Cas clinique en hémodynamique

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Conflit d'intérêt

Membre du Medical Advisory Board
de Pulsion Medical Systems

Quel monitorage hémodynamique ?

Chez un patient en insuffisance circulatoire aiguë

3 options thérapeutiques

- vasopresseur
- expansion volémique
- inotrope positif

monitoring hémodynamique

?

- vasoplégie ?
- réponse à l'expansion volémique ?
- déficit de contractilité VG ?

Cas clinique

Mme M., 52 ans

Antécédents :

- Hépatite C chronique
- Alcoolisme

Myalgies et fièvre depuis quatre jours
Dyspnée croissante depuis la veille

27/02/2012 : Admission en réanimation

Cas clinique

Défaillance respiratoire

FR = 42 resp/min (O_2 = 10 L/min)

pH	7,41
PaO_2	57 mmHg
$PaCO_2$	37 mmHg
HCO_3^-	22 mmol/L

Cas clinique

Défaillance respiratoire

Défaillance hémodynamique

Défaillance rénale

Confusion mentale

t° = 39°C

Marbrures cutanées

FC = 104 batt/min

PA = 69/34/45 mmHg

Lactate	3.1 mmol/L
Urée	23 mmol/L
Créat.	180 µmol/L
CRP	85 mg/L

30 premières minutes:

SSI 2 000 mL

noradrénaline 0,20 µg/kg/min

intubation + ventilation mécanique

CVC et cathéter artériel

Cas clinique

30 min après l'admission

FC	101 batt/min
PA	80/35/50 mmHg
PVC	14 mmHg
VPP	6 %

Lactate	2,7 mmol/L

SSI	2 000 mL
Noradré	0,20 µg/kg/min
Propof	100 mg/h
Ceftriaxone + levofloxacin	

FR	22/min
Vt	420 mL (6mL/kg)
Pplat	29 cmH_2O
PEEP	10 cmH_2O
PaO_2 / FiO_2	160 mmHg

?#1 Que faites-vous maintenant ? (choix multiple)

1. J'augmente la dose de noradrénaline
2. J'ai besoin d'une échocardiographie
3. J'ai besoin d'une mesure directe du débit cardiaque
4. La seule pression artérielle me suffit à ce stade

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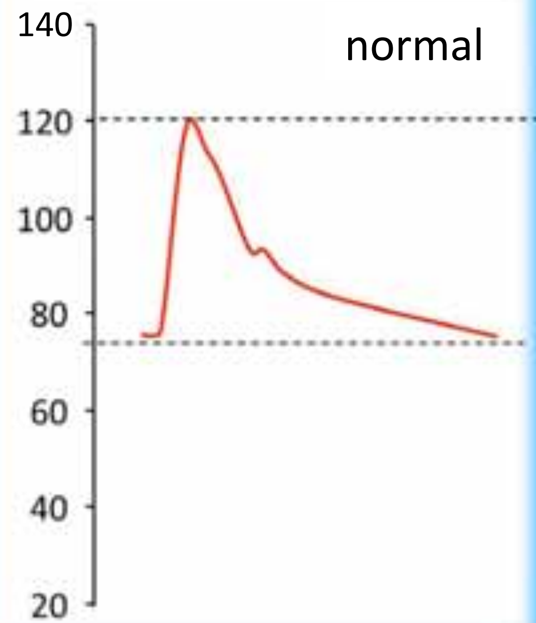
Pression artérielle

outil de monitorage "de base"



Pression artérielle

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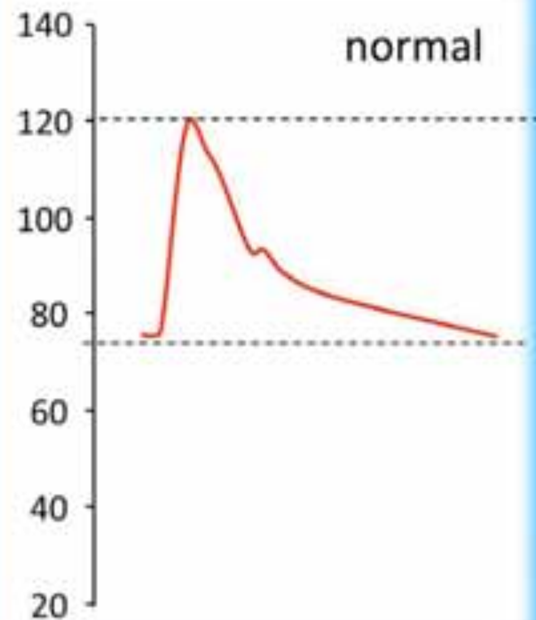

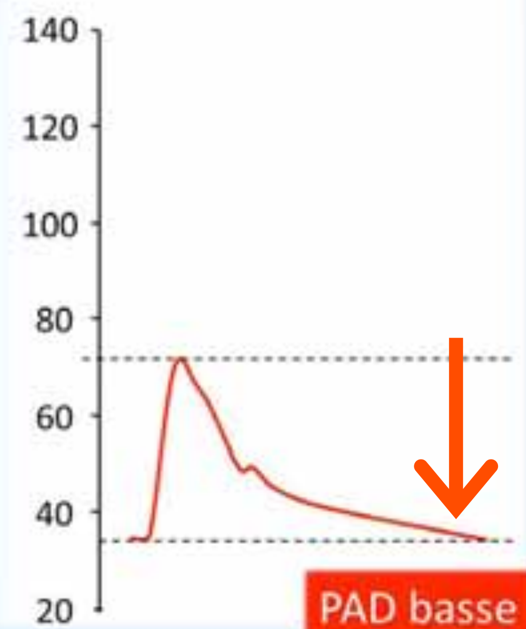

indique qu'il existe une vasoplégie

oriente vers la nature septique du choc

incite à administrer un vasopresseur

Surviving Sepsis Campaign: International guidelines for management of severe sepsis and septic shock: 2008

R. Phillip Dellinger, MD; Mitchell M. Levy, MD; Jean M. Carlet, MD; Julian Bion, MD; Margaret M. Parker, MD; Roman Jaeschke, MD; Konrad Reinhart, MD; Derek C. Angus, MD, MPH; Christian Brun-Buisson, MD; Richard Beale, MD; Thierry Calandra, MD, PhD; Jean-Francois Dhainaut, MD; Herwig Gerlach, MD; Maurene Harvey, RN; John J. Marini, MD; John Marshall, MD; Marco Ranieri, MD; Graham Ramsay, MD; Jonathan Sevransky, MD; B. Taylor Thompson, MD; Sean Townsend, MD; Jeffrey S. Vender, MD; Janice L. Zimmerman, MD; Jean-Louis Vincent, MD, PhD; for the International Surviving Sepsis Campaign Guidelines Committee

Crit Care Med 2008

and urine output, is important. Adequate fluid resuscitation is a fundamental aspect of the hemodynamic management of patients with septic shock and should ideally be achieved before vasopressors and inotropes are used, but using vasopressors early as an emergency measure in patients with severe shock is frequently necessary. When

Quel monitorage hémodynamique ?

Chez un patient en insuffisance circulatoire aiguë

monitoring hémodynamique

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vasoplégie ?

↘ débit cardiaque ?

PA diastolique

vasopresseur

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Intensive Care Med (2007) 33:575–590
DOI 10.1007/s00134-007-0531-4

INTERNATIONAL CONSENSUS CONFERENCE

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Jean Chastre
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Rui P. Moreno
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Thomas Stewart
Antoni Torres

Hemodynamic monitoring in shock and implications for management

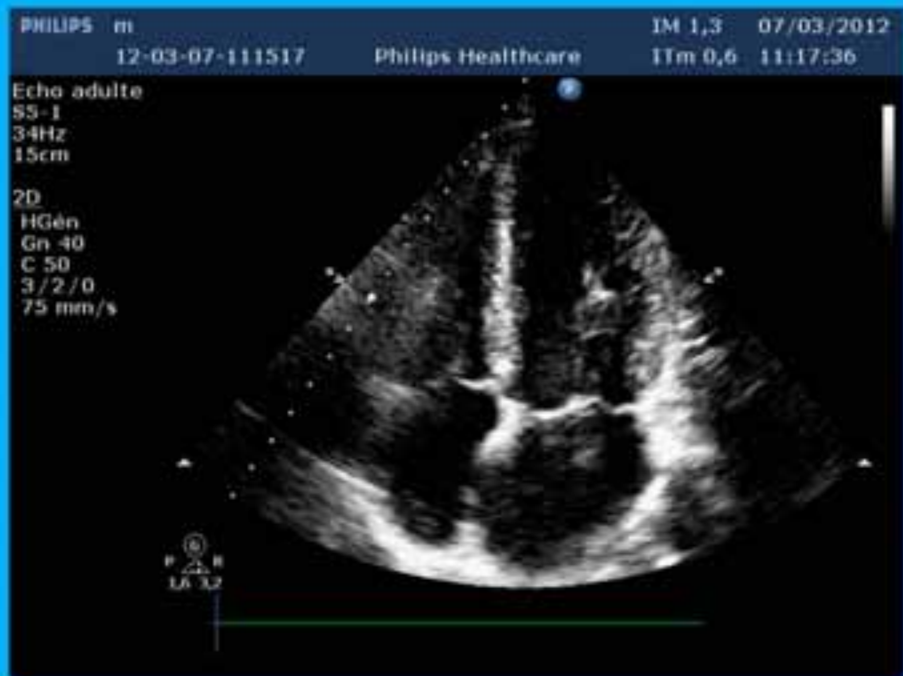
International Consensus Conference, Paris, France, 27–28 April 2006

Jury recommendations

10. We do not recommend routine measurement of CO for patients with shock.
Level 1; QoE moderate (B)

11. We suggest considering echocardiography or measurement of CO for diagnosis in patients with clinical evidence of ventricular failure and persistent shock despite adequate fluid resuscitation.
Level 2 (weak); QoE moderate (B)

Cas clinique



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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

*

r = 0.56
n = 228

Changes in PP induced by VE (%)

300
250
200
150
100
50
0
-50

-50 0 50 100 150 200 250 300

Changes in CI induced by VE (%)

r = 0.21
n = 145

Changes in PP induced by NE (%)

300
250
200
150
100
50
0
-50

-50 0 50 100 150 200 250 300

Une mesure directe du débit cardiaque est nécessaire chez les patients recevant des vasopresseurs

Débit cardiaque PiCCO

PiCCO

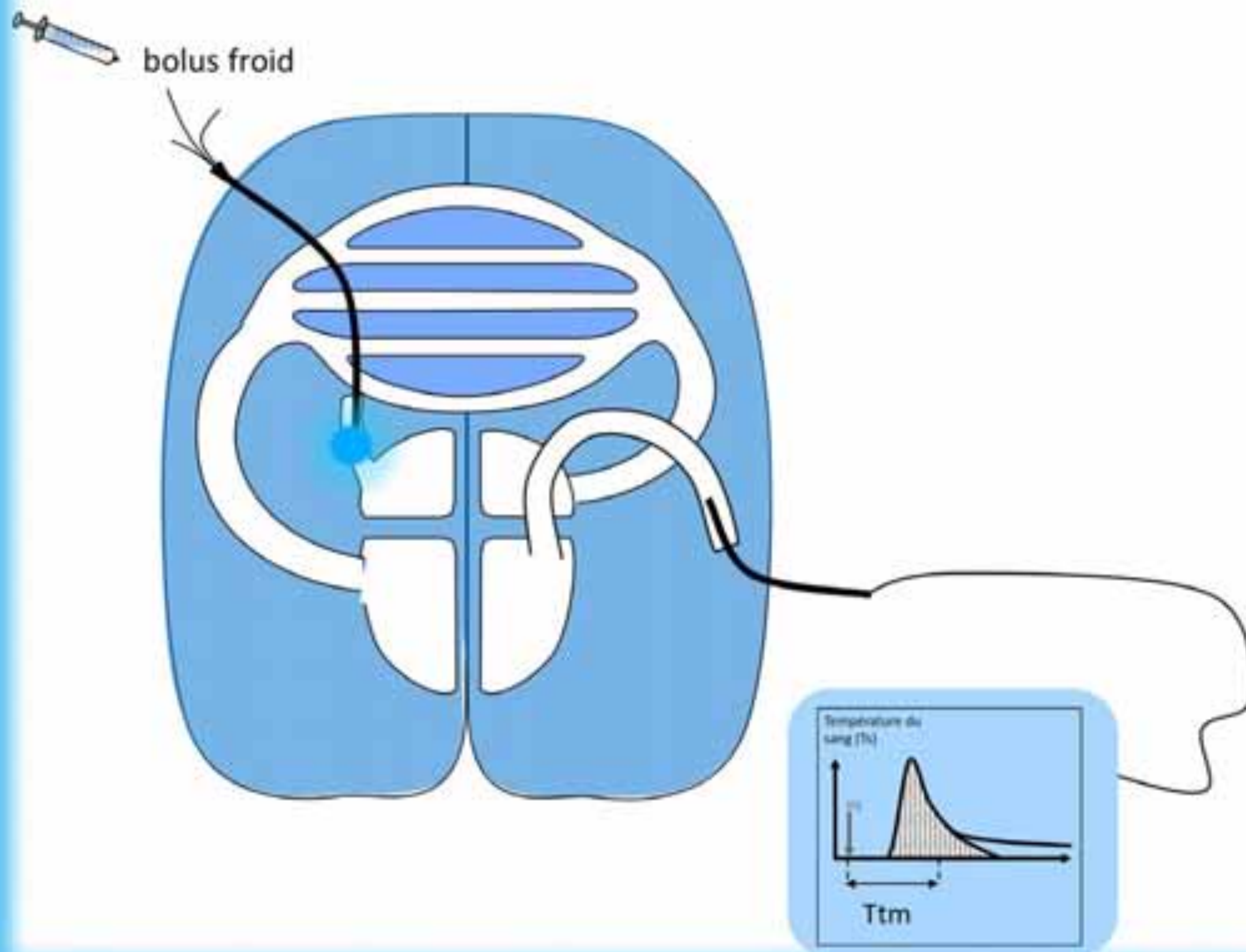
- thermodilution transpulmonaire
- analyse du contour de l'onde de pouls

