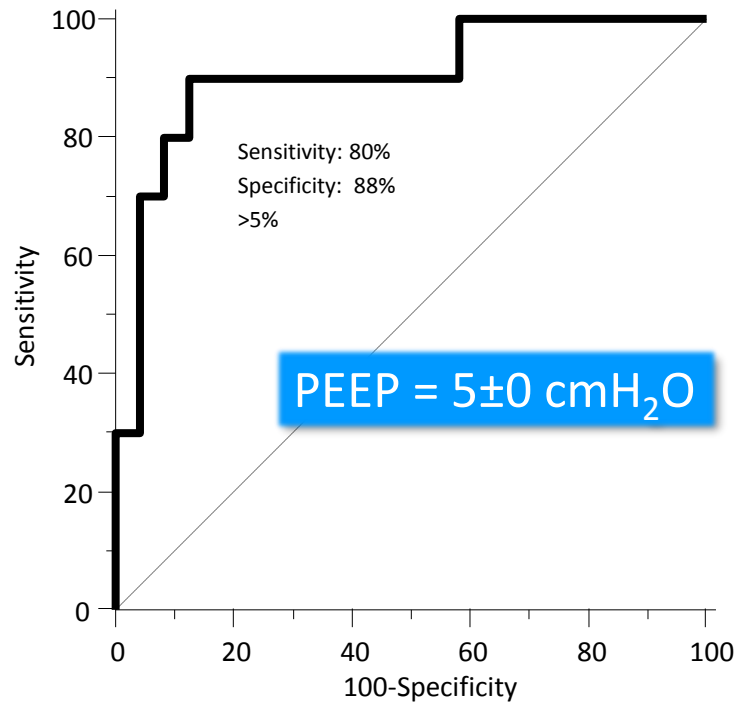
Niveau de PEP ?

Test d'occlusion télé-expiratoire

The end-expiratory occlusion test predicts fluid responsiveness independently from the level of positive end-expiratory pressure during ARDS

Serena SILVA^{1,2}, Mathieu JOZWIAK^{1,2}, Jean-Louis TEBOUL^{1,2}, Romain PERSICHINI^{1,2}, Christian RICHARD^{1,2}, Xavier MONNET^{1,2}

in revision



34 ARDS patients

EEO test at PEEP=5 cmH₂O and Pplat=30 cmH₂O

Le test d'EEO est valable quelque soit le niveau de PEP

Test d'occlusion télé-expiratoire limites

Niveau de PEP ? s patients qui ne sont pas intubés

mais a-t-on besoin de prédire la réponse à l'EV chez ces patients ?

Patients ne pouvant soutenir une pause expiratoire

Plus facile avec une mesure continue du débit cardiaque

Chez un patient avec une insuffisance circulatoire



réponse à l'expansion
volémique

?

Arythmies, SDRA, ventilation spontanée ?

non

VVP, VVE...

EEO test

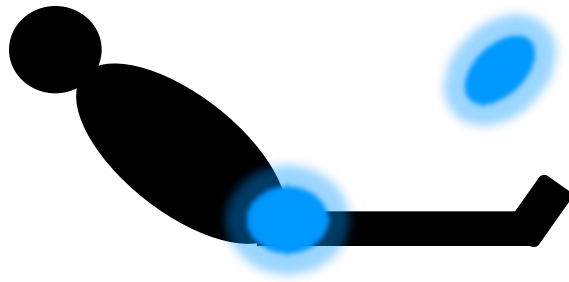
?

oui

EEO test

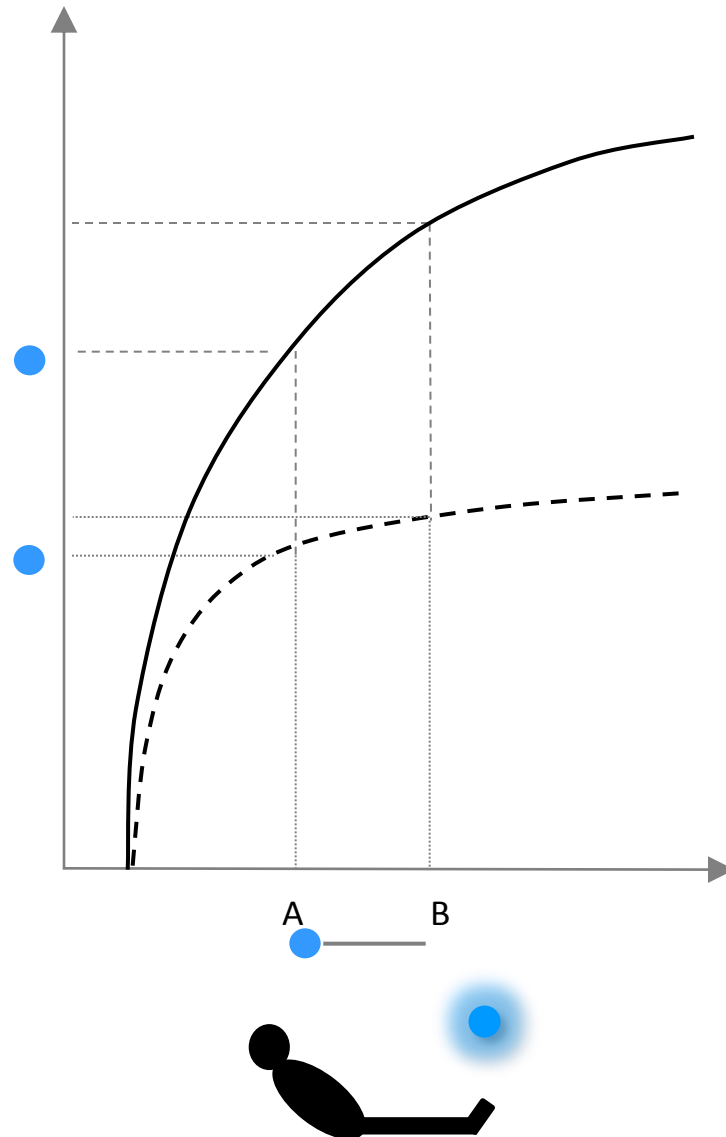
?

