Extravascular lung water and pulmonary permeability

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Link of interest

Member of the Medical Advisory Board of Maquet

Extravascular lung water and pulmonary permeability

?

What is lung water?

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What is lung water ?

Jozwiak et al. Ann. Intensive Care (2015) 5:38
DOI 10.1186/s13613-015-0081-9

Annals of Intensive Care
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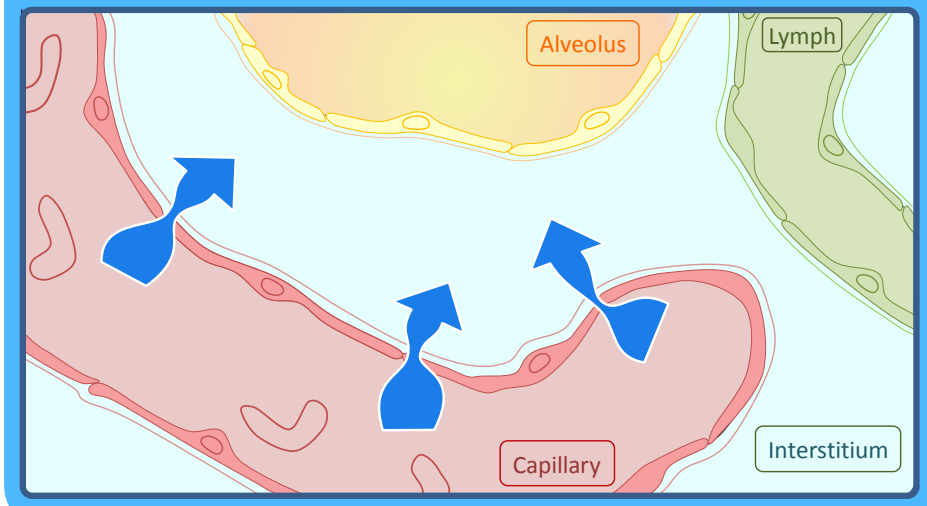
REVIEW Open Access

Extravascular lung water in critical care: recent advances and clinical applications

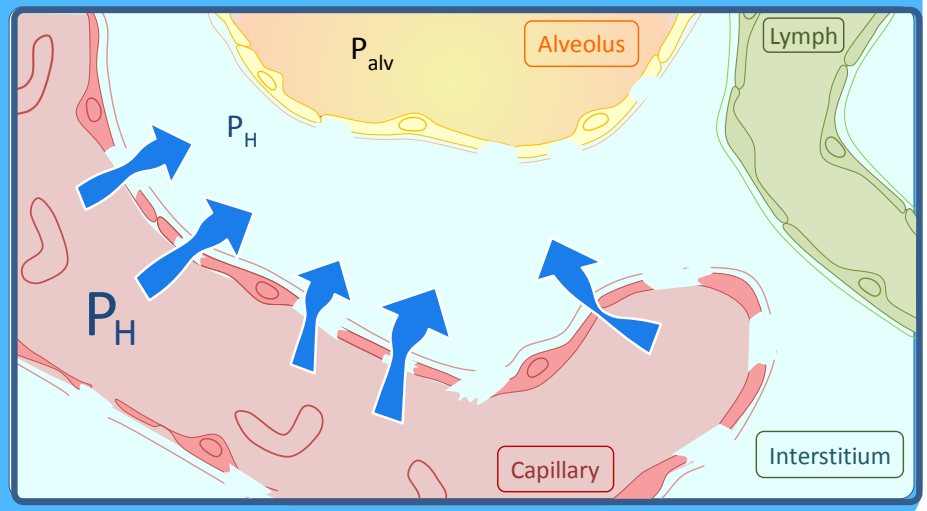
Mathieu Jozwiak[1,2,3*], Jean-Louis Teboul[1,2,3] and Xavier Monnet[1,2,3]

Ann. Intensive Care (2015) 5:38

Hydrostatic Oedema



Inflammatory Oedema



Important pathophysiological variable

How to measure lung water ?

How to measure lung water ? ⟨ gravimetry !