Débit cardiaque

PiCCO

PiCCO	thermodilution transpulmonaire
	analyse du contour de l'onde de pouls

Débit cardiaque | PiCCO | thermodilution transpulmonaire



Débit cardiaque | PiCCO | thermodilution transpulmonaire

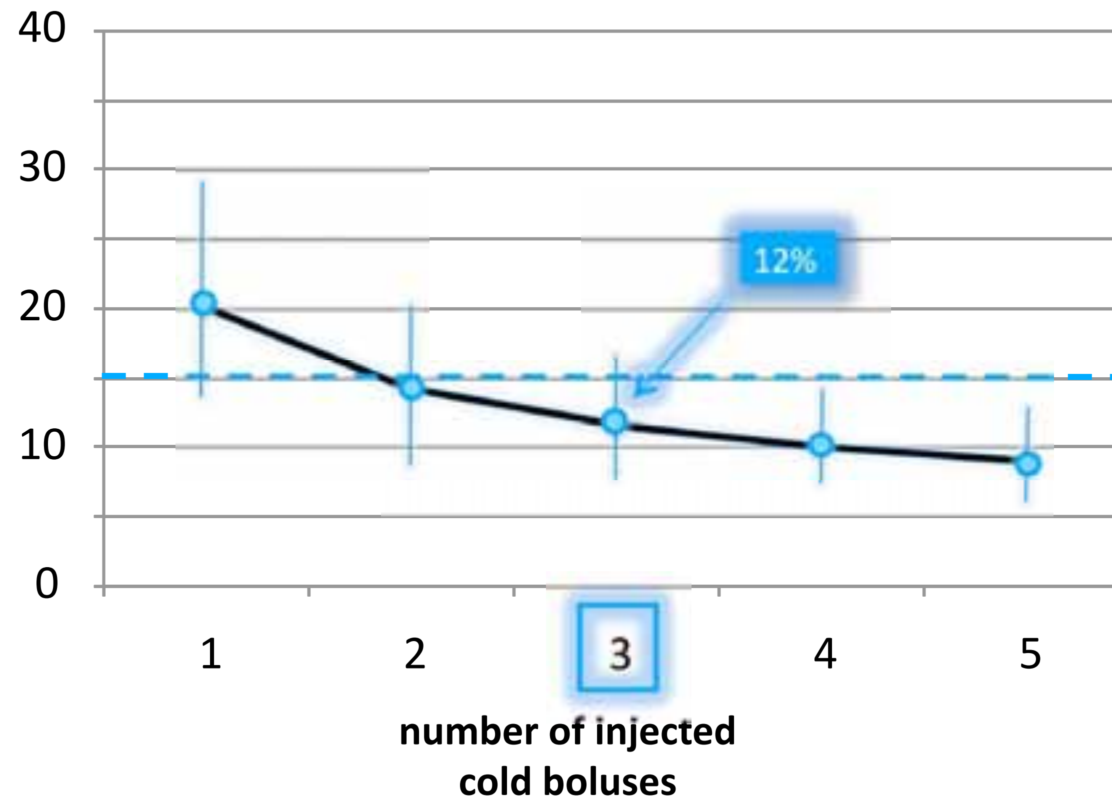
Critical Care 2011

RESEARCH — Open Access

Precision of the transpulmonary thermodilution measurements

100 TPTD measurements in critically ill patients

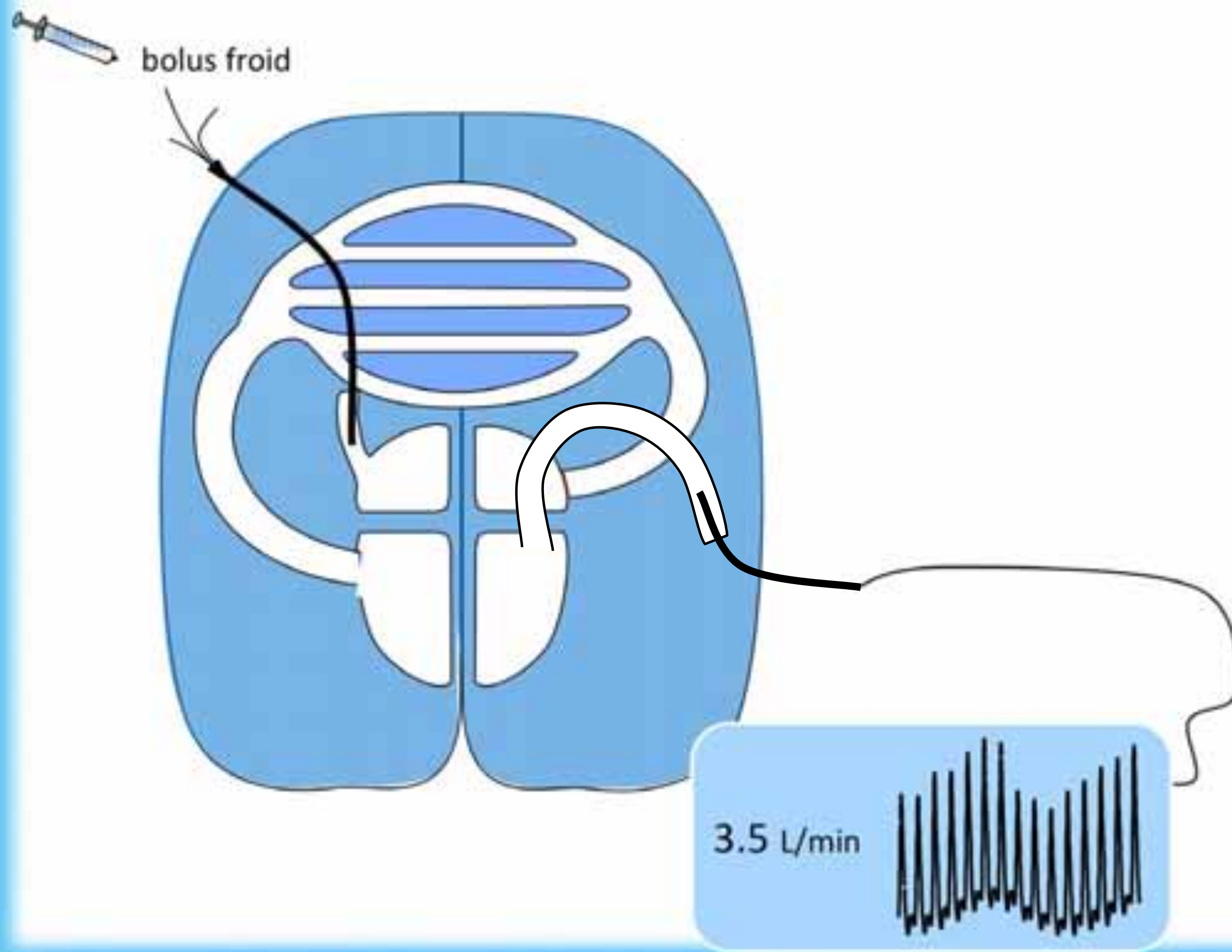
La thermodilution transpulmonaire permet une mesure précise du débit cardiaque



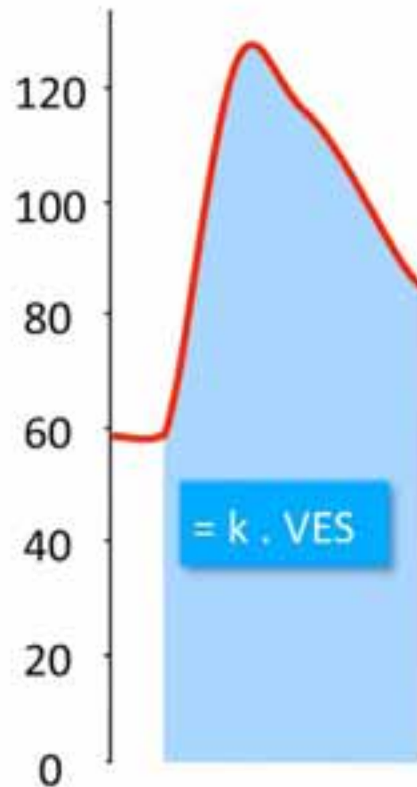
Débit cardiaque

PiCCO

analyse du contour de l’onde de pouls



Débit cardiaque | PiCCO | analyse du contour de l'onde de pouls



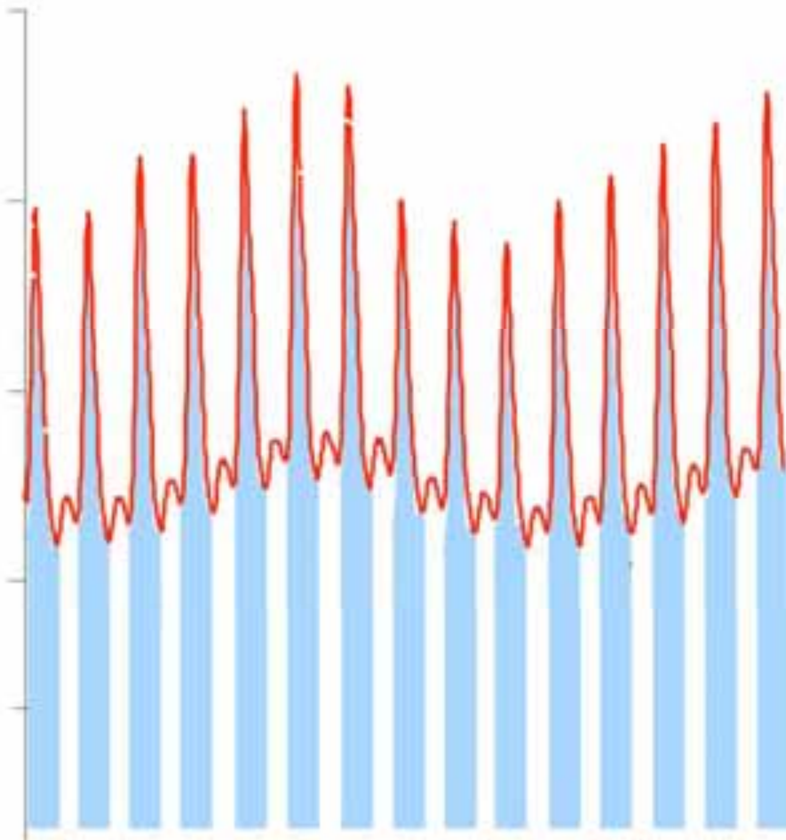
L'aire sous la portion systolique de la courbe de PA est proportionnelle au débit cardiaque

k est inversement proportionnel à la compliance artérielle

k n'est pas mesuré

k est calibré à partir d'une thermodilution

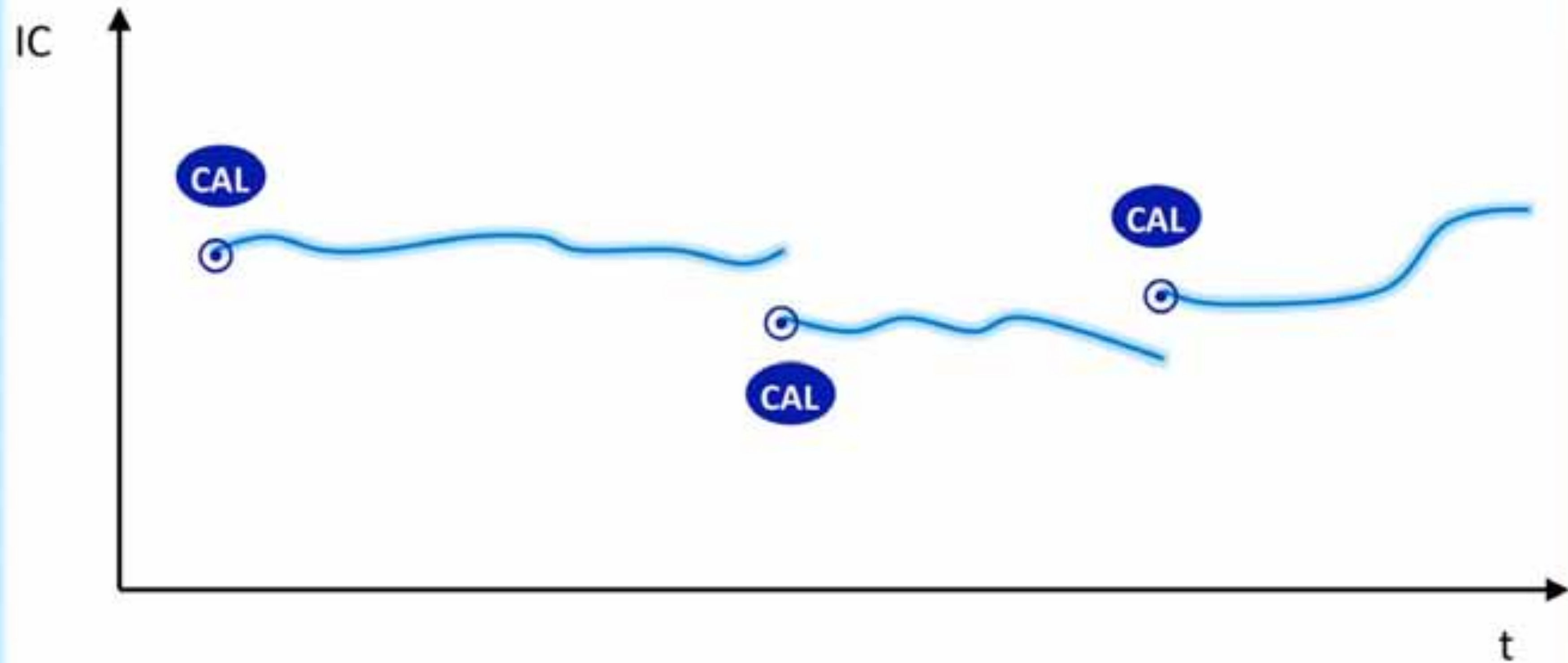
Débit cardiaque | PiCCO | analyse du contour de l'onde de pouls



L'analyse du contour de l'onde de pouls permet une estimation battement par battement du VES

Débit cardiaque | PiCCO | analyse du contour de l'onde de pouls

Débit cardiaque PiCCO analyse du contour de l'onde de pouls



Débit cardiaque | PiCCO | analyse du contour de l'onde de pouls

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 from the Previous Calibration)	n	r^2	p	Bias ± SD, L/min/m^2	Percentage Error
Within the first half hour	60	.79	<.001	0.04 ± 0.47	27
Between 30 mins and 1 hr	72	.74	<.001	0.07 ± 0.46	26
Between 1 and 2 hrs	66	.72	<.001	0.09 ± 0.58	32
Between 2 and 3 hrs	59	.65	<.001	0.16 ± 0.66	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

La mesure du débit cardiaque par analyse du contour de l'onde de pouls nécessite une recalibration fréquente

Quel monitorage hémodynamique ?