Test de lever de jambes passif



Le test de LJP agit comme un
« auto test de précharge »

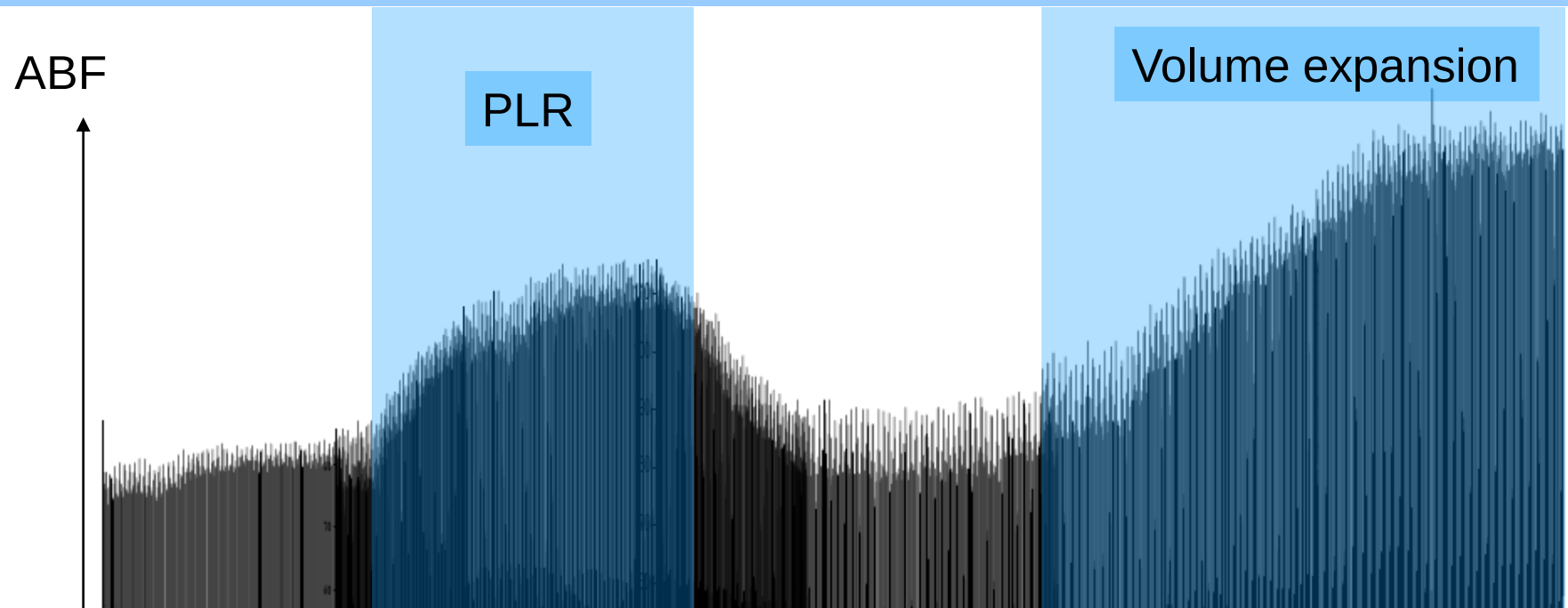
Test de lever de jambes passif



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



Test de lever de jambes passif

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Eso Doppler

Crit Care Med 2006;

Research

Open Access

Changes in aortic blood flow induced by passive leg raising predict fluid responsiveness in critically ill patients

A Lafanechère, F Pène, C Goulenok, A Delahaye, V Mallet, G Choukroun, JD Chiche, JP Mira and A Cariou

Eso Doppler

Critical Care 2006, 10:R132

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

echo

Intensive Care Med (2007) 33:1125–1132

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

Diagnosis of central hypovolemia by using passive leg raising

echo

Intensive Care Med (2007) 33:1133–1138

Brahim Benomar
Alexandre Ouattara
Philippe Estagnasie
Alain Bruneel
Pierre Squara

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

echo

Intensive Care Med (2010)

Research

Open Access

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

Matthieu Blais, Lionel Vidil, Philippe Sarabay, Vincent Cottenceau, Philippe Revel and François Sztark

Flotrac/vigileo

Critical Care 2009

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PiCCO

Crit Care Med 2009

Passive leg raising can predict fluid responsiveness in patients placed on venovenous extracorporeal membrane oxygenation

Pierre-Grégoire Guinot¹, Eli Zogheib¹, Mathieu Delave¹, Mona Moubarak¹, Vincent Hubert¹, Louise Badoux¹, Eugénie Bernard¹, Patricia Besserve², Thierry C...
Critical Care 2011,

bioreactance

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

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Crit Care Med 2012

PiCCO

Passive leg raising is predictive of fluid responsiveness in spontaneously breathing patients with severe sepsis or acute pancreatitis*

Sébastien Prêtre, MD; Fabienne Saulnier, MD; Florent Dewavrin, MD; Alain Durocher, MD; Jean-Luc Chagnon, MD

Crit Care Med 2010

echo and arterial flow

Research

Open Access

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 ...