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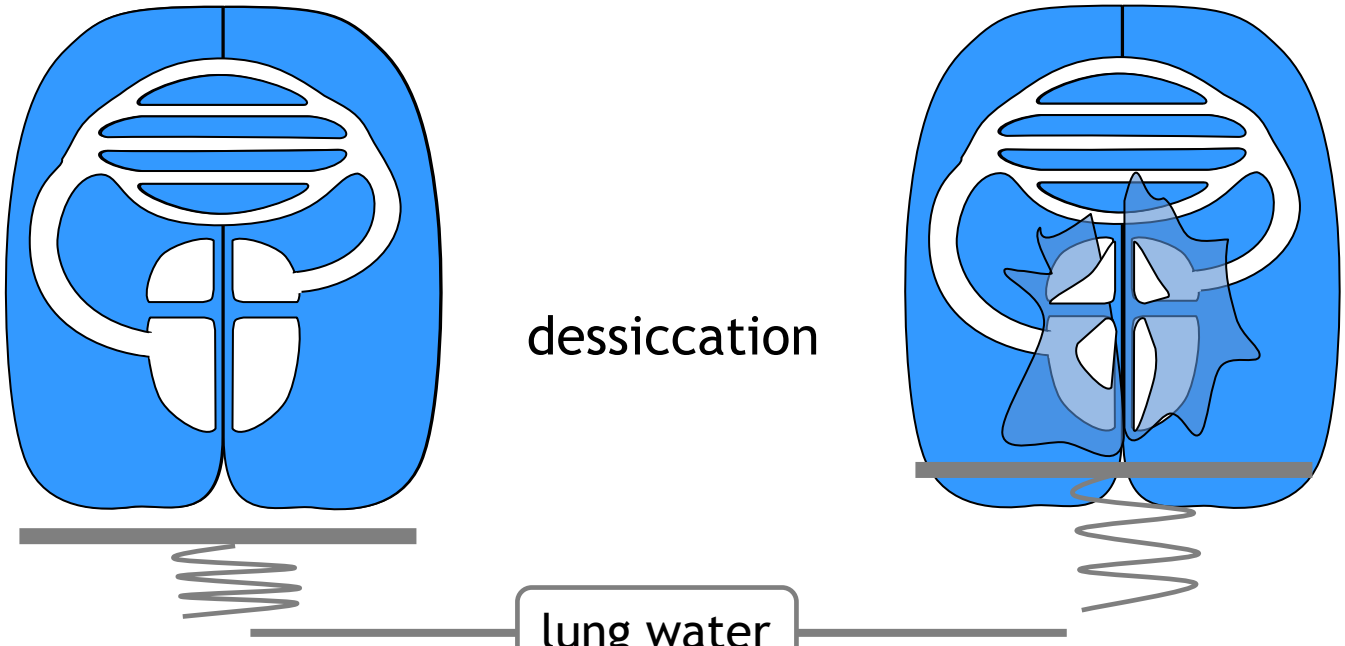
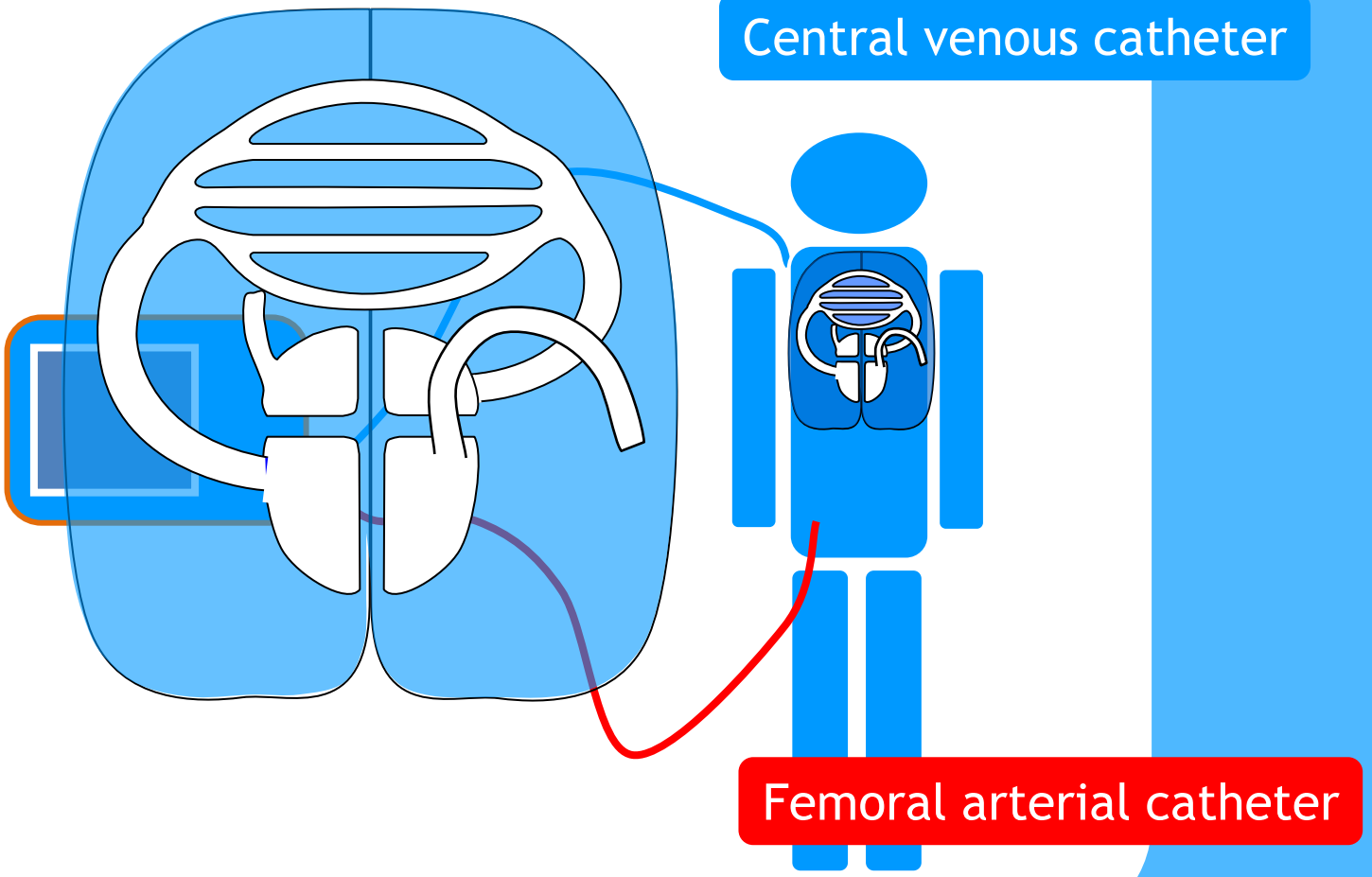