Chez un patient en insuffisance circulatoire aiguë

monitoring hémodynamique

?

vasoplégie ?

↘ débit cardiaque ?

précharge dépendance ?

↘ fonction contractile ?

Cas clinique

PiCCO en place

FC	98 batt/min	
PA	75/47/57 mmHg	
PVC	11 mmHg	
VPP	7 %	
VVE	7 %	
IC	2,9 L/min/m^2	
VTDI	720 mL/m^2	N:650-800
EPEVI	12 mL/kg	N:3-7
IPVP	4,5	N<3
IFC	4,0	

CVVHF	
SSI	2 000 mL
Noradré	0,37 µg/kg/min
Propof	100 mg/h

FR	22/min
Vt	420 mL (6mL/kg)
Pplat	29 cmH_2O
PEEP	10 cmH_2O

RT-PCR grippe (H3N2)	+
Ag *S pneumoniae*	-
Ag *L pneumophila*	-

$ScvO_2$	70%

contractility

?#2 Que faites-vous maintenant ? (choix multiple)

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Non utilisable si

- arythmie cardiaque
- activité respiratoire spontanée
- SDRA avec compliance faible

3 situations fréquentes en réanimation

Quel monitorage hémodynamique ?

monitoring hémodynamique

?

vasoplégie ?

expansion volémique ?

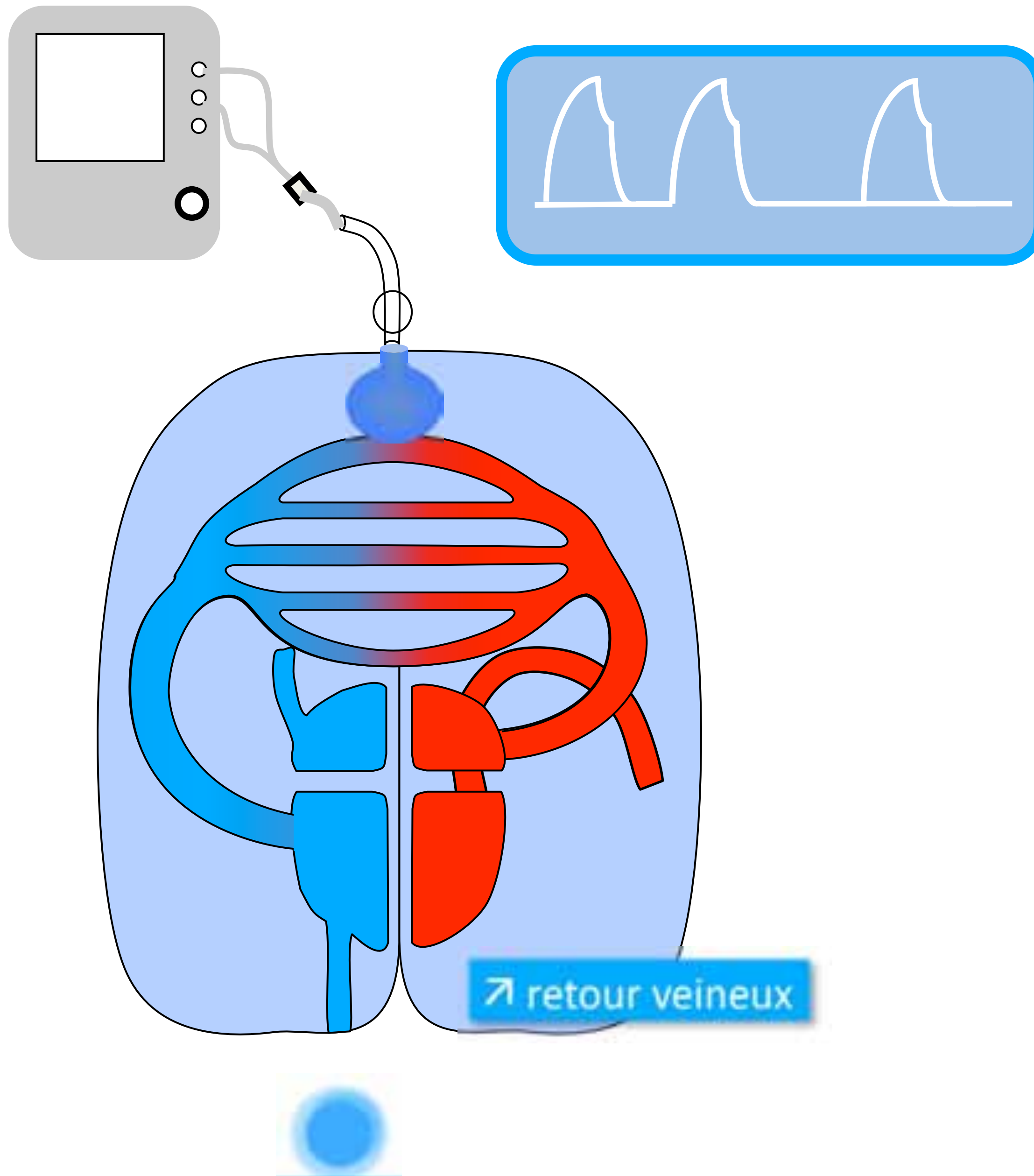
↘ fonction contractile ?

quand administrer l'EV ?

VS ou arythmie ou faible Vt?

- non
  - PPV
  - SVV
- oui
  - quelle alternative ?

Test d'occlusion télé-expiratoire



Test d'occlusion télé-expiratoire

Plus facile avec une mesure continue du débit cardiaque

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

Effects of end-expiratory pause on continuous cardiac index

50
40
30
20
10
0
-10

NR R

increase ≥ 5%
Se = 91%
Sp = 100 %

Cas clinique

PiCCO en place

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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

Eso Doppler

Research — Open Access

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

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

Critical Care 2006, 10:R132

Eso Doppler

Boucbra 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

echo

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

Diagnosis of central hypovolemia by using passive leg raising

Intensive Care Med (2007) 33:1133–1138

echo

Brahim Benomar, Alexandre Ouattara, Philippe Estagnasie, Alain Brusset, Pierre Squara

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

Intensive Care Med (2010)

echo

Research — Open Access

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

Flotrac/vigileo

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Crit Care Med 2009

PiCCO

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

Pierre-Grégoire Guinot, Elie Zogheib, Mathieu Detave, Mona Moubarak, Vincent Hubert, Louise Badoux, Eugénie Bernard, Patricia Besserve, Thierry ...

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

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

PiCCO

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

Sébastien Préau, 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 ...

Critical Care 2009

USCOM

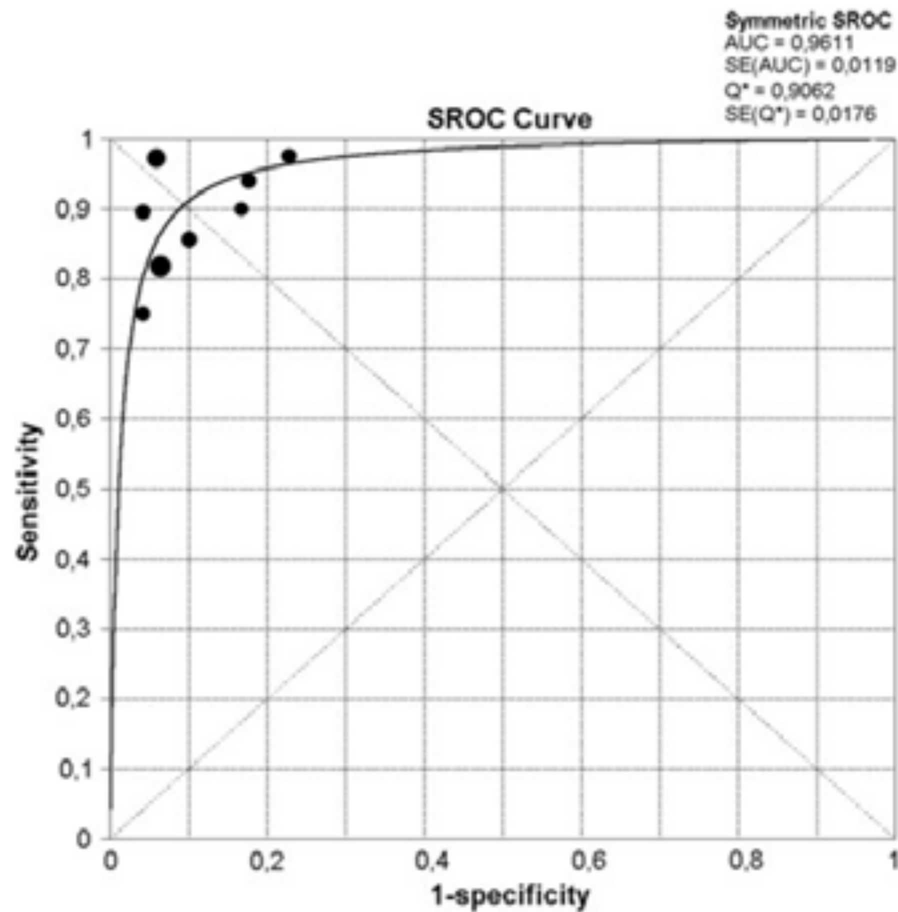
Test de lever de jambes passif

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 7 studies with PLR and volume expansion

Test de lever de jambes passif

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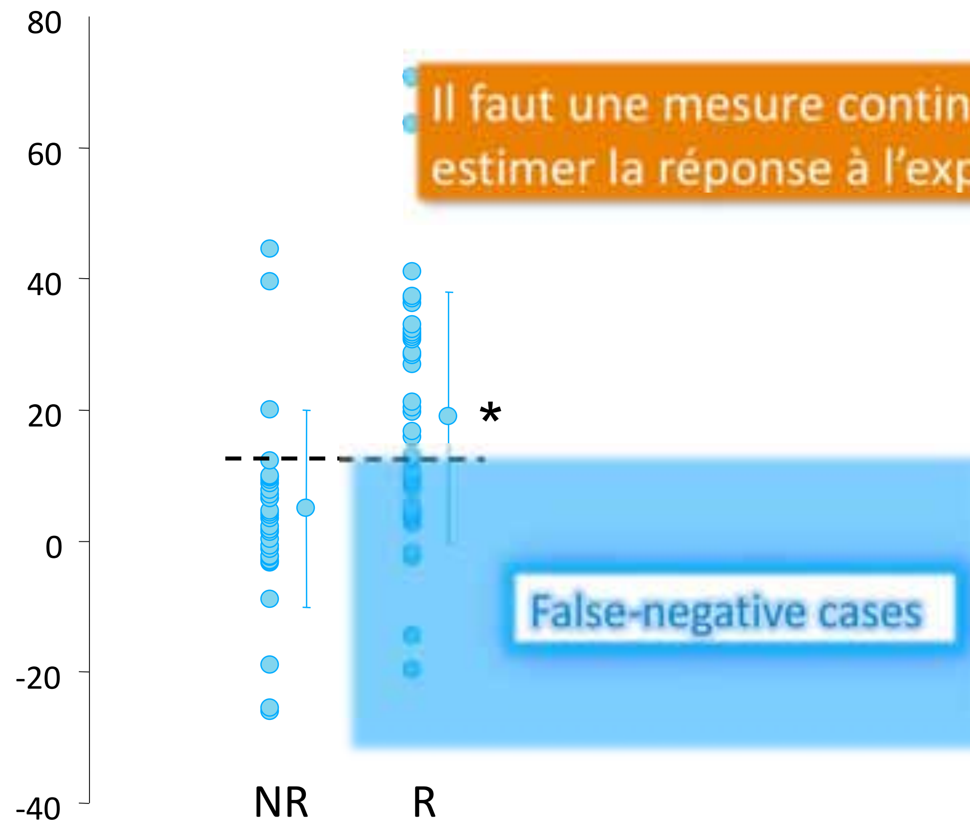
USCOM

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; 34



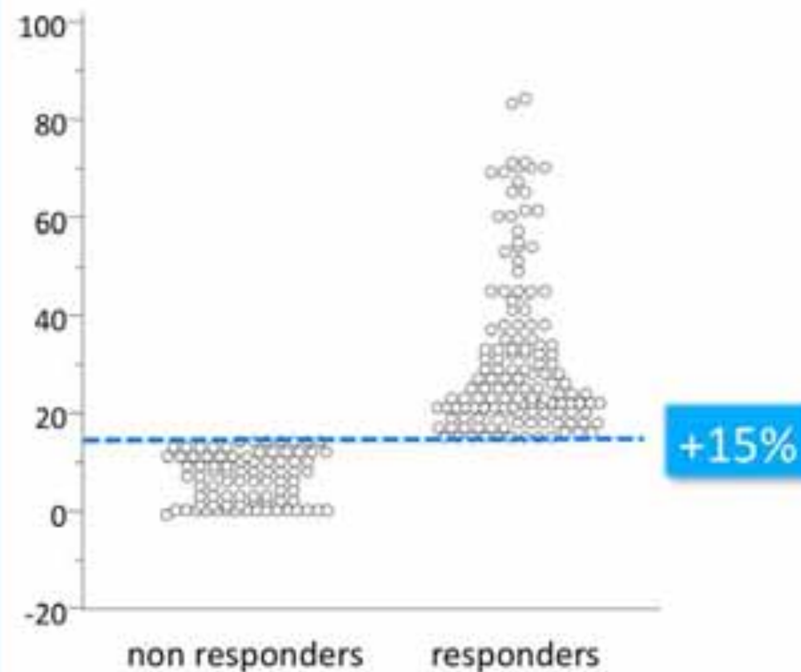
Il faut une mesure continue du débit cardiaque pour estimer la réponse à l'expansion volémique

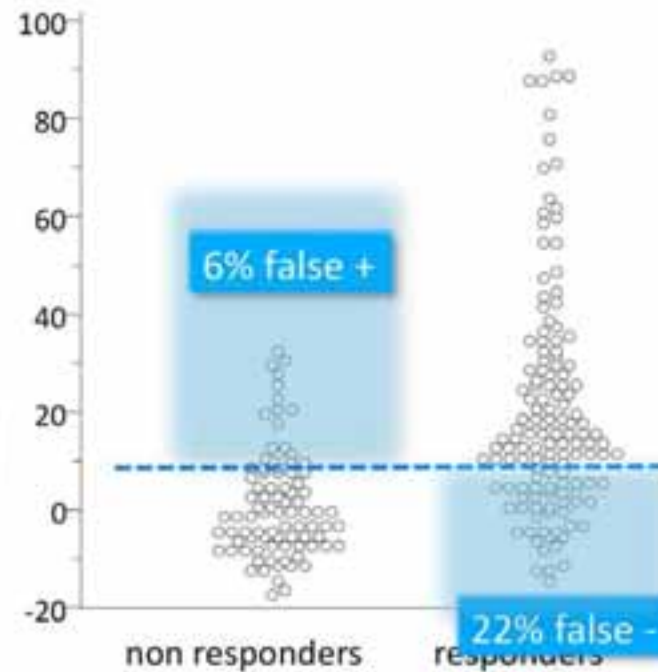
Arterial pressure allows monitoring the changes in cardiac output induced by volume expansion but not by norepinephrine*