USCOM

Critical Care 2009

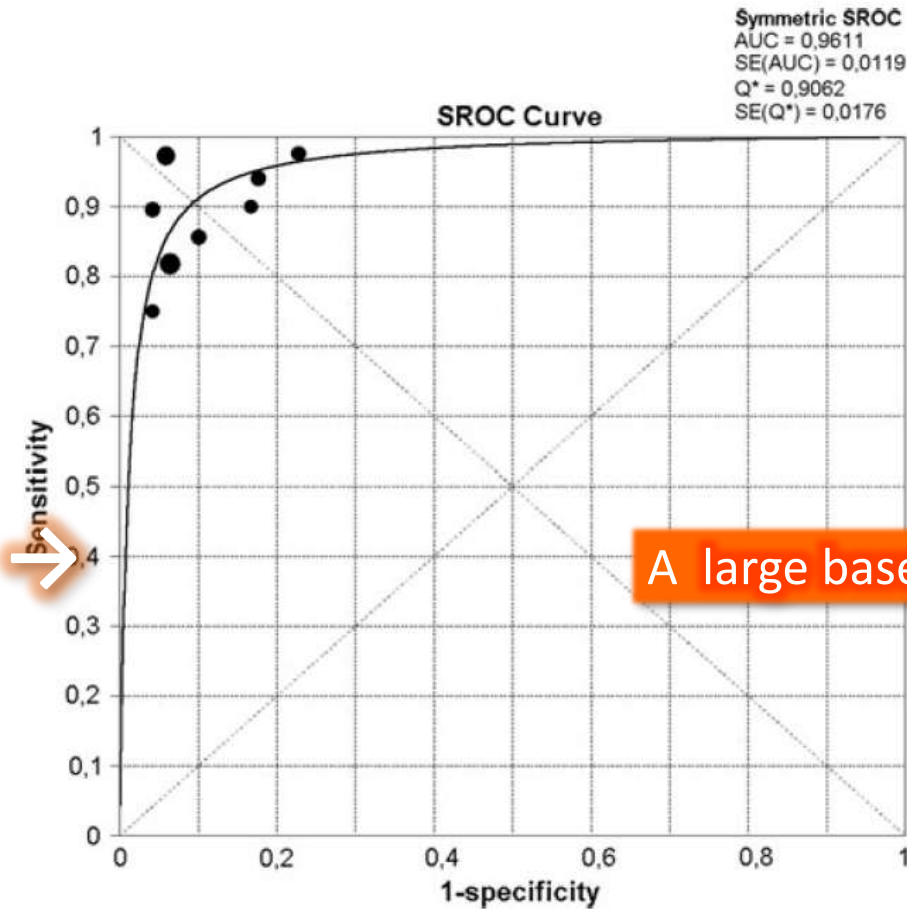
Test de lever de jambes passif

Intensive Care Med
DOI 10.1007/s00134-010-1929-y

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



Meta-analysis of 8 studies with PLR and volume expansion

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Eso Doppler

Crit Care Med 2006;

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Flotrac/vigileo

Critical Care 2009

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PiCCO

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Crit Care Med 2012

PiCCO

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Crit Care Med 2010

echo and arterial flow

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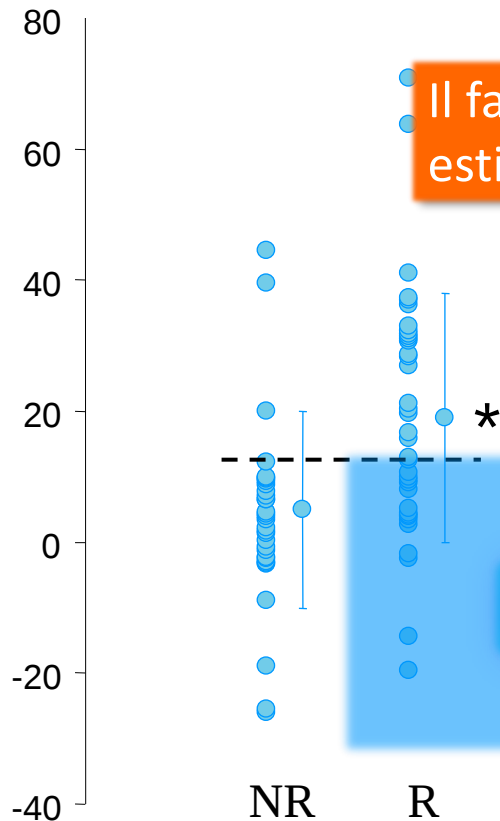
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Crit Care Med 2006; 34

PLR-induced changes in
arterial pulse pressure



Il faut une mesure continue du débit cardiaque pour estimer la réponse à l'expansion volémique