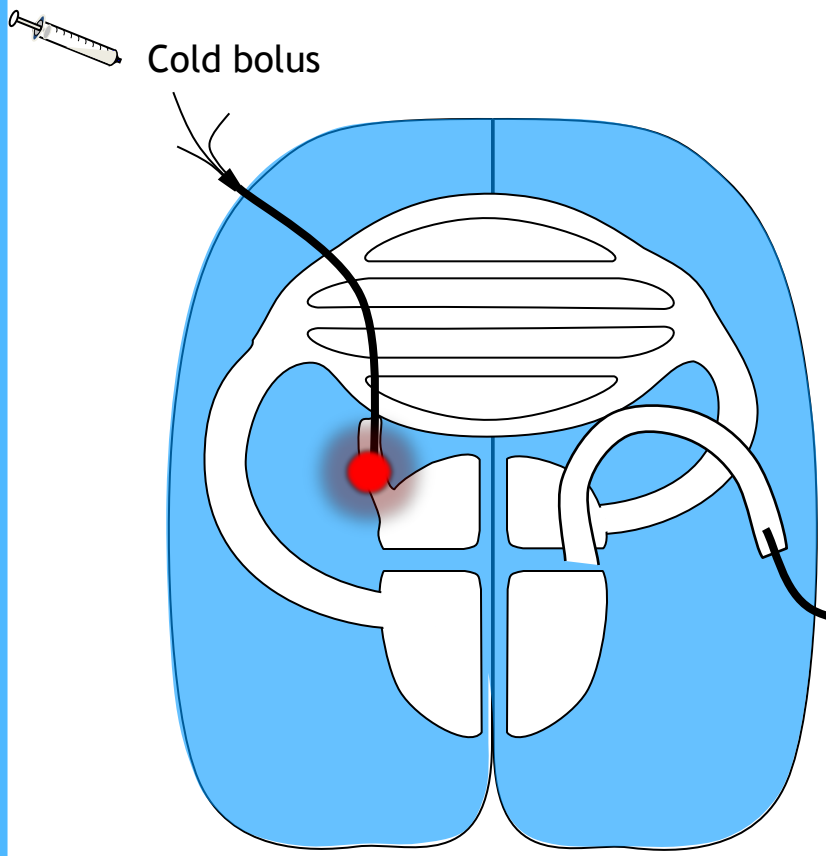
How to do at the bedside ?

Estimation of lung water with transpulmonary thermodilution

How does transpulmonary thermodilution work ?

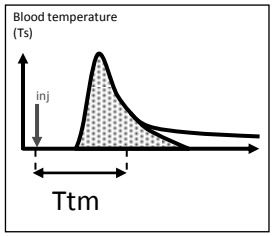


Estimation of lung water with transpulmonary thermodilution

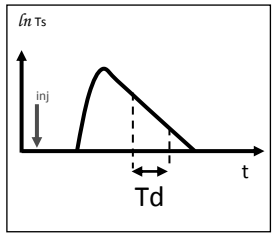


Extravascular lung water
indexed for ideal body weight

Thermodilution curve



Logarithmic transformation



The 4 messages

1. The only way to measure extravascular lung water at the bedside is transpulmonary thermodilution

2. ?

   Is the estimation of lung water reliable?

3. 3 arguments

   1

   2

   3

4.

Is the estimation of lung water reliable ?

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

CRITICAL CARE

RESEARCH Open Access

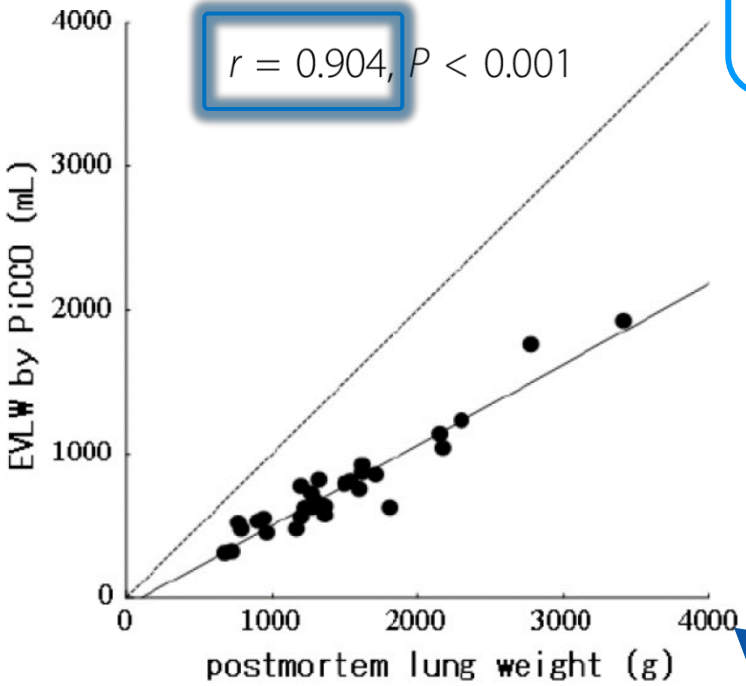
Validation of extravascular lung water measurement by single transpulmonary thermodilution: human autopsy study

Takashi Tagami[1*], Shigeki Kushimoto[2], Yasuhiro Yamamoto[3], Takahiro Atsumi[2], Ryoichi Tosa[1], Kiyoshi Matsuda[4], Renpei Oyama[5], Takanori Kawaguchi[6], Tomohiko Masuno[2], Hisao Hirama[1], Hiroyuki Yokota[2]

Validated in humans

30 pts
EVLW measured by TPTD and by postmortem gravimetry

Lung water estimated by PiCCO



Lung water measured by the gold standard

Is the estimation of lung water reliable ?