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





Il faut une mesure directe du débit cardiaque pour apprécier précisement les effets de l'expansion volémique

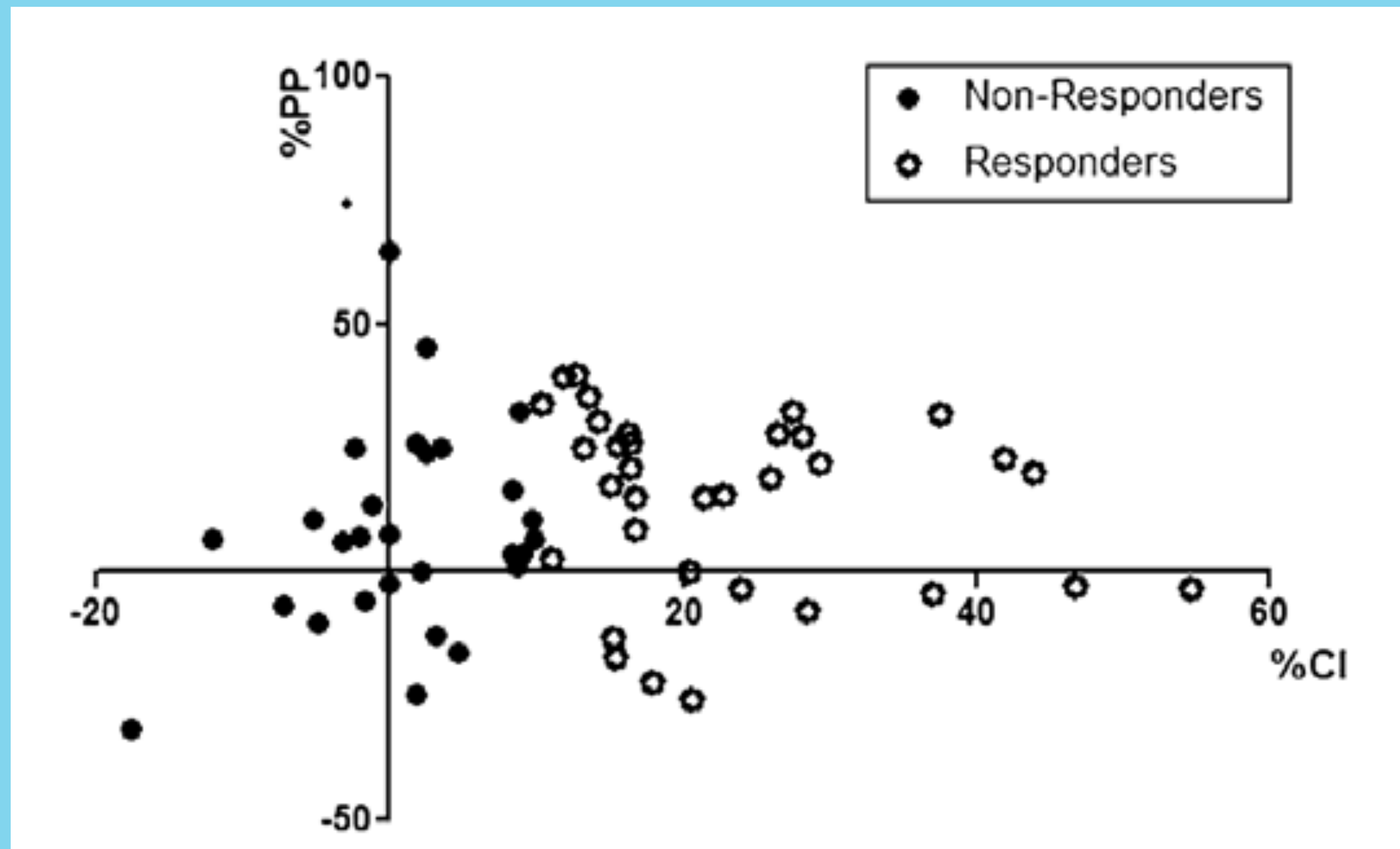
Intensive Care Med (2012) 38:422–428
DOI 10.1007/s00134-011-2457-0

ORIGINAL

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



Cas clinique

12 heures plus tard

FC	98 batt/min	
PA	91/40/57 mmHg	
PVC	9 %	
VPP	11 %	
IC	2,9 L/min/m²	
VTDI	701 mL/m²	N:650-800
EPEVI	24 mL/kg	N:3-7
IPVP	7,1	N<3
IFC	4,1	
LIP	CI +20%	

CVVHF	
SSI	2 000 mL
Noradré	0,45 µg/kg/min
Propof	100 mg/h
Tamiflu Amox-clav	

$ScvO_2$	70%
Lactate	2.1 mmol/L

FR	20/min
Vt	420 mL (6mL/kg)
Pplat	29 cmH_2O
PEEP	9 cmH_2O

?#3 Que faites-vous maintenant ? (choix multiple)

1. Rien de plus
2. Expansion volémique
3. Augmentation de noradrénaline
4. Ré-estimation de l'eau et de la perméabilité pulmonaire dans les heures suivantes

Cas clinique

12 heures plus tard

FC	98 batt/min	
PA	91/40/57 mmHg	
PVC	9 %	
VPP	11 %	
IC	2,9 L/min/m²	
VTDI	701 mL/m²	N:650-800
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1. Rien de plus
2. Expansion volémique
3. Augmentation de noradrénaline
4. Ré-estimation de l'eau et de la perméabilité pulmonaire dans les heures suivantes

Comment estimer le risque de l'expansion volémique ?

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
Pseudomonas 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

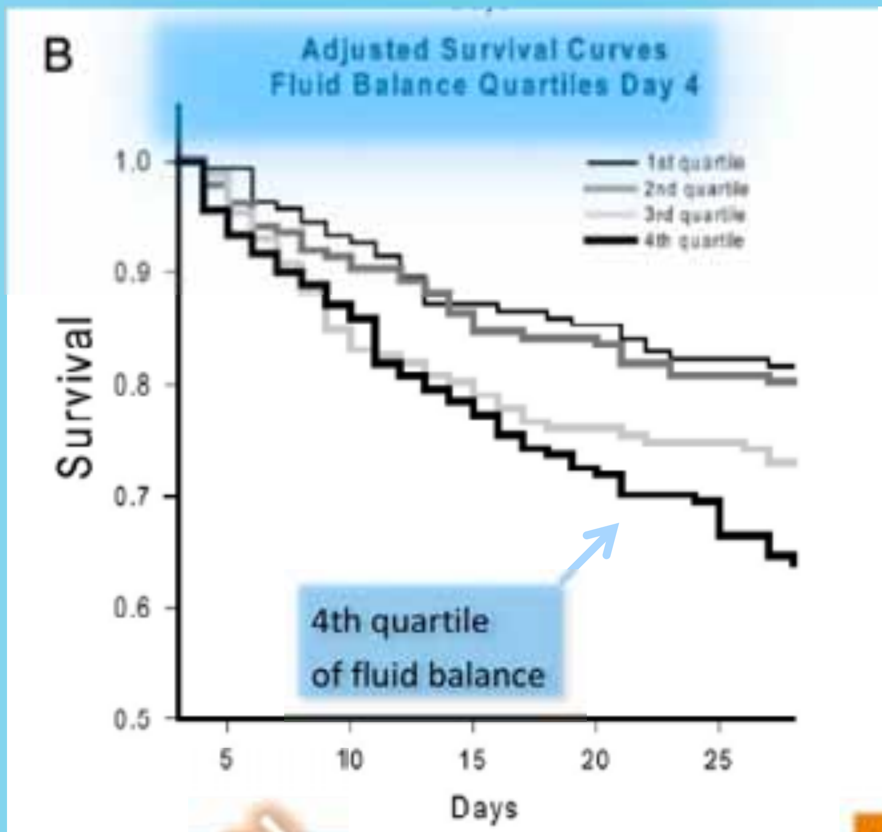
Comment estimer le risque de l'expansion volémique ?

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



Une administration liquidienne excessive est délétère chez les patients en choc septique

Clinical case

12 hours later

HR	98 beats/min	
AP	91/40/57 mmHg	
PPV	9 %	
SVV	11 %	
CI	2.9 L/min/m²	
GEDVI	701 mL/m²	N:650-800
EVLWI	24 mL/kg	N:3-7
PVPI	7.1	N<3
CFI	4.1	
PLR	CI +20%	

CVVHF	
Saline	2 000 mL
Norepi	0.45 µg/kg/min
Propof	100 mg/h
Tamiflu Amox-clav	

$ScvO_2$	70%
Lactate	2.1 mmol/L

RR	20/min
Vt	420 mL (6mL/kg)
Pplat	29 cmH_2O
PEEP	9 cmH_2O

?#4 Which statement(s) seems appropriate at this stage?

1. One can rely on PAOP for assessing the risk of fluid administration
2. One can rely on lung water for assessing the risk of fluid administration
3. The value of PAOP is a predictor of mortality in such a patient
4. The value of lung water is a predictor of mortality in such a patient
5. Transpulmonary thermodilution reliably estimates lung water

Clinical case

12 hours later

HR	98 beats/min	
AP	91/40/57 mmHg	
PPV	9 %	
SVV	11 %	
CI	2.9 L/min/m^2	
GEDVI	701 mL/m^2	N:650-800
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4. The value of lung water is a predictor of mortality in such a patient
5. Transpulmonary thermodilution reliably estimates lung water

Comment estimer le risque de l'expansion volémique ?

La PAPO n'est physiologiquement qu'un mauvais indicateur du risque pulmonaire de l'expansion volémique au cours du SDRA

Clinical case

12 hours later

HR	98 beats/min	
AP	91/40/57 mmHg	
PPV	9 %	
SVV	11 %	
CI	2.9 L/min/m²	
GEDVI	701 mL/m²	N:650-800
EVLWI	24 mL/kg	N:3-7
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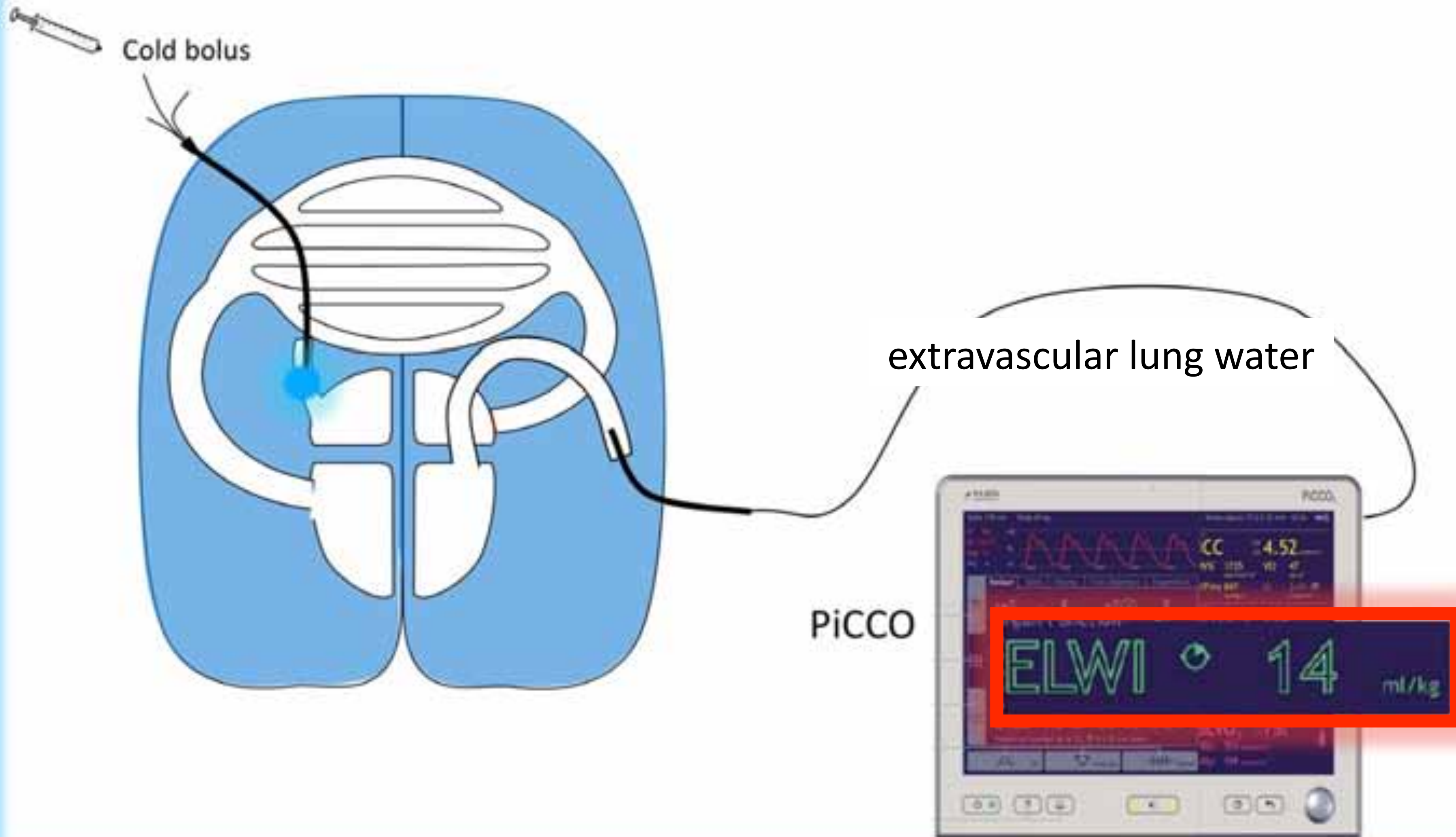
$ScvO_2$	70%
Lactate	2.1 mmol/L

RR	20/min
Vt	420 mL (6mL/kg)
Pplat	29 cmH_2O
PEEP	9 cmH_2O

#5 What do you do now? (multiple choice)