False-negative cases

Test de lever de jambes passif

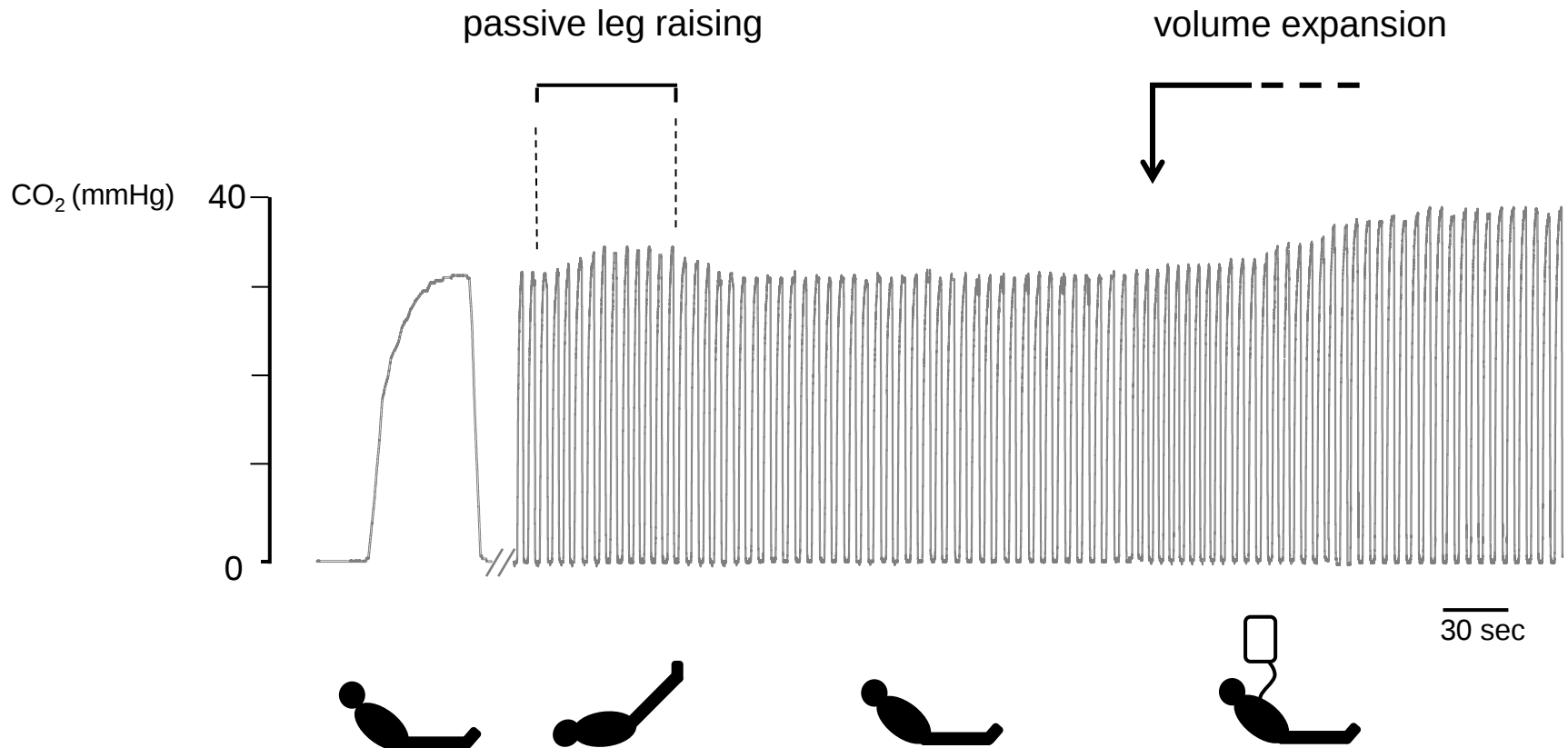
Intensive Care Med
DOI 10.1007/s00134-012-2693-y

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

65 pts receiving volume expansion
Monitoring of end-expiratory CO₂



Test de lever de jambes passif

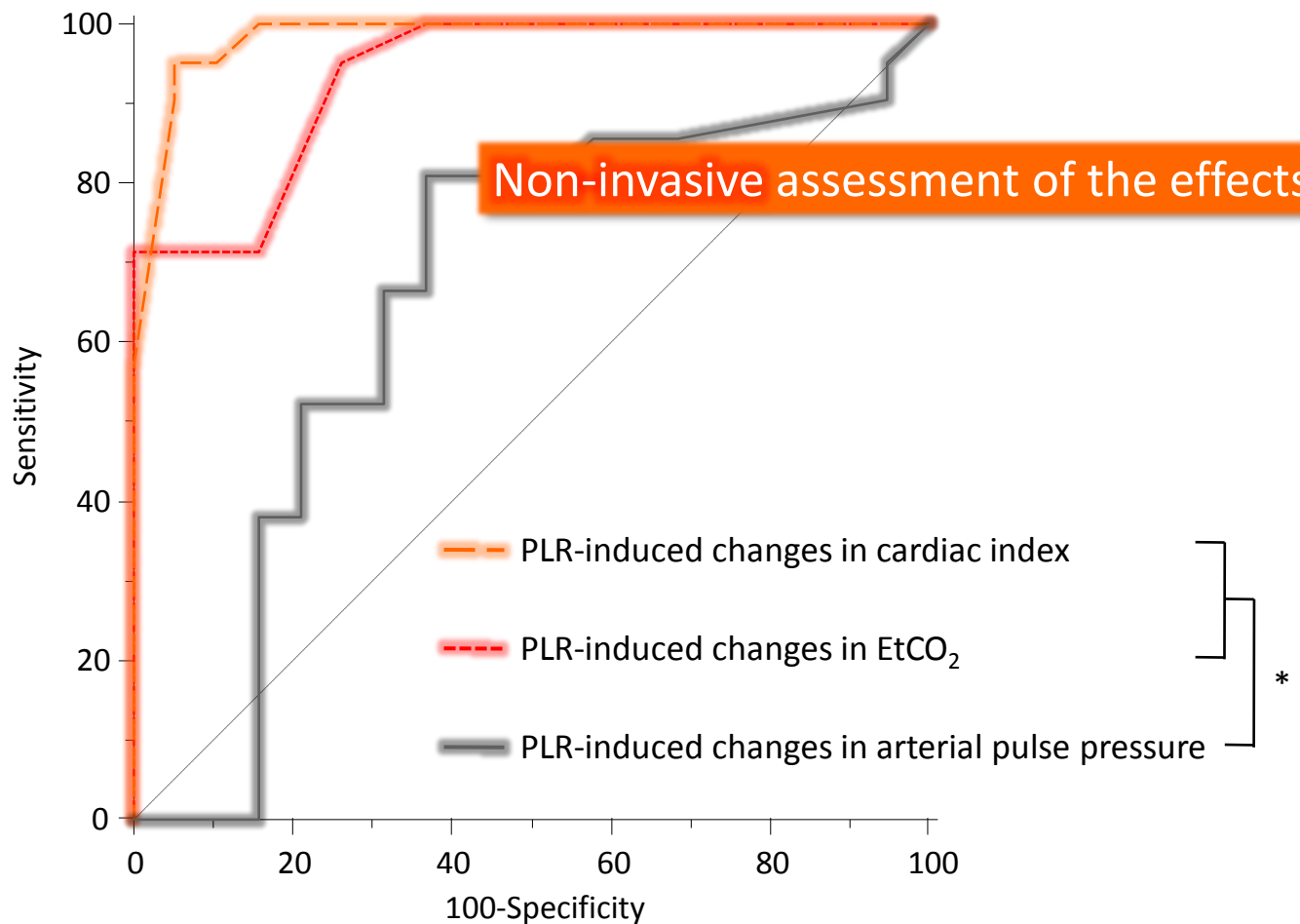
Intensive Care Med
DOI 10.1007/s00134-012-2693-y