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 Osi
Christian Richard, MD; Jean-Louis Teboul, MD, PhD; Xavier Monnet, MD, PhD

Crit Care Med 201

Validated in humans

Independently predicts mortality

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*

...tt, MD; Stephen M. Smith, PhD, FJFICM

Crit Care Med 2008

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 Angue
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Brown *et al. Annals of Intensive Care* 2013, **3**:25
http://www.annalsofintensivecare.com/content/3/1/25

Annals of Intensive Care
a SpringerOpen Journal

Open Access

Comparison of thermodilution measured extravascular lung water with chest radiographic assessment of pulmonary oedema in patients with acute lung injury

Lisa M Brown[1,2], Carolyn S Calfee[3,4], James P Howard[2,5], Thelma R Craig[6,7], Michael A Matthay[2,3,8*]
nd Daniel F McAuley[6,7]

Is the estimation of lung water reliable ?

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

200 pts wi
EVLW me
PiCCO dev

Independently predicts mortality

	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_2O)	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

Estimation of lung water by transpulmonary thermodilution makes sense

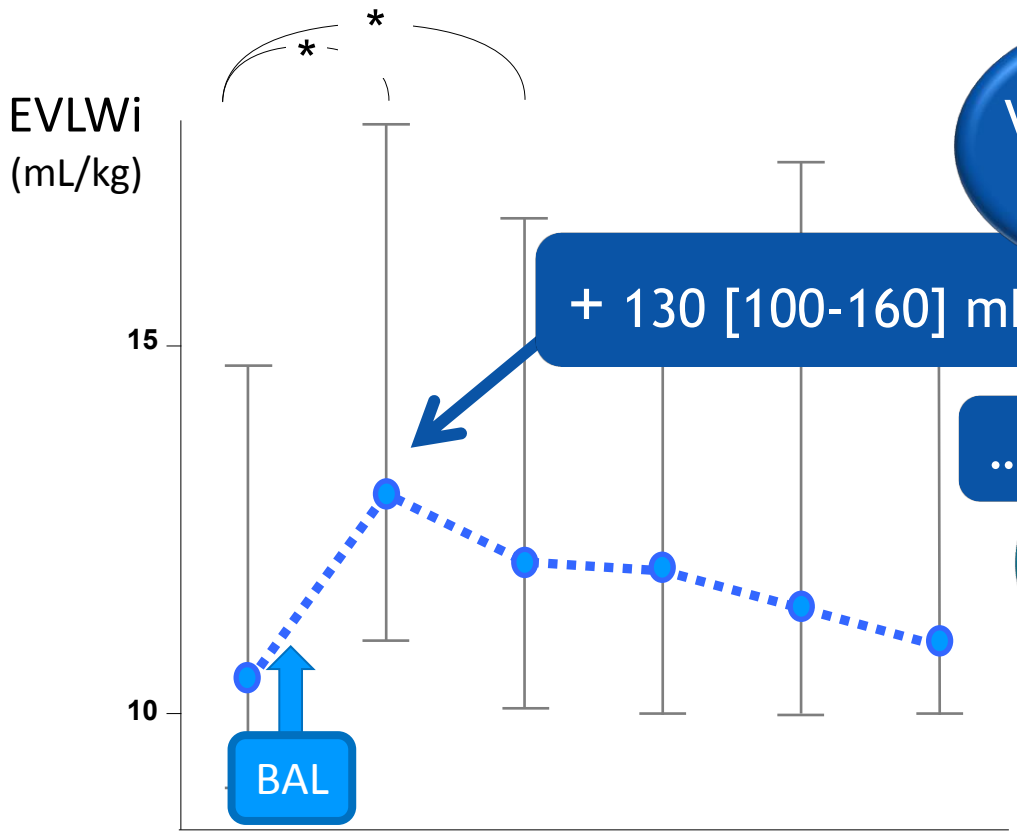
Is the estimation of lung water reliable ?

Transpulmonary Thermodilution Enables to Detect Small Short-Term Changes in Extravascular Lung Water Induced by a Bronchoalveolar Lavage

Martin Dres, MD[1,2]; Jean-Louis Teboul, MD, PhD[1,2]; Laurent Guerin, MD[1,2]; Nadia Anguel, MD[1,2]; Virginie Amilien, MD[1,2]; Marie-Philippine Clair, MD[1,2]; Aurélie Grüner, MD[1,2]; Christian Richard, MD[1,2]; Xavier Monnet, MD, PhD[1,2]

(*Crit Care Med* 2014; 42:1869–1873)

28 BALs
EVLW measured by PiCCO device



Validated in humans

Independently predicts mortality

... on!