1. One can rely on PAOP for assessing the risk of fluid administration
2. One can rely on lung water for assessing the risk of fluid administration
3. The value of PAOP is a predictor of mortality in such a patient
4. The value of lung water is a predictor of mortality in such a patient
5. Transpulmonary thermodilution reliably estimates lung water

How to avoid excessive fluid loading? lung water



Monitoring avancé

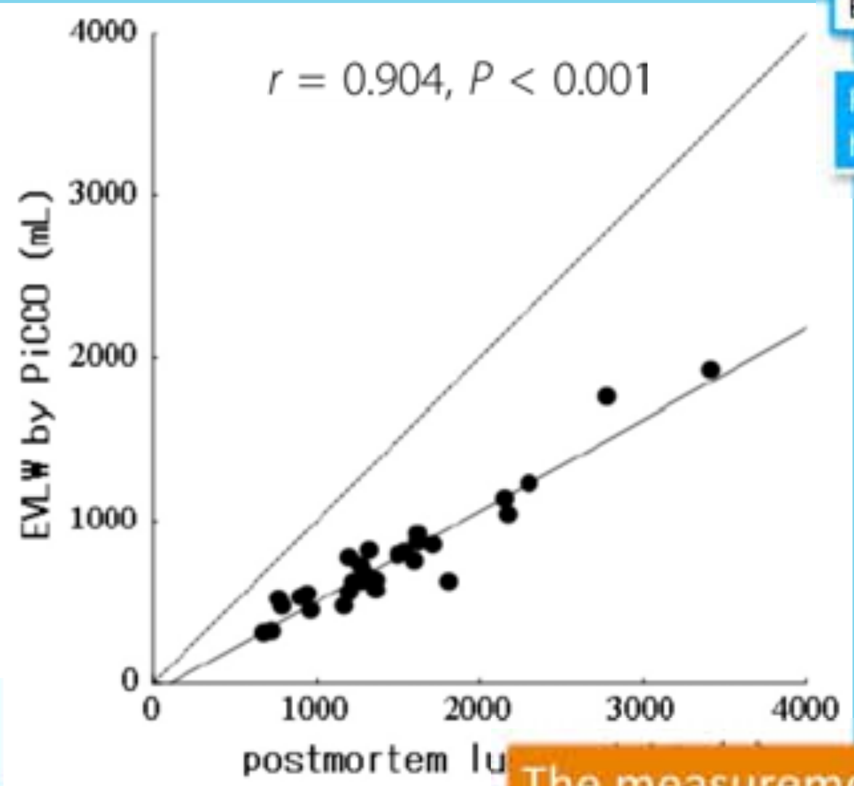
Lung water for estimating the risk of volume expansion?

Tagami et al. Critical Care 2010, 14:R162

RESEARCH Open Access

Validation of extravascular lung water measurement by single transpulmonary thermodilution: human autopsy study

Takashi Tagami, Shigeki Kushimoto, Yasuhiro Yamamoto, Takahiro Atsumi, Ryoichi Tosa, Kiyoshi Matsuda, Renpei Oyama, Takanori Kawaguchi, Tomohiko Masuno, Hisao Hirama, Hiroyuki Yokota



30 pts
EVLW measured by TPTD and by postmortem gravimetry

First validation of EVLW-TPTD evaluation in humans

→ The measurement of lung water is validated in human beings

How to avoid excessive fluid loading? lung water

Tagami et al. Critical Care 2010, 14:R162
http://ccforum.com/content/14/5/R162

RESEARCH Open Access

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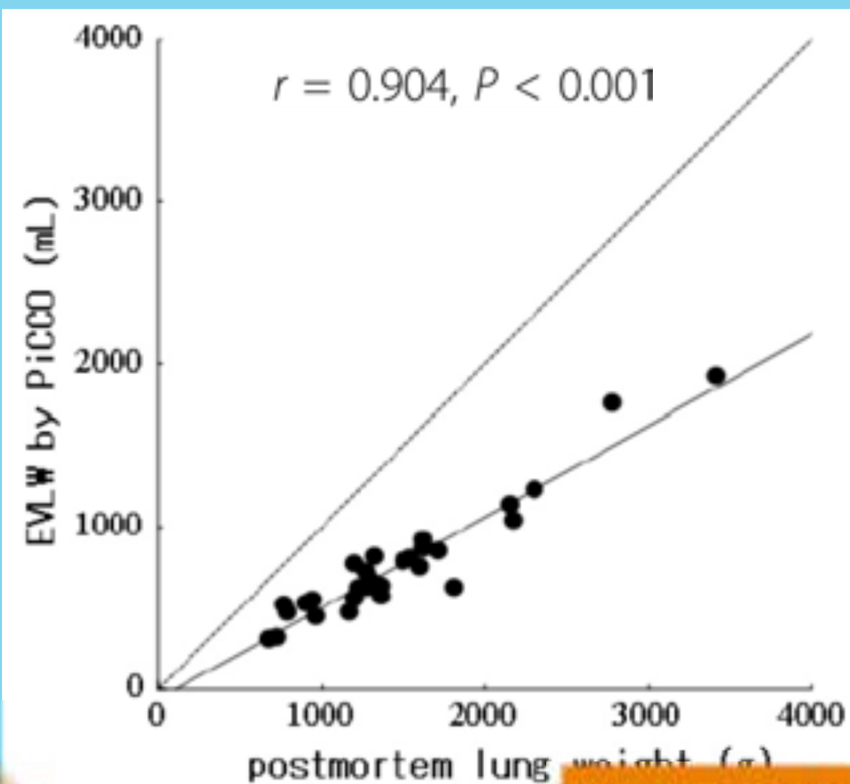


30 pts
EVLW measured by TPTD and by postmortem gravimetry

First validation of EVLW-TPTD evaluation in humans

Measurement of lung water by transpulmonary thermodilution is validated in humans

How to avoid excessive fluid loading? lung water

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 *in revision*

200 pts with ARDS
EVLW measured by PiCCO device

	Odds Ratio (CI 95%)		p value
Maximal blood lactate	0.81	(0.71 - 0.93)	0.002
Mean PEEP	1.25	(1.07 - 1.47)	0.005
$EVLWI_{max}$	0.94	(0.87 - 0.98)	0.01
SAPS II	0.97	(0.95 - 0.99)	0.02
Mean fluid balance	0.9996	(0.9993 - 0.9999)	0.02
Minimal P/F ratio	1.01	(1.00 - 1.02)	0.02
Minimal pH	35.97	(0.47 - 2769.52)	0.10

Lung water measured by transpulmonary thermodilution has a real physiological significance

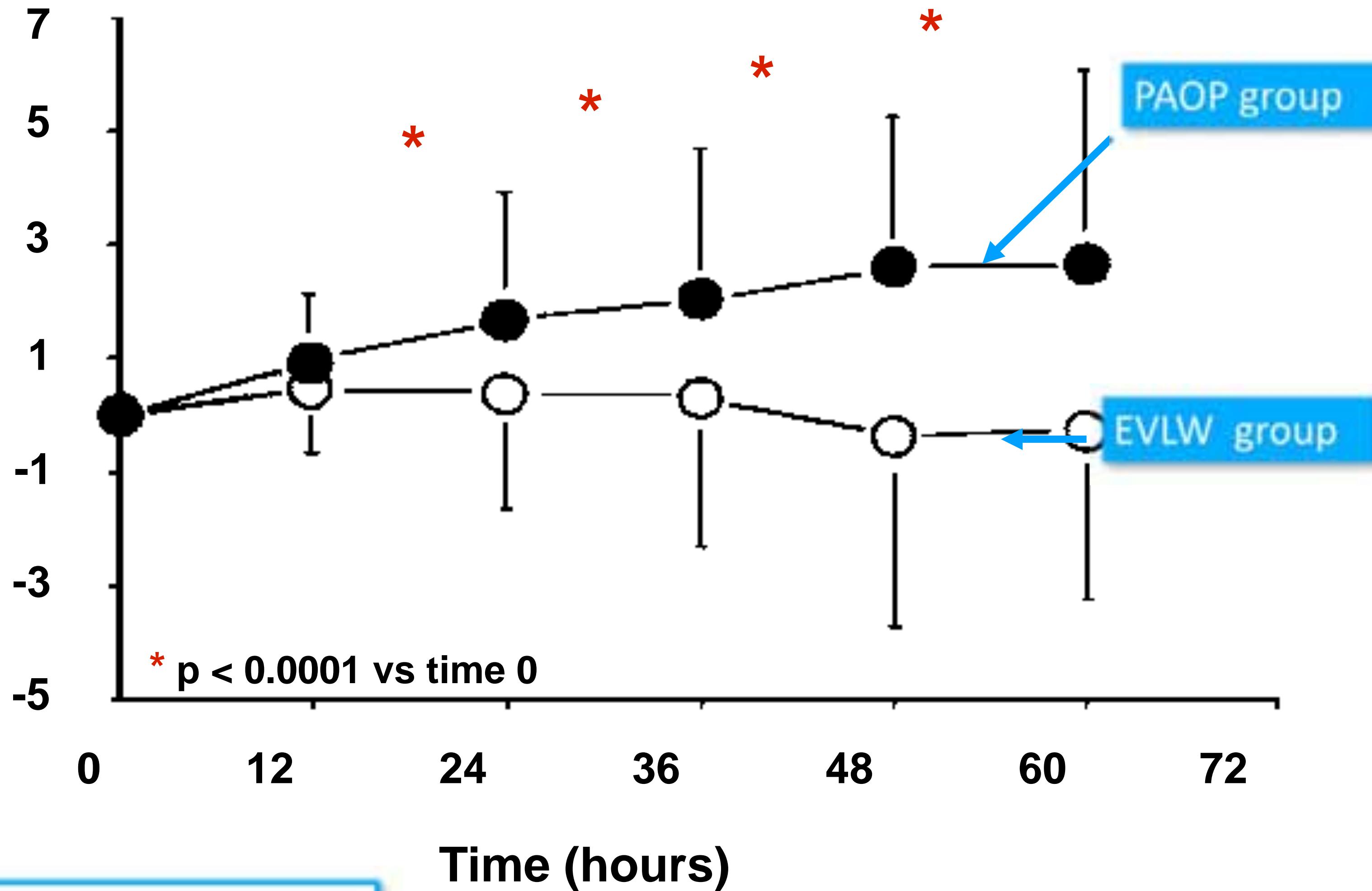
Quel monitorage hémodynamique ?

monitoring hémodynamique

?

- vasoplégie ?
- expansion volémique ?
  - quand administrer l'EV ?
    - VS ou arythmie ou faible Vt?
      - non
        - PPV, SVV
        - ΔABF
        - LJP
        - TOE
      - oui
        - LJP
        - TOE
  - quand arrêter l'EV ?
    - Indices de précharge-dépendance négativés
    - eau pulmonaire élevée
- ↘ fonction contractile ?

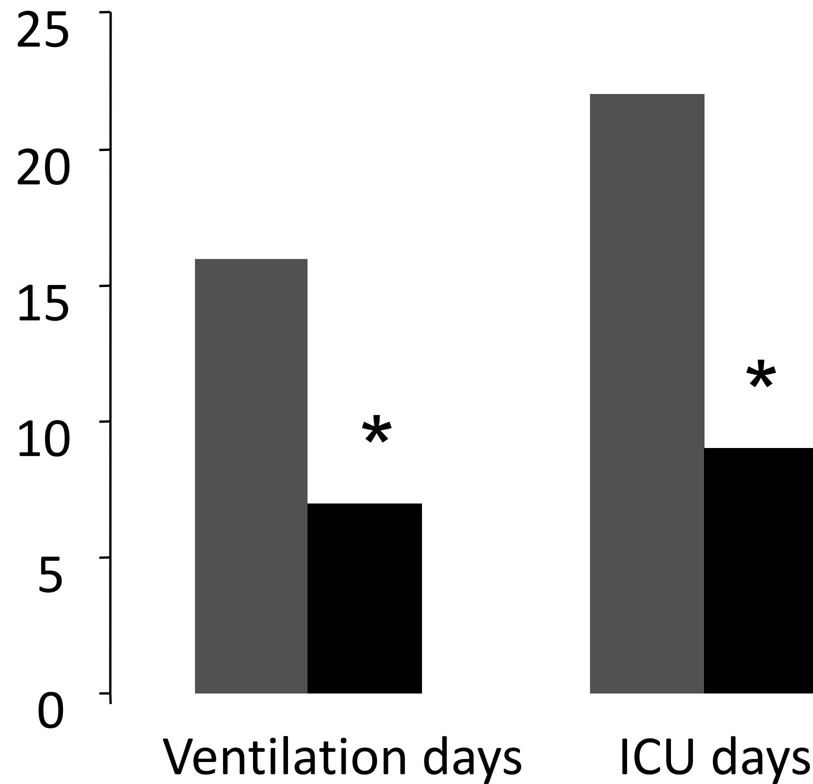
How to avoid excessive fluid loading? lung water



101 ARDS patients
randomized to EVLW-guided management vs.
PAOP-guided management

Mitchell JP et al., Am Rev Respir Dis 1992

How to avoid excessive fluid loading? lung water



Management of fluid therapy with :