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

65 pts receiving volume expansion
Monitoring of end-expiratory CO₂



Non-invasive assessment of the effects of the PLR test

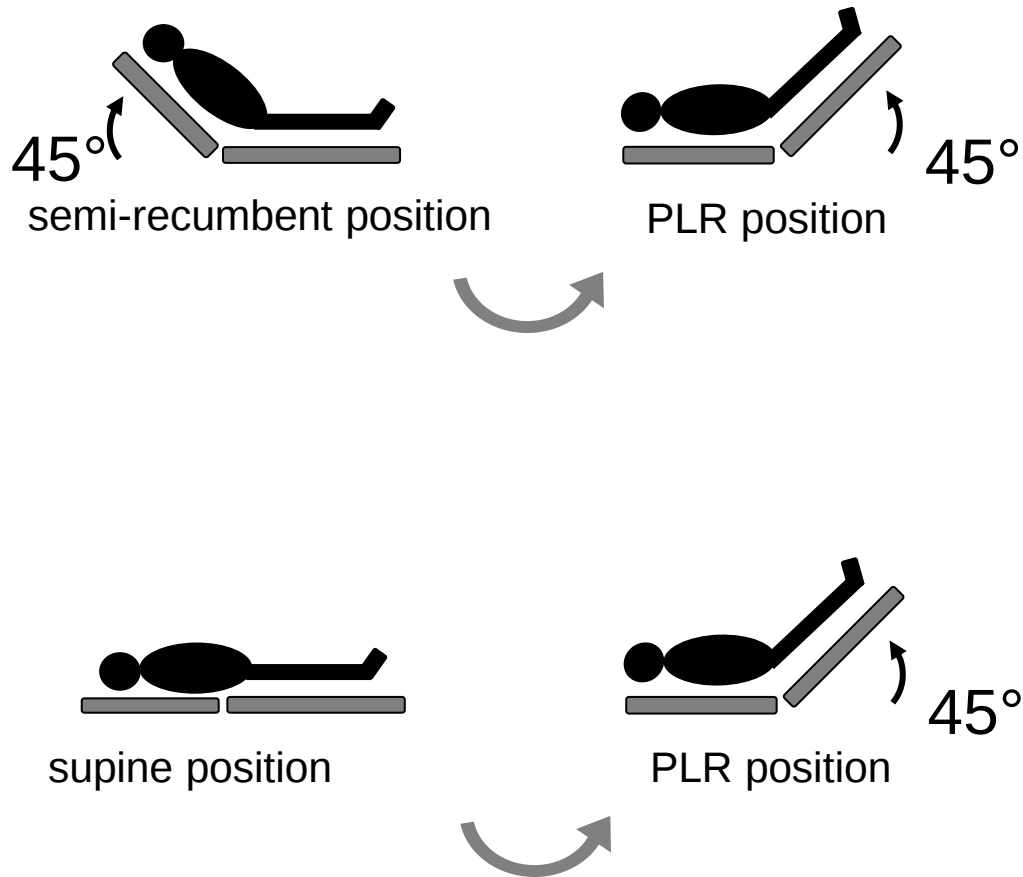
Test de lever de jambes passif

Intensive Care Med
DOI 10.1007/s00134-008-1293-3

ORIGINAL

Julien Jabot
Jean-Louis Teboul
Christian Richard
Xavier Monnet

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



Test de lever de jambes passif

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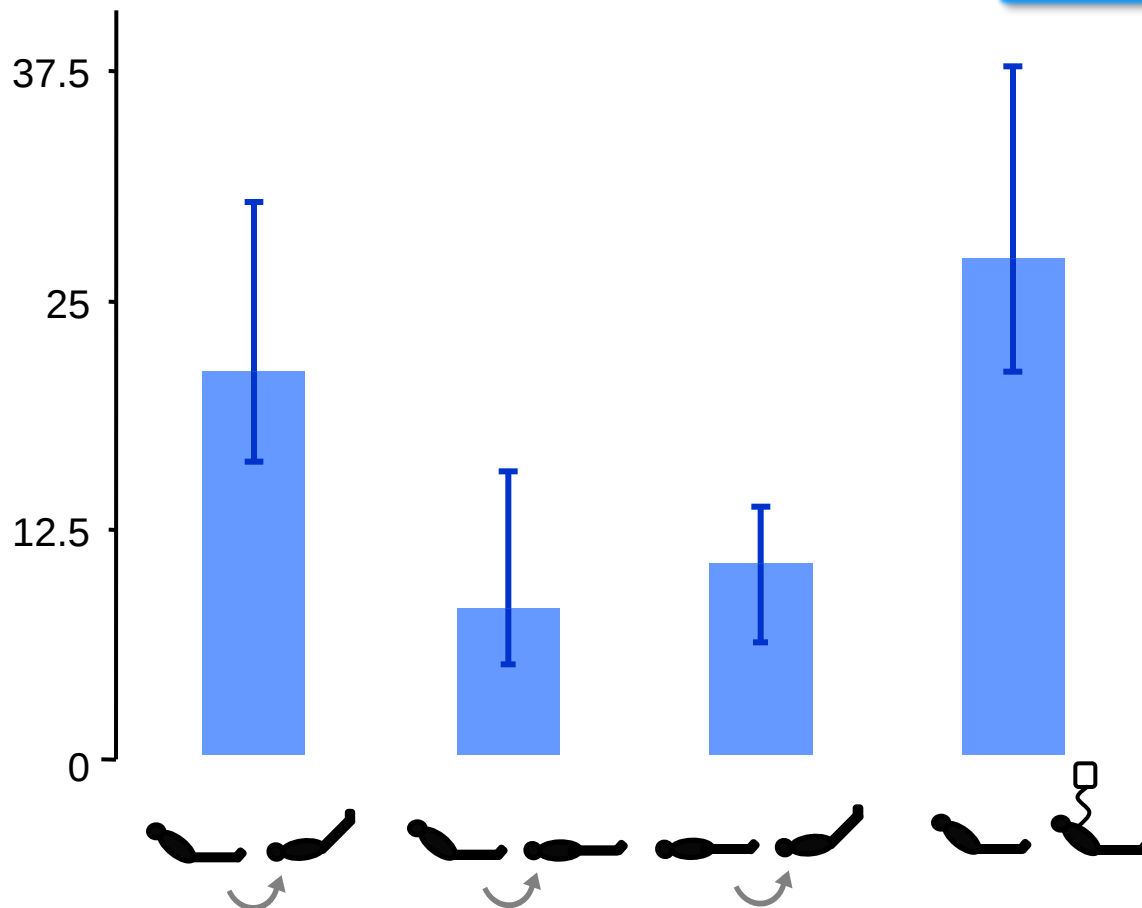
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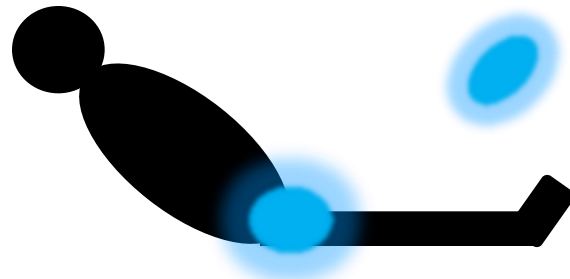
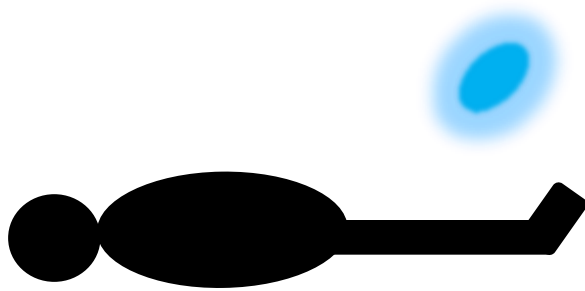
Passive leg raising for predicting fluid responsiveness: importance of the postural change

35 patients
All responders to PLR

% change in cardiac
index from baseline



Test de lever de jambes passif



Ne peut être utilisé en cas de :

absence de mesure en **temps réel** du débit cardiaque

hypertension intracrânienne

bloc opératoire

Les 5 messages-clés

- 1 Tous les patients **ne répondent pas** à l'expansion volémique par une augmentation **significative** du débit cardiaque
- 2 L'administration liquidienne excessive est **délétère** chez les patients atteints de **sepsis** et de **SDRA**
- 3 La variabilité respiratoire des signaux hémodynamiques ne peut être utilisée en cas **d'arythmie**, de **ventilation spontanée** et de **SDRA**
- 4 Les tests d'**EEO** et de **PLR** sont des alternatives **valables** dans ces cas fréquents en réanimation

5

Chez un patient avec une insuffisance circulatoire



réponse à l'expansion
volémique

?

Arythmies, SDRA, ventilation spontanée ?

non

oui

VVP, VVE...

EEO test

LJP test

+

+

EEO test

LJP test

volume expansion

Comment estimer les effets
hémodynamiques ?