Detects small short term changes

The 4 messages

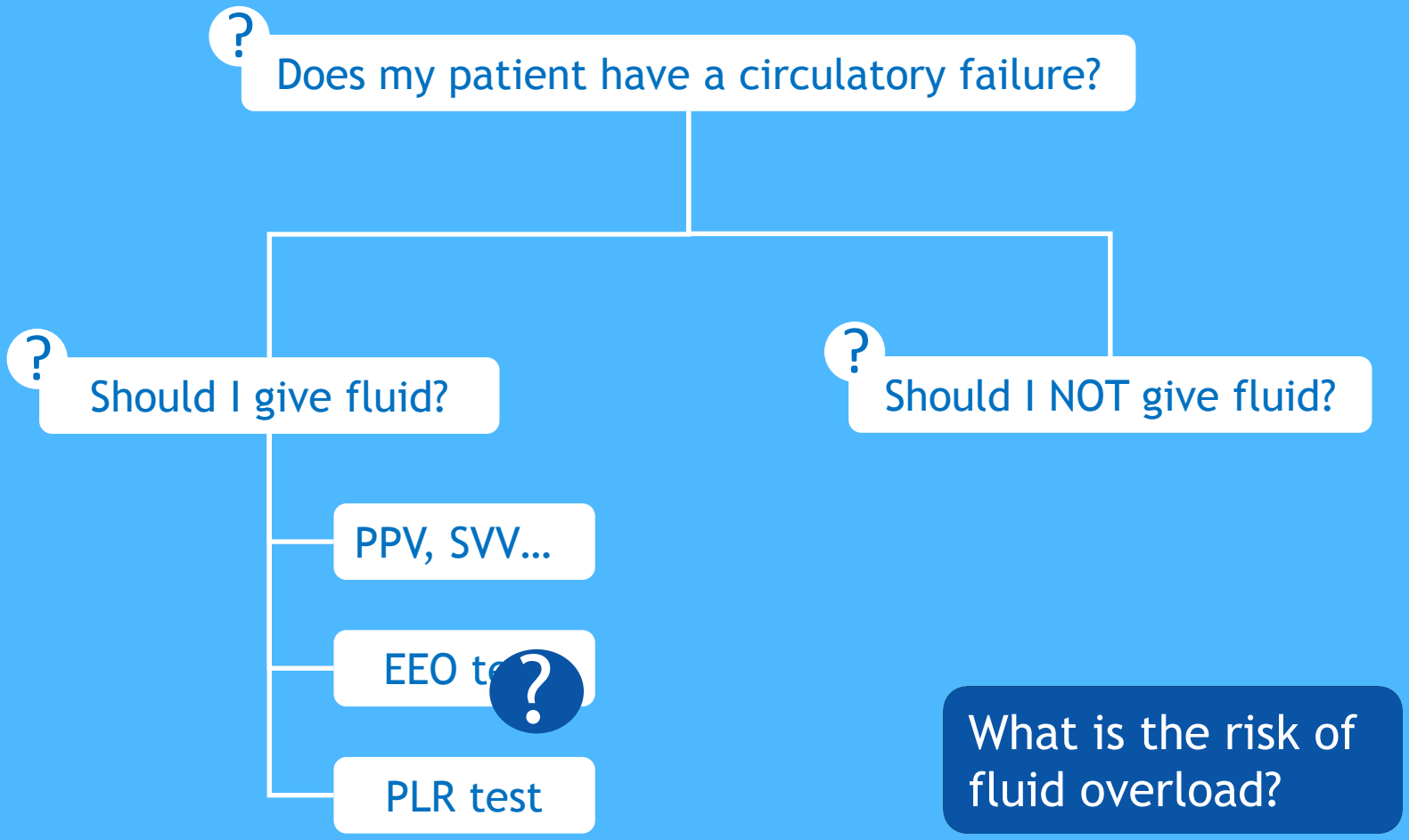
1. The only way to measure extravascular lung water at the bedside is transpulmonary thermodilution

2. Estimation of lung water by transpulmonary thermodilution is reliable and precise

3. 

   How could it be useful in practice?

4.


Does my patient have a circulatory failure?
Should I give fluid?
Should I NOT give fluid?
PPV, SVV…
EEO t
PLR test
What is the risk of fluid overload?

The risk of volume expansion

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		.008
Pseudomonas infection		.017
Medical admission		.049
Female gender		.044

Fluid overload increases mortality during sepsis

The risk of volume expansion

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

200 pts with ARDS

	Odds Ratio (CI 95%)	p value
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Maximum blood lactate (1 unit = 1 mmol/L)	1.29 (1.14 - 1.46)	0.0001
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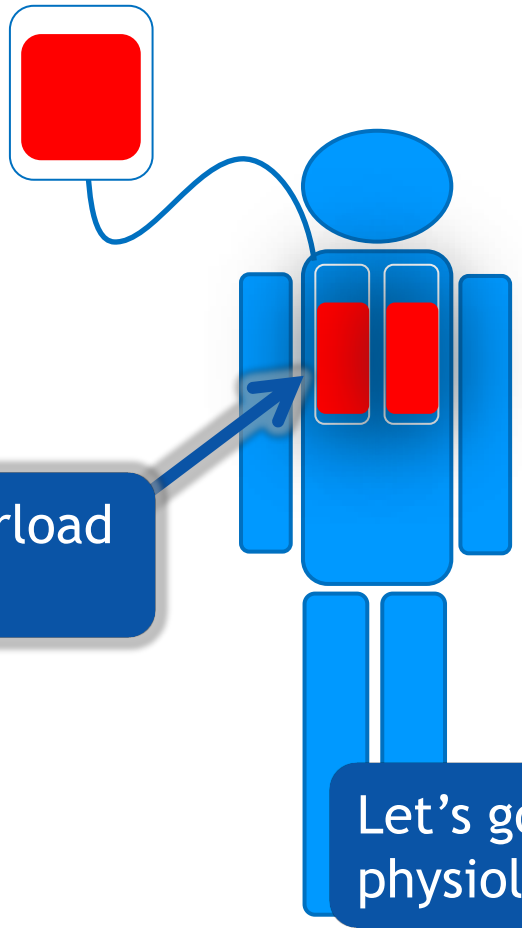
Fluid overload increases mortality during ARDS

The risk of volume expansion



THE main risk of fluid overload is to worsen lung edema

Let’s go back to physiology!