- PAOP Group
- EVLW Group

101 ARDS patients
randomized to EVLW-guided management vs.
PAOP-guided management

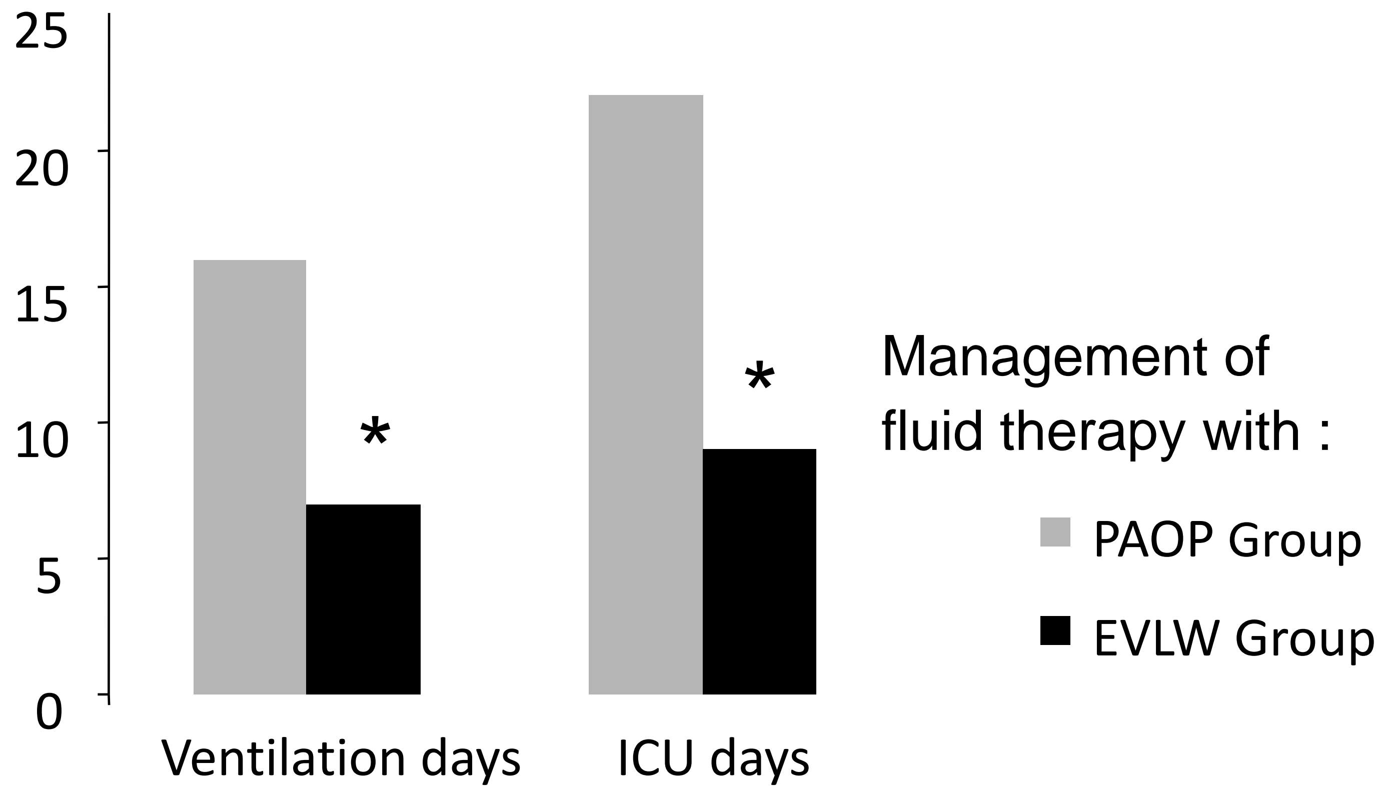
Mitchell JP et al., Am Rev Respir Dis 1992

Lung water may guide fluid therapy during ARDS

Monitoring avancé

Eau pulmonaire pour estimer le risque de l'expansion volémique

La mesure de l'eau pulmonaire permet de guider l'expansion volémique



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Quel monitorage hémodynamique ?

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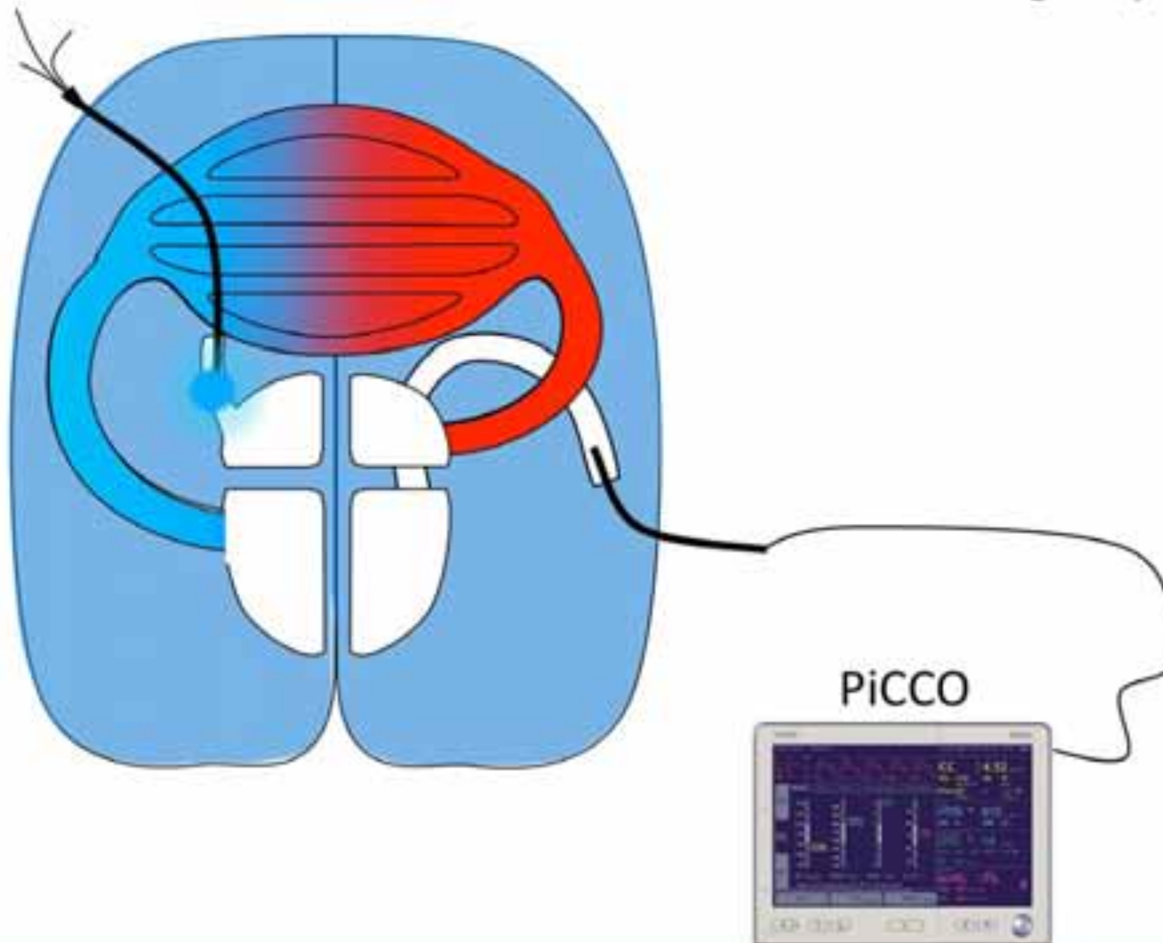
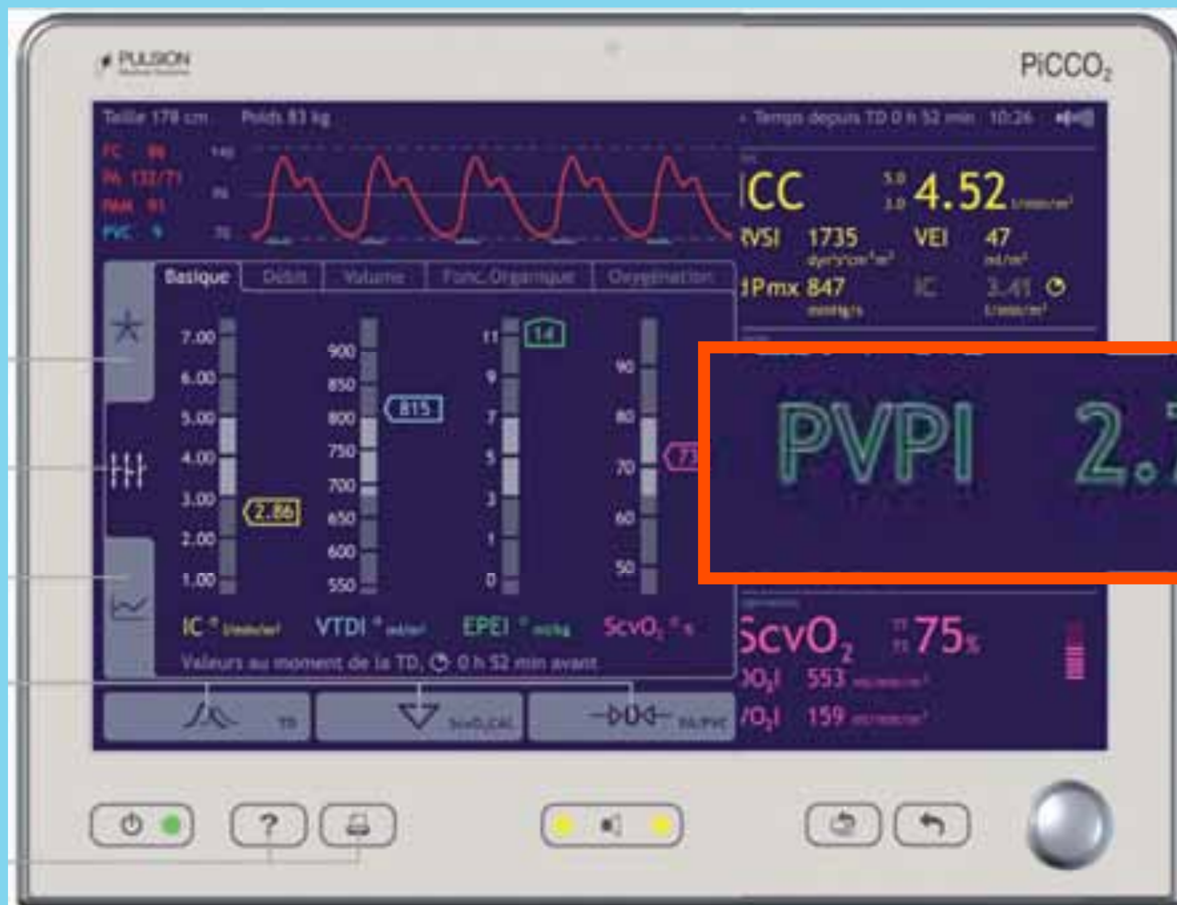
  - quand arrêter l'EV ?
    - Indices de précharge-dépendance négativés
    - eau pulmonaire élevée
    - perméabilité pulmonaire élevée
- ↘ fonction contractile ?

Quand arrêter l'expansion volémique

$$\text{IPVP} = \frac{\text{eau pulmonaire}}{\text{volume sanguin pulmonaire}}$$



Perméabilité pulmonaire



Perméabilité pulmonaire

Intensive Care Med 2007

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

ORIGINAL

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

48 patients

established diagnosis of pulmonary edema

- bilateral lung infiltrates
- PaO_2/FiO_2 < 300 mmHg
- lung water > 12 mL/kg

differential diagnosis by experts

- past history
- examination
- CXR
- cardiac echo
- BNP

ALI / ARDS — vs. — hydrostatic PE

Perméabilité pulmonaire

Intensive Care Med (2007) 33:448–453
DOI 10.1007/s00134-006-0498-6

ORIGINAL

Xavier Monnet
Nadia Anguel
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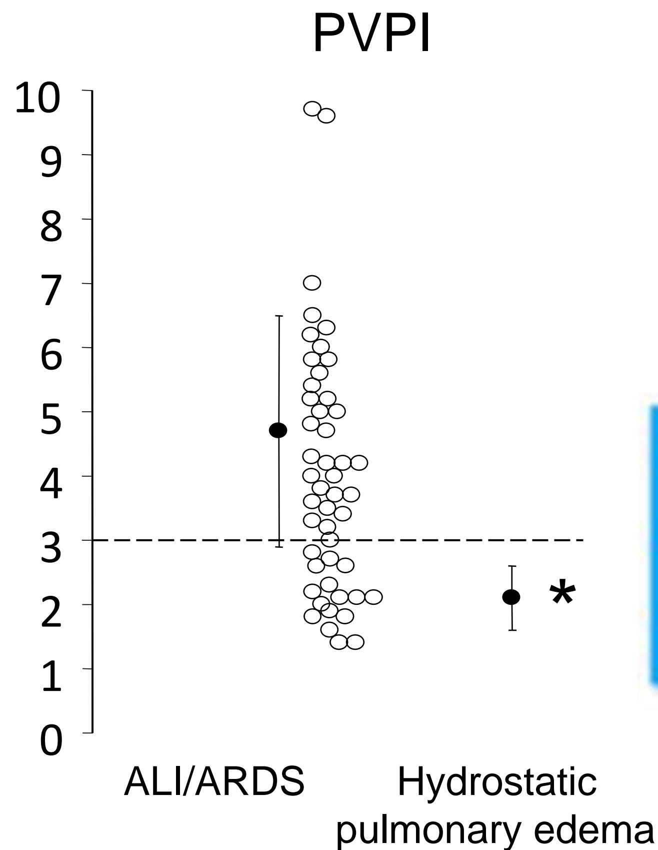
Assessing pulmonary permeability by transpulmonary thermodilution allows differentiation of hydrostatic pulmonary edema from ALI/ARDS



48 patients with pulmonary edema
inflammatory vs. hydrostatic discriminated by experts
PVPI by the PiCCO device

Cut-off : 3
Se = 85 %
Sp = 100 %

Clinical case

12 hours later

HR	98 beats/min
AP	91/40/57 mmHg
PPV	9 %
SVV	11 %
CI	2.9 L/min/m²
GEDVI	701 mL/m²
EVLWI	24 mL/kg
PVPI	7.1
CFI	4.1
PLR	CI +20%

HR	97 beats/min
AP	110/50/70 mmHg
PPV	8 %
SVV	9 %
CI	3.4 L/min/m²
GEDVI	712 mL/m²
EVLWI	24 mL/kg
PVPI	7.1
CFI	4.1
PLR	CI +10%

Saline	2 000 mL
Norepi	0.37 µg/kg/min

Saline	2 000 mL
Norepi	0.55 µg/kg/min

Quel monitorage hémodynamique ?

monitoring hémodynamique

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- expansion volémique ?
  - quand administrer l'EV ?
    - VS ou arythmie ou faible Vt?
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        - LJP
        - TOE
  - quand arrêter l'EV ?
    - eau pulmonaire élevée
    - perméabilité pulmonaire élevée
- ↘ fonction contractile ?

Cas clinique

PiCCO en place

FC	102 batt/min	
PA	90/52/63 mmHg	
PVC	12 mmHg	
VPP	6 %	
VVE	8 %	
IC	3., L/min/m²	
VTDI	690 mL/m²	N:650-800
EPEVI	11 mL/kg	N:3-10
IPVP	4.0	N<3
IFC	4.6	

CVVHF	
SSI	1 500 mL
Noradré	0.48 µg/kg/min
Propof	150 mg/h

FR	18/min
Vt	400 mL (6mL/kg)
Pplat	28 cmH_2O
PEEP	9 cmH_2O

Lactate	2,7 mmol/L
P/F	190
$ScvO_2$	53%

?