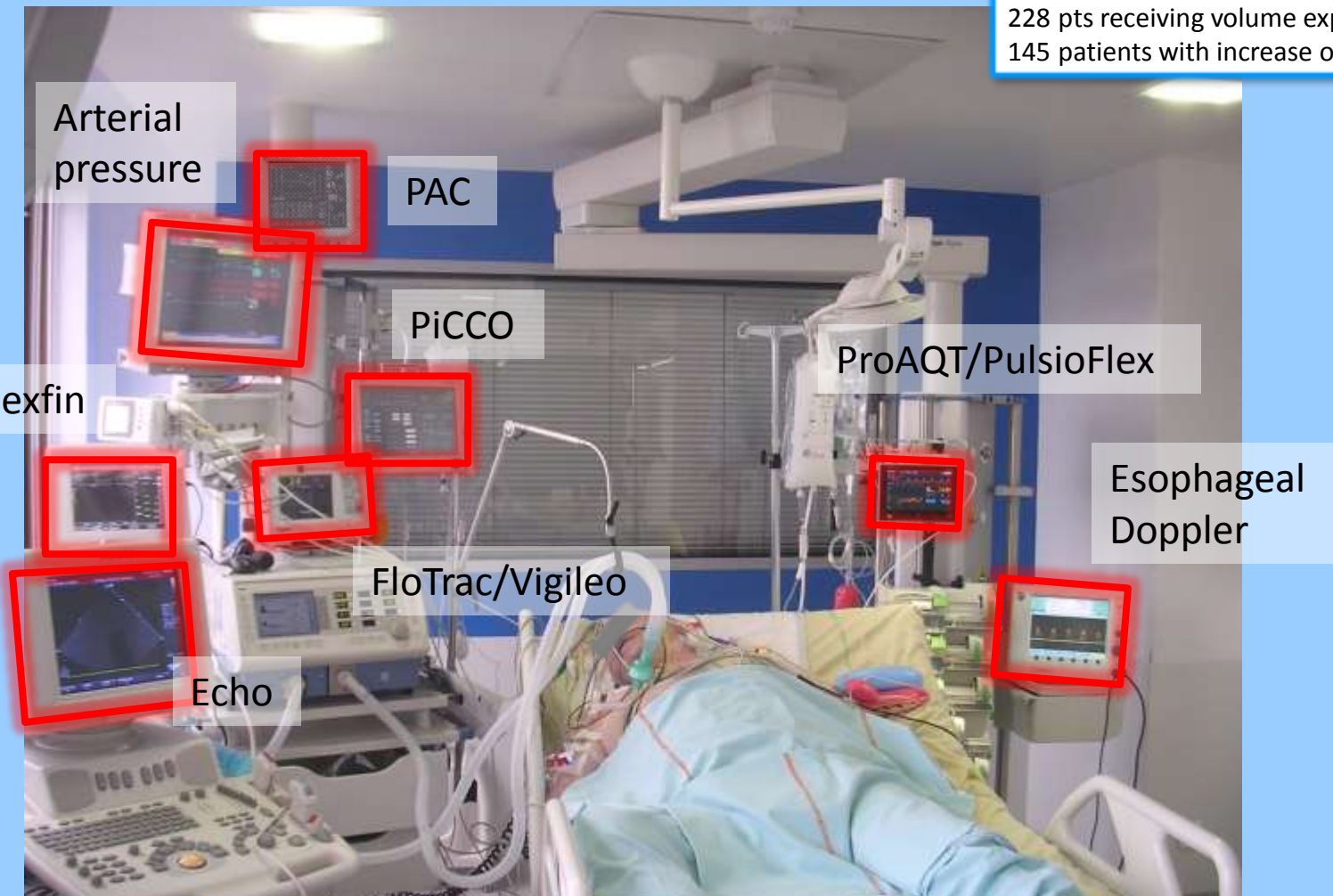
Comment estimer les effets de l'expansion volémique ?

Arterial pressure allows monitoring the changes in cardiac output induced by volume expansion but not by norepinephrine*

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

Crit Care Med 2011

228 pts receiving volume expansion
145 patients with increase of NE



Comment estimer les effets de l'expansion volémique ?

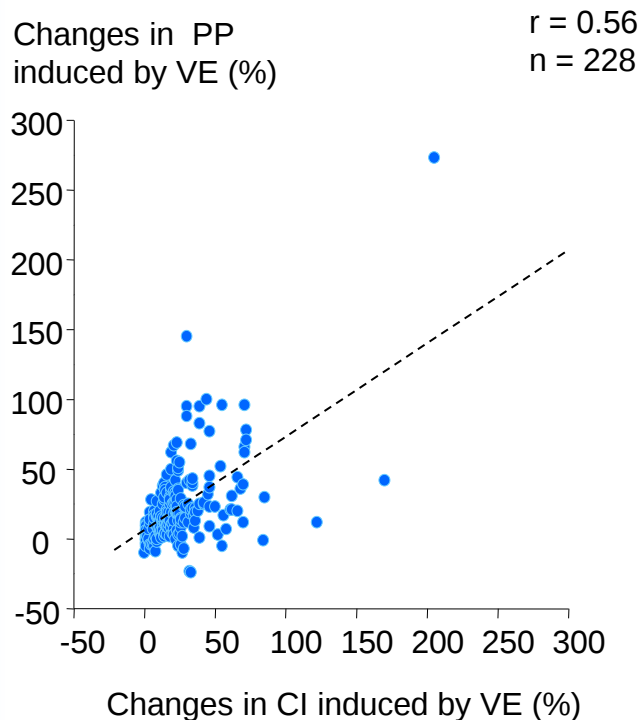
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Crit Care Med 2011

Pulse pressure is $\approx$ reliable for tracking changes in CI induced by volume expansion

228 pts receiving volume expansion
145 patients with increase of NE



Comment estimer les effets de l'expansion volémique ?