How to estimate the risk of fluid administration ?

Jozwiak et al. Ann. Intensive Care (2015) 5:38
DOI 10.1186/s13613-015-0081-9

Annals of Intensive Care
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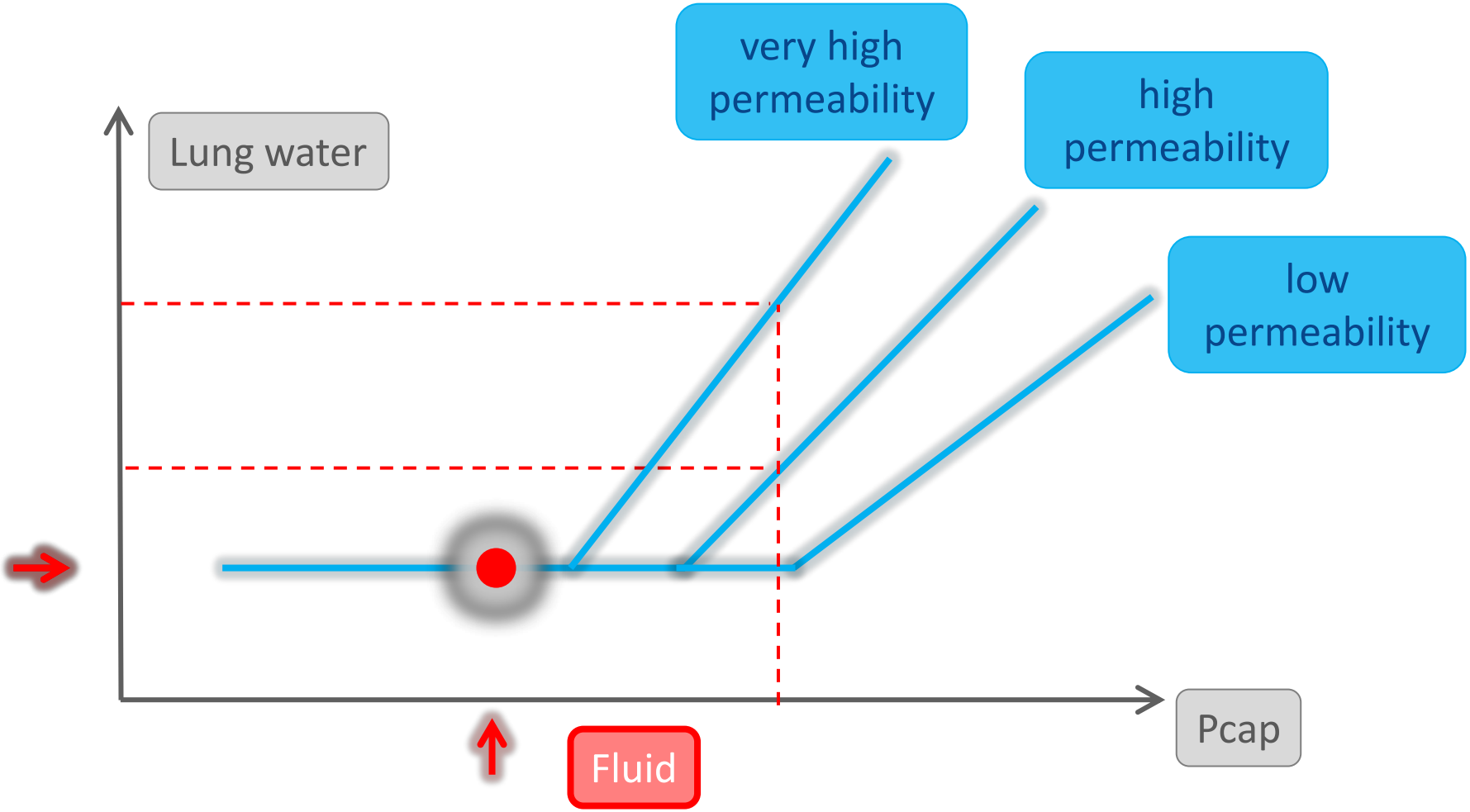
Mathieu Jozwiak[1,2,3*], Jean-Louis Teboul[1,2,3] and Xavier Monnet[1,2,3]

Ann. Intensive Care (2015) 5:38

What is demonstrated ?