Que faites-vous maintenant ? (choix multiple)

1 un test de LJP en observant la pression artérielle

2 un test de LJP en observant le débit cardiaque continu

3 un test d'occlusion télé-inspiratoire

4 un test d'occlusion télé-expiratoire

Cas clinique

PiCCO en place

FC	102 batt/min	
PA	90/52/63 mmHg	
PVC	12 mmHg	
VPP	6 %	
VVE	8 %	
IC	3., L/min/m^2	
VTDI	690 mL/m^2	N:650-800
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P/F	190
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Que faites-vous maintenant ? (choix multiple)

1. un test de LJP en observant la pression artérielle
2. un test de LJP en observant le débit cardiaque continu
3. un test d'occlusion télé-inspiratoire
4. un test d'occlusion télé-expiratoire

Cas clinique

PiCCO en place

FC	102 beats/min	
PA	90/52/63 mmHg	
PVC	12 mmHg	
VPP	6 %	
VVE	8 %	
IC	3.1 L/min/m²	
VTDI	690 mL/m²	N:650-800
EPEVI	11 mL/kg	N:3-10
IPVP	4.0	N<3
IFC	4.6	
EEO test	CI + 11%	

$ScvO_2$	53%	
Lactate	2,7 mmol/L	

SSI	1 500 mL
NAD	0.48 µg/kg/min

FC	103 beats/min	
PA	110/55/74 mmHg	
PVC	14 mmHg	
VPP	6 %	
SVV	9 %	
IC	4.1 L/min/m²	
VTDI	860 mL/m²	N:650-800
EPEVI	11 mL/kg	N:3-10
IPVP	4.0	N<3
IFC	4.7	

$ScvO_2$	69%	
lactate	2,4 mmol/L	

SSI	1 500 + 500 mL
NAD	0.48 µg/kg/min

Cas clinique

6 heures plus tard

FC	104 beats/min	
PA	78/45/56 mmHg	
VPP	7 %	
VVE	8%	
IC	3,2 L/min/m²	
VTDI	695 mL/m²	N:650-800
EPEVI	18 mL/kg	N:3-10
IPVP	7.0	N<3
IFC	4,7	
PLJP	CI +20%	
EEO	CI + 12%	

SSI	2 000 mL
NAD	0.60 µg/kg/min

FR	20/min
Vt	400 mL (6mL/kg)
Pplat	29 cmH_2O
PEEP	9 cmH_2O

Lactate	2,1 mmol/L
P/F	170
$ScvO_2$	70%

?

Que faites-vous maintenant ? (choix multiple)

1 expansion volémique

2 dobutamine

3 noradrénaline

4 rien de plus

Prédiction de la réponse à l'expansion volémique

Concept

Research

Open Access

Extravascular lung water in patients with severe sepsis: a prospective cohort study

Greg S Martin[1], Stephanie Eaton[2], Meredith Mealer[3] and Marc Moss[4]

Critical Care 2005, **9**:R74-R82

Prognostic Value of Extravascular Lung Water in Critically Ill Patients*

Samir G. Sakka, MD; DEAA; Magdalena Klein; Konrad Reinhart, MD; and Andreas Meier-Hellmann, MD

Extravascular lung water in sepsis-associated acute respiratory distress syndrome: Indexing with predicted body weight improves correlation with severity of illness and survival*

Charles R. Phillips, MD; Mark S. Chesnutt, MD; Stephen M. Smith, PhD, FJFICM

Crit Care Med 2008

Extravascular lung water indexed to predicted body weight is a novel predictor of intensive care unit mortality in patients with acute lung injury*

Thelma R. Craig, MB; Martin J. Duffy, MB; Murali Shyamsundar, MB; Cliona McDowell, BSc; Brian McLaughlin; J. Stuart Elborn, MD; Daniel F. McAuley, MD

Crit Care Med 2010

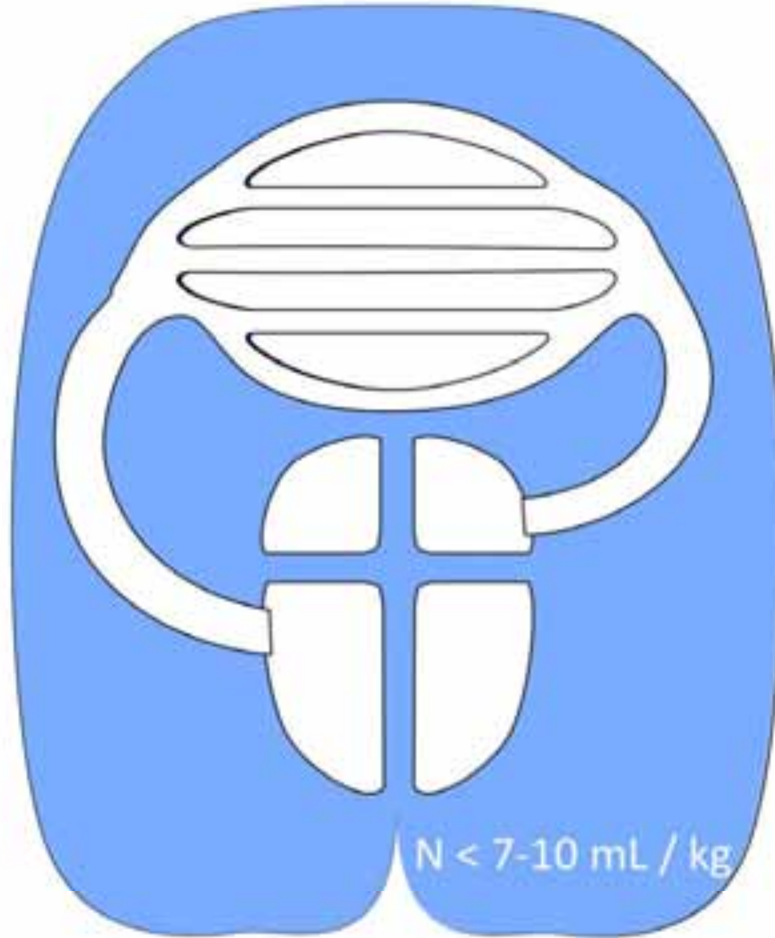
Comment limiter l'expansion volémique ?

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 *submitted*

209 pts with ARDS
EVLW measured by PiCCO device

	Odds Ratio (CI 95%)		p value
Maximal blood lactate	0.81	(0.71 - 0.93)	0.002
Mean PEEP	1.25	(1.07 - 1.47)	0.005
$EVLWI_{max}$	0.94	(0.87 - 0.98)	0.01
SAPS II	0.97	(0.95 - 0.99)	0.02
Mean fluid balance	0.9996	(0.9993 - 0.9999)	0.02
Minimal P/F ratio	1.01	(1.00 - 1.02)	0.02
Minimal pH	35.97	(0.47 - 2769.52)	0.10

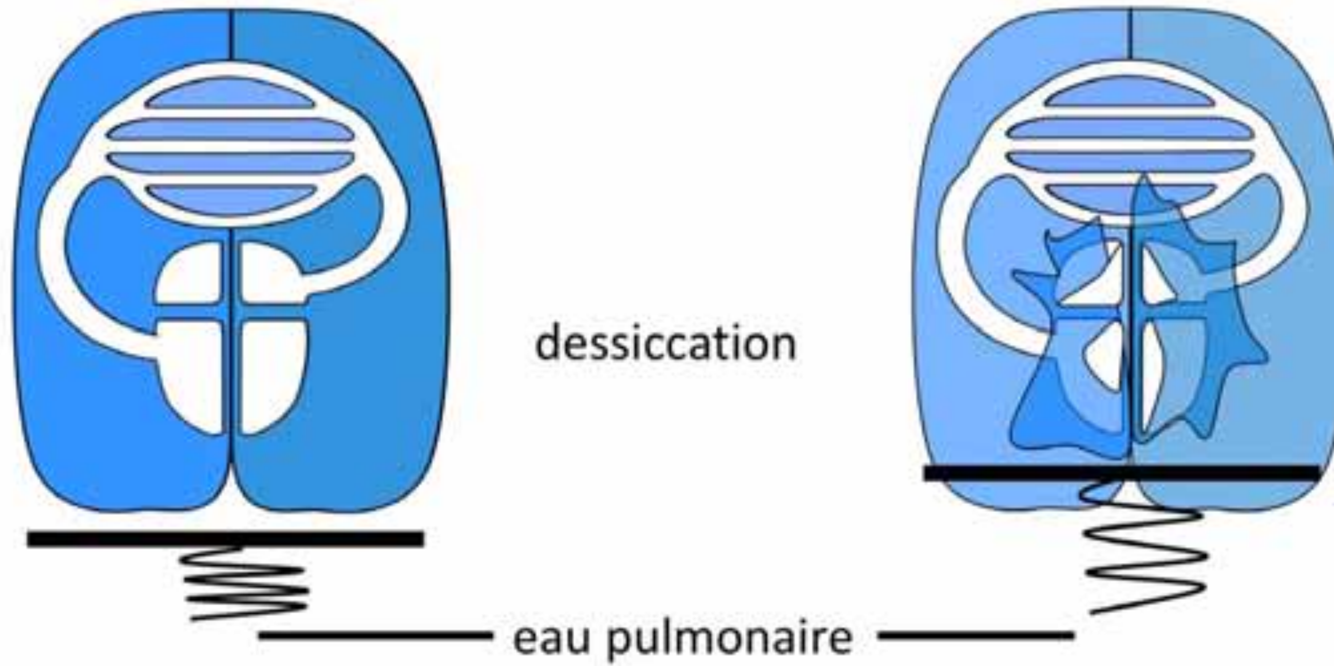


eau extravasculaire pulmonaire = volume de l'œdème pulmonaire

Comment quantifier l'eau pulmonaire ?

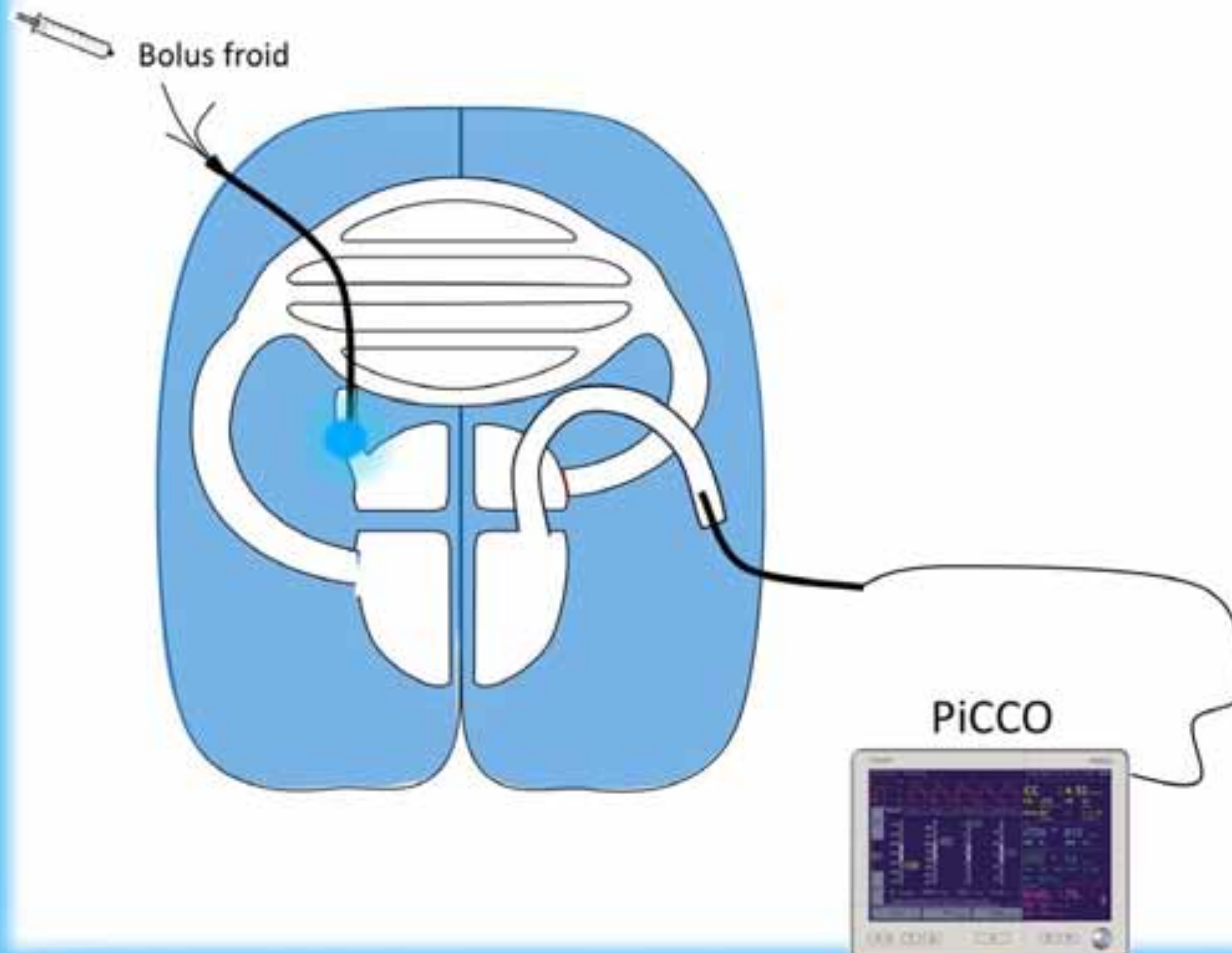
Comment quantifier l'eau pulmonaire

gravimétrie



Comment quantifier l'eau pulmonaire

thermodilution transpulmonaire



Comment quantifier l'eau pulmonaire

thermodilution transpulmonaire

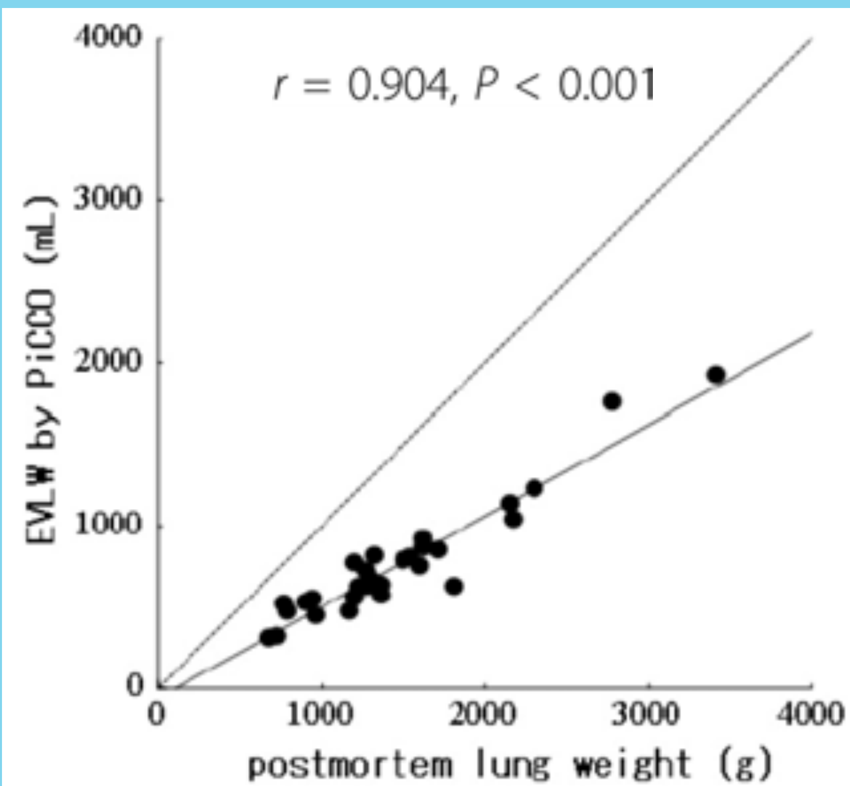
Comment quantifier l'eau pulmonaire

thermodilution transpulmonaire

RESEARCH — Open Access

Validation of extravascular lung water measurement by single transpulmonary thermodilution: human autopsy study