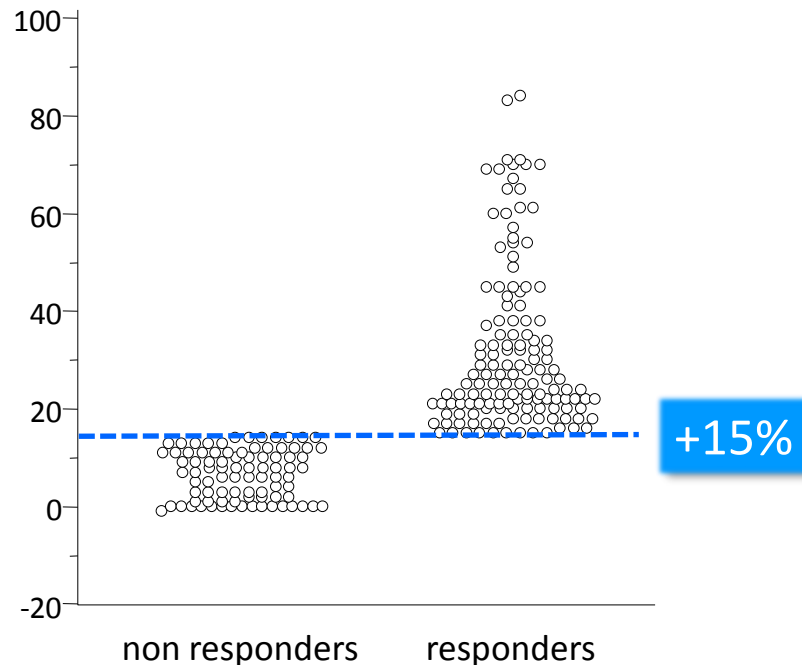
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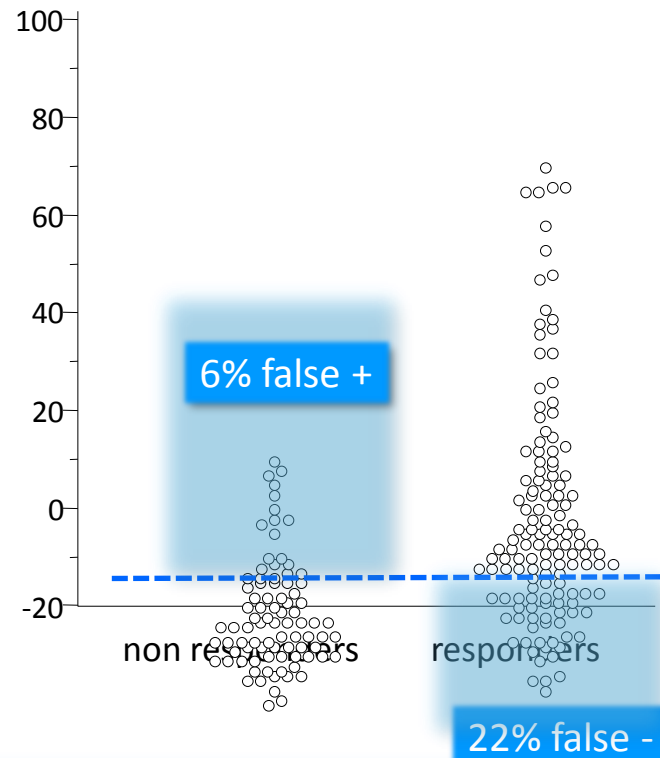
Crit Care Med 2011

228 pts receiving volume expansion
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changes in CI (%)



changes in PP (%)



Comment estimer les effets de l'expansion volémique ?

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DOI 10.1007/s00134-011-2457-0

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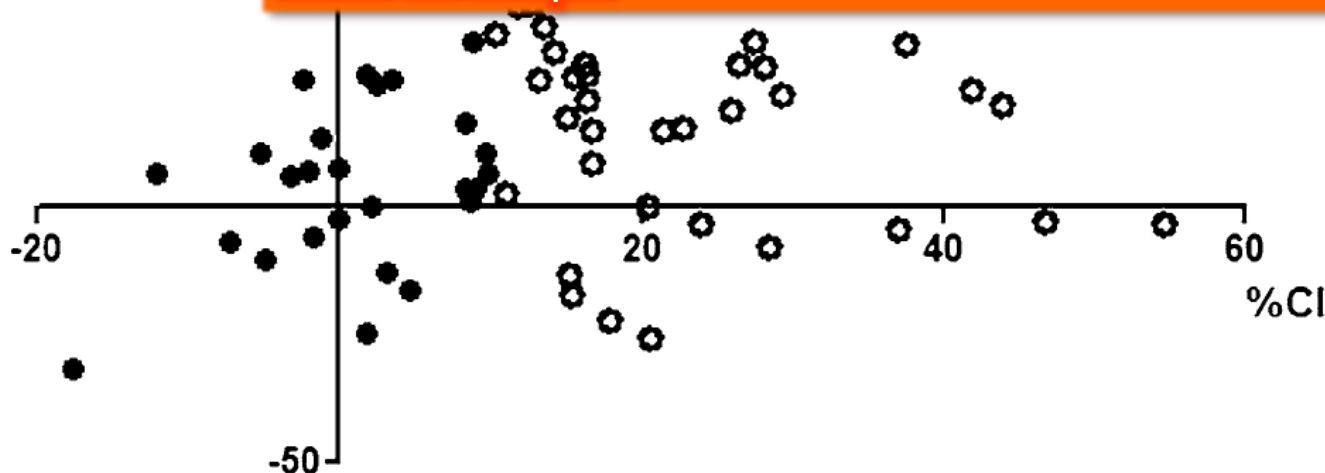
Charalampos Pierrakos
Dimitrios Velissaris
Sabino Scolletta
Sarah Heenen
Daniel De Backer
Jean-Louis Vincent

Can changes in arterial pressure be used to detect changes in cardiac index during fluid challenge in patients with septic shock?

51 pts receiving volume expansion

La pression artérielle n'est qu'un reflet imparfait du débit cardiaque

Chez les patients à risque, il faut une mesure directe du débit cardiaque



Chez un patient avec une insuffisance circulatoire



réponse à l'expansion
volémique

?

Arythmies, SDRA, ventilation spontanée ?

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oui

VVP, VVE...

EEO test

LJP test

+

+

EEO test

LJP test

expansion volémique

estimer les effets
hémodynamiques

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- 4 Les tests d'**EEO** et de **PLR** sont des alternatives **valables** dans ces cas fréquents en réanimation
- 5 Il faut une **mesure directe du débit cardiaque** pour mesurer les effets de l'expansion volémique chez les patients à risque