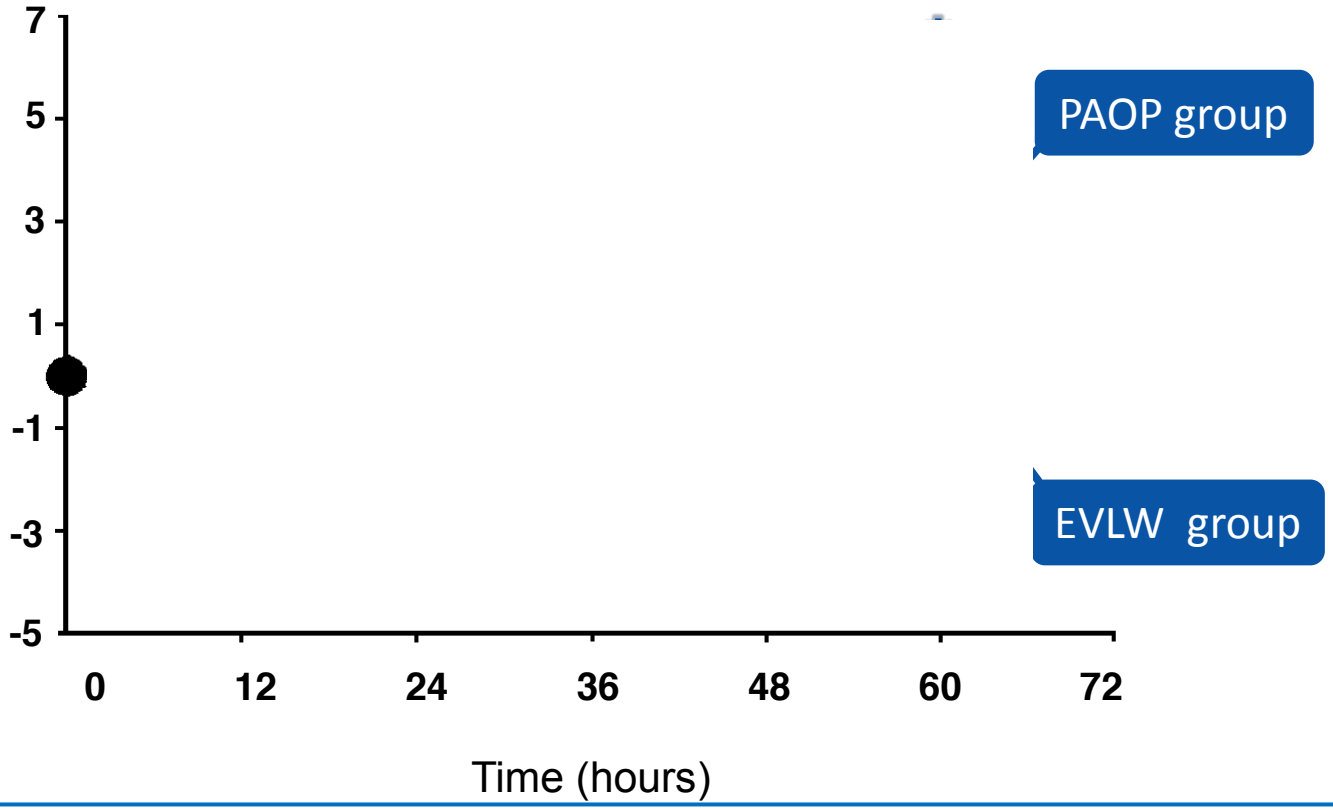
How to limit the risk of fluid administration ?

Improved Outcome Based on Fluid Management in Critically Ill Patients Requiring Pulmonary Artery Catheterization[1–3]