Takashi Tagami[1*], Shigeki Kushimoto[2], Yasuhiro Yamamoto[3], Takahiro Atsumi[2], Ryoichi Tosa[1], Kiyoshi Matsuda[4], Renpei Oyama[3], Takanori Kawaguchi[4], Tomohiko Masuno[2], Hisao Hirama[5], Hiroyuki Yokota[2]



30 pts
EVLW measured by TPTD and by postmortem gravimetry

First validation of EVLW-TPTD evaluation in humans

validation chez l'homme

Cas clinique

6 heures plus tard

FC	104 batt/min
PA	78/45/56 mmHg
VPP	7 %
VVE	8 %
IC	3,2 L/min/m²
VTDI	695 mL/m²
EPEVI	18 mL/kg
IPVP	5.0
IFC	4.7
LJP	CI +20%
EEO	CI + 12%

FC	100 batt/min
PA	115/55/75 mmHg
VPP	6 %
VVE	7 %
IC	3,7 L/min/m²
VTDI	711 mL/m²
EPEVI	18 mL/kg
IPVP	5.1
IFC	5.2
LJP	CI +8%
EEO	CI + 4%

SSI	2 000 mL
NAD	0,60 µg/kg/min

SSI	2 000 mL
NAD	0,84 µg/kg/min

Cas clinique

A 3 heures du matin, dans la nuit du 4 au 5 janvier

04/01/2009 à 22h	
FC	95 batt/min (RS)
PA	115/55/75 mmHg
PPV	6 %
SVV	7 %
IC (thermo)	2,8 L/min/m²
VTDGi	790 mL/m²
EPEVi	12 mL/kg
IPVP	7
IFC	6,1

05/01/2009 à 3h	
FC	87 batt/min (RS)
PA	95/50/65 mmHg
PPV	5 %
SVV	7 %
IC (thermo)	2,0 L/min/m²
VTDGi	810 mL/m²
EPEVi	13 mL/kg
IPVP	8
IFC	3,8
$ScvO_2$	70%

FR	23/min
Vt	400 mL
Pplat	29 cmH_2O
PEEP	10 cmH_2O

HFVV	
Sérum salé	2 000 mL
NAD	2,8 mg/h

?

Que faites-vous maintenant ? (choix multiple)

1. augmenter la noradrénaline
2. faire une échocardiographie
3. expansion volémique
4. rien de plus

Cas clinique

A 3 heures du matin, dans la nuit du 4 au 5 janvier

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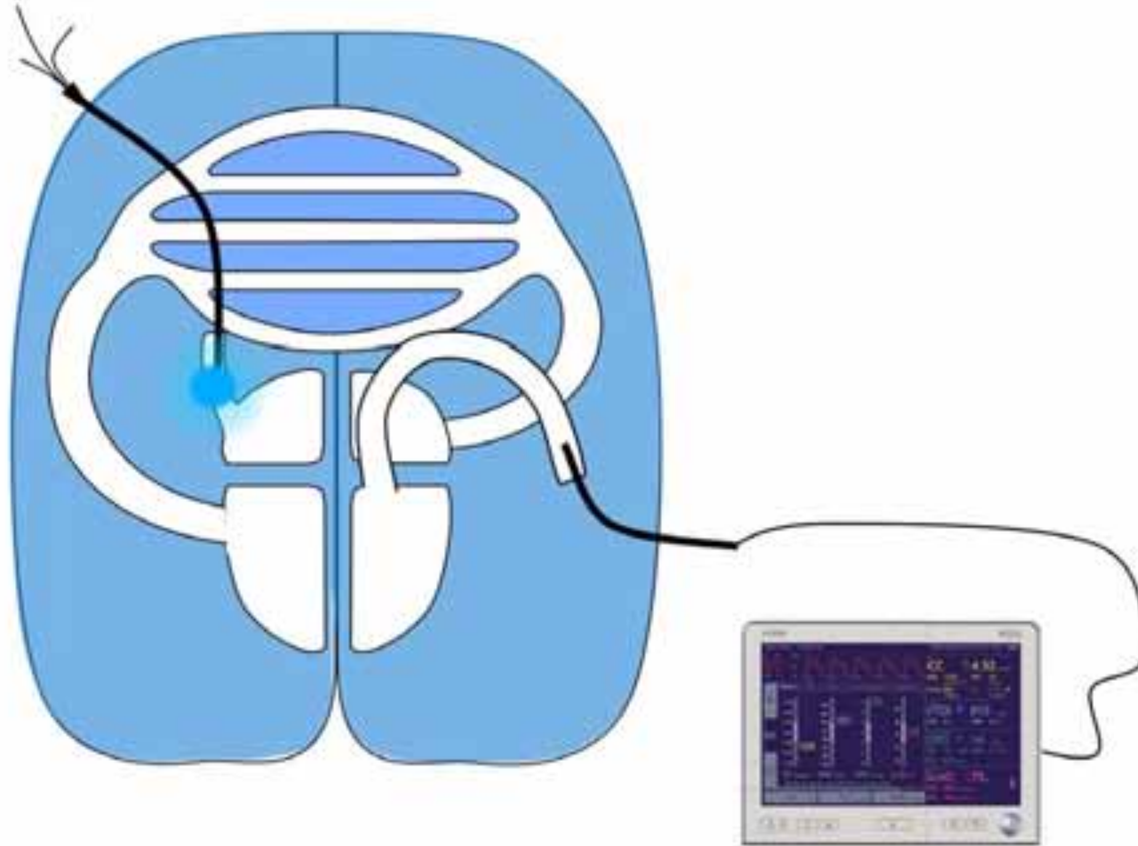
3. expansion volémique
4. rien de plus

Dysfonction contractile | comment la détecter ? | thermodilution TP

$$FEVG = \frac{VES}{\text{volume télédiastolique VG}}$$

bolus froid



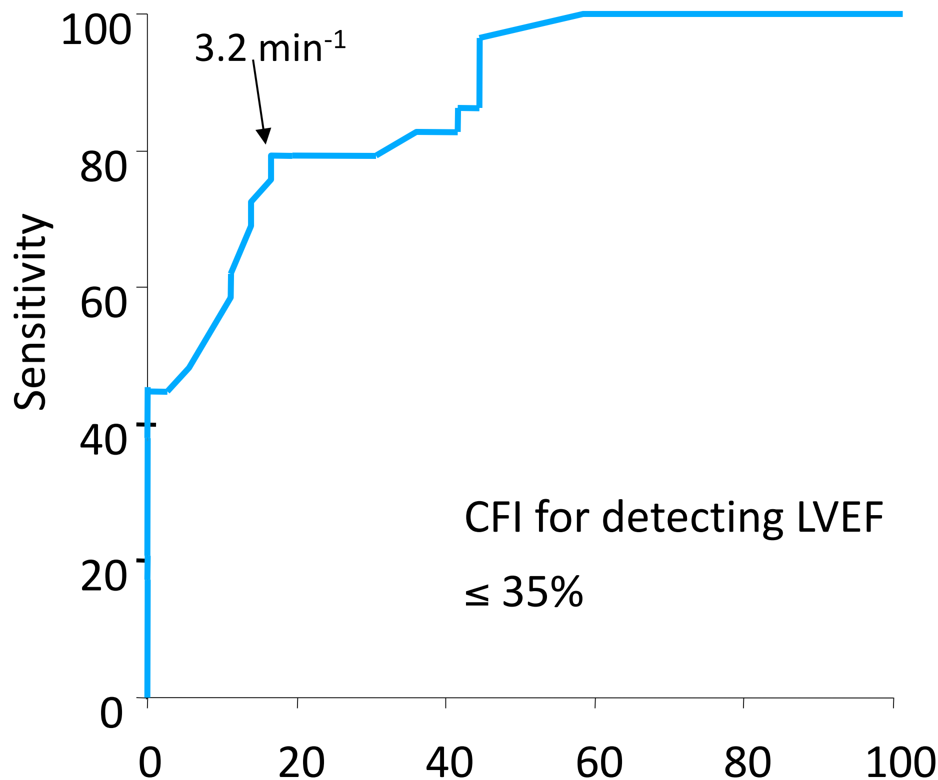
Monitoring avancé

Comment détecter une dysfonction contractile ?

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



60 pts
Monitoring with PiCCO and TTE

CFI reflects LVEF

→ La thermodilution transpulmonaire permet une estimation facile de la fonction systolique

Dysfonction contractile | comment la détecter ? | thermodilution TP

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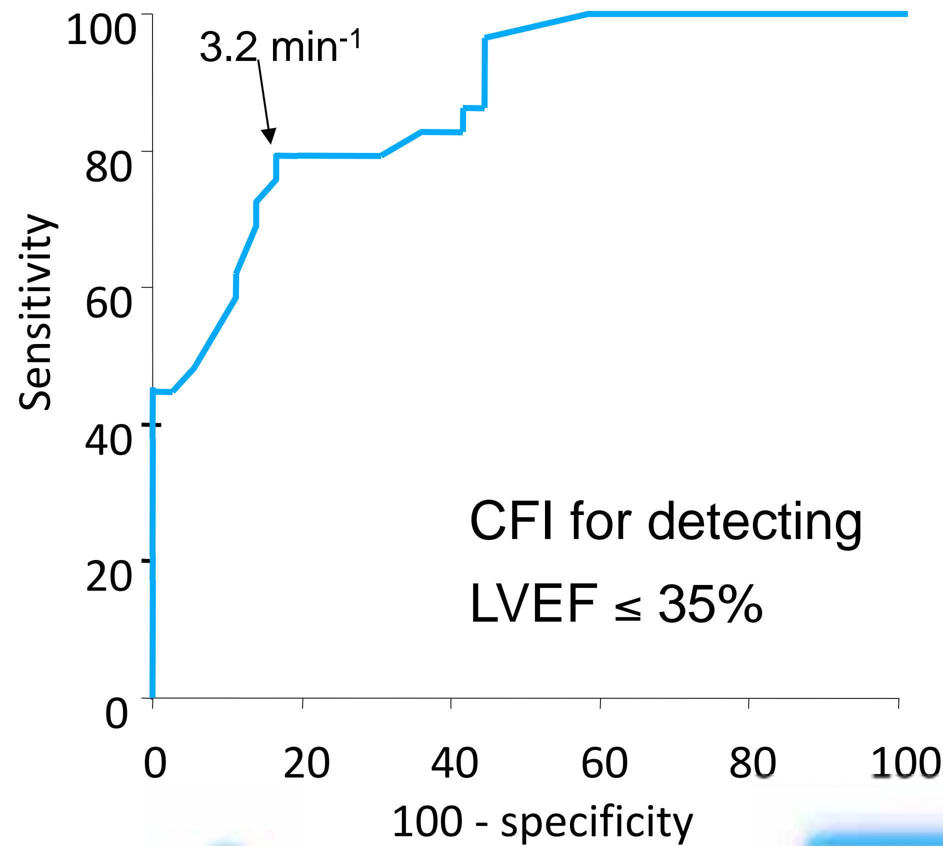

l'IFC permet de détecter une ↘ de la FEVG

Cas clinique

A 3 heures du matin, dans la nuit du 4 au 5 janvier

FEVG	55%
Contractilité segmentaire	normale
VG	non dilaté
Cavités droites	non dilatées

FEVG	45%
Contractilité segmentaire	normale
VG	non dilaté
Cavités droites	non dilatées

Cas clinique

A 3 heures du matin, dans la nuit du 4 au 5 janvier

05/01/2009 à 3h	
FC	87 batt/min (RS)
PA	95/50/65 mmHg
PPV	5 %
SVV	7 %
IC (thermo)	2,0 L/min/m^2
VTDGi	810 mL/m^2
EPEVi	13 mL/kg
IPVP	8
IFC	3,8
$ScvO_2$	70%

05/01/2009 à 3h	
FC	87 batt/min (RS)
PA	115/50/71 mmHg
PPV	5 %
SVV	7 %
IC (thermo)	2,9 L/min/m^2
VTDGi	810 mL/m^2
EPEVi	13 mL/kg
IPVP	8
IFC	5,8
$ScvO_2$	74%

FR	23/min
Vt	400 mL
Pplat	29 cmH_2O
PEEP	10 cmH_2O

HFVV	
SSI	2 000 mL
NAD	2,8 mg/h
Dobutamine	5 µg/kg/min

Quel monitorage hémodynamique ?

- monitoring hémodynamique
  - ?
    - vasoplégie ?
    - expansion volémique ?
      - quand administrer l'EV ?
        - VS ou arythmie ou faible Vt?
          - non
            - PPV
            - SVV
            - LJP
            - OTE
          - oui
            - LJP
            - OTE
      - quand arrêter l'EV ?
        - IPVP
        - EPEV
    - ↘ fonction contractile ?
      - IFC

PiCCO

débit cardiaque

précharge et précharge dépendance

eau et perméabilité pulmonaire

fonction systolique

oxygénation tissulaire