AM REV RESPIR DIS 1992

JOHN P. MITCHELL, DAN SCHULLER, FRANK S. CALANDRINO, and DANIEL P. SCHUSTER

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



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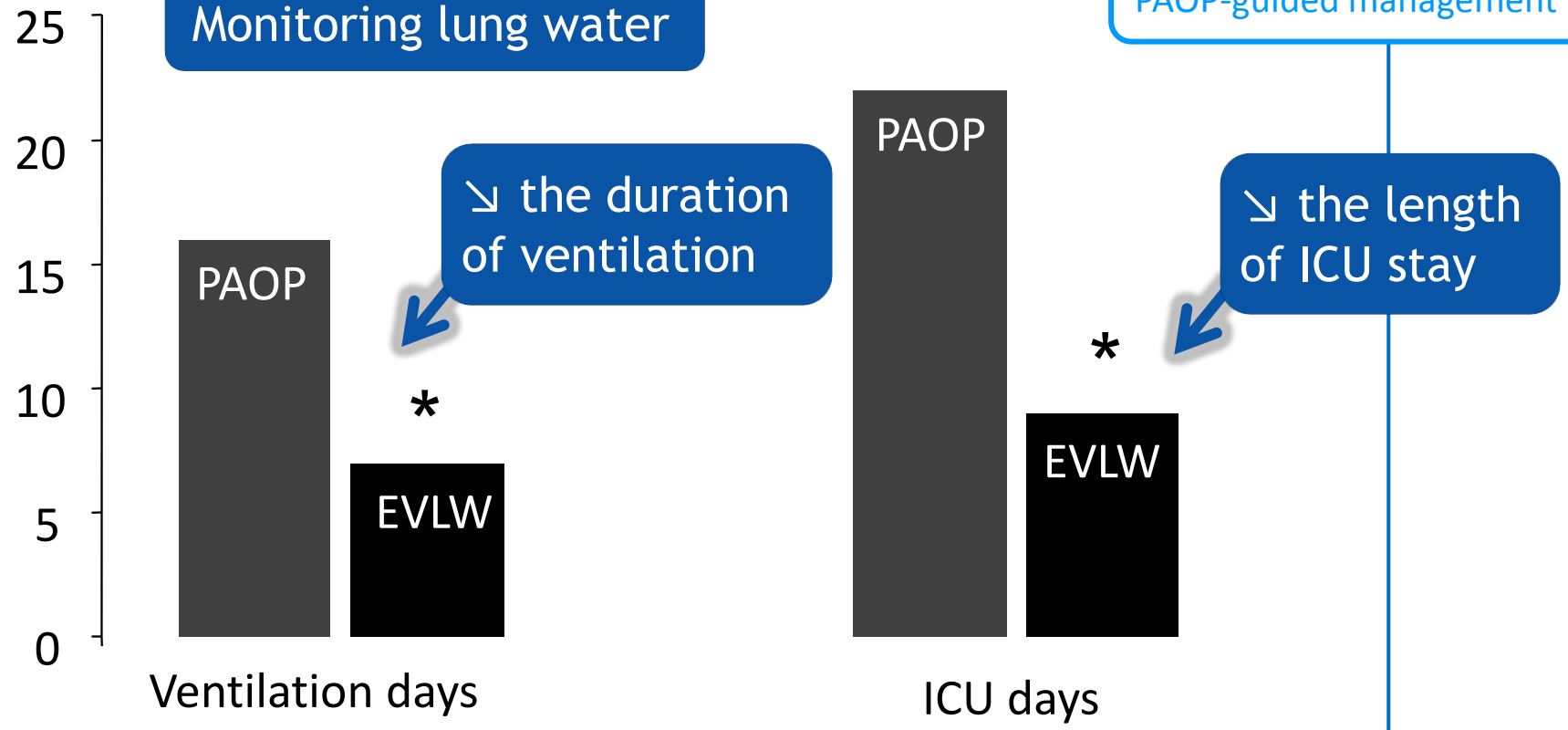
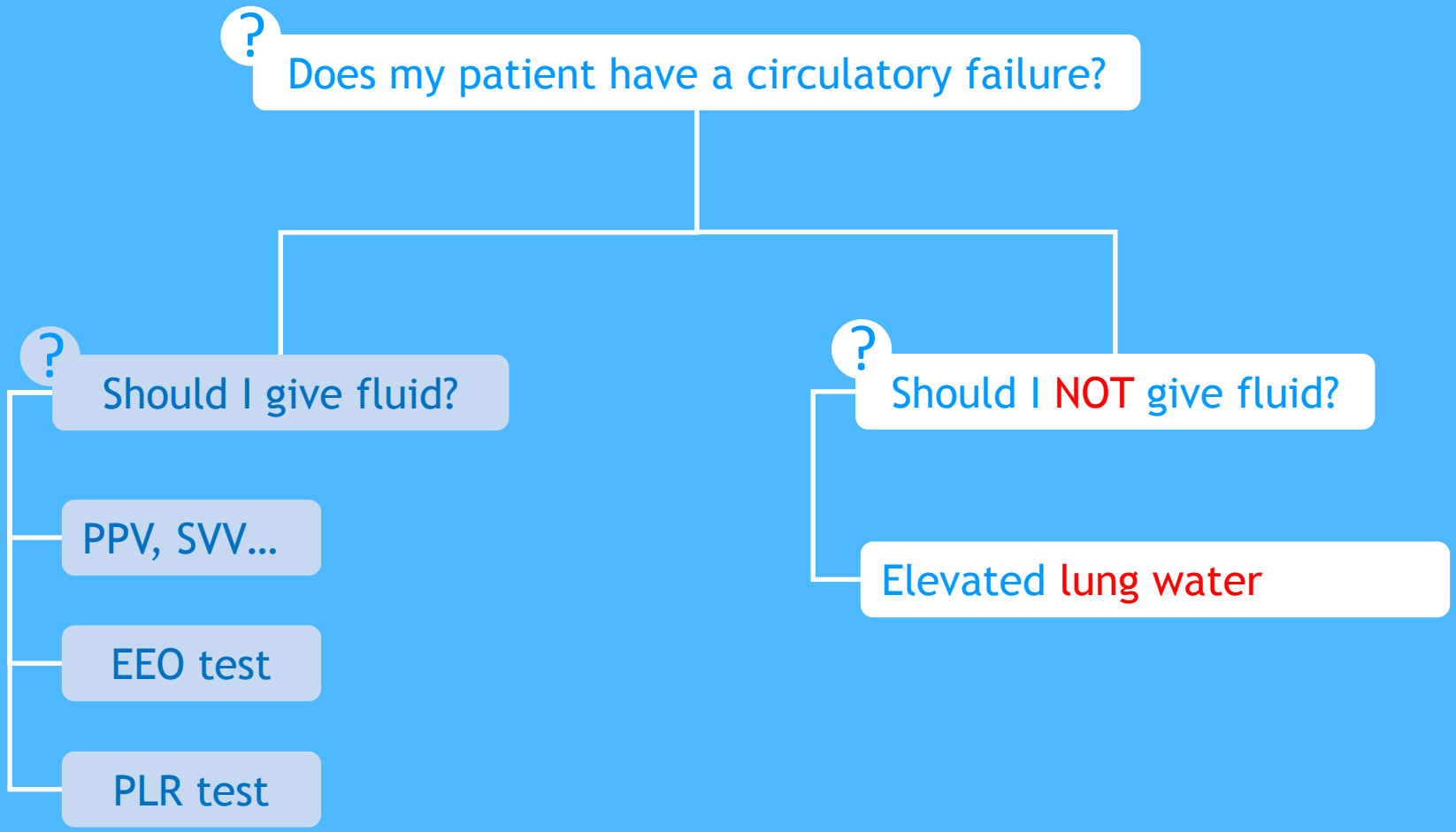
101 ARDS patients
EVLW-guided management vs.
PAOP-guided management

Monitoring lung water




Does my patient have a circulatory failure?
Should I give fluid?
PPV, SVV…
EEO test
PLR test
Should I NOT give fluid?
Elevated lung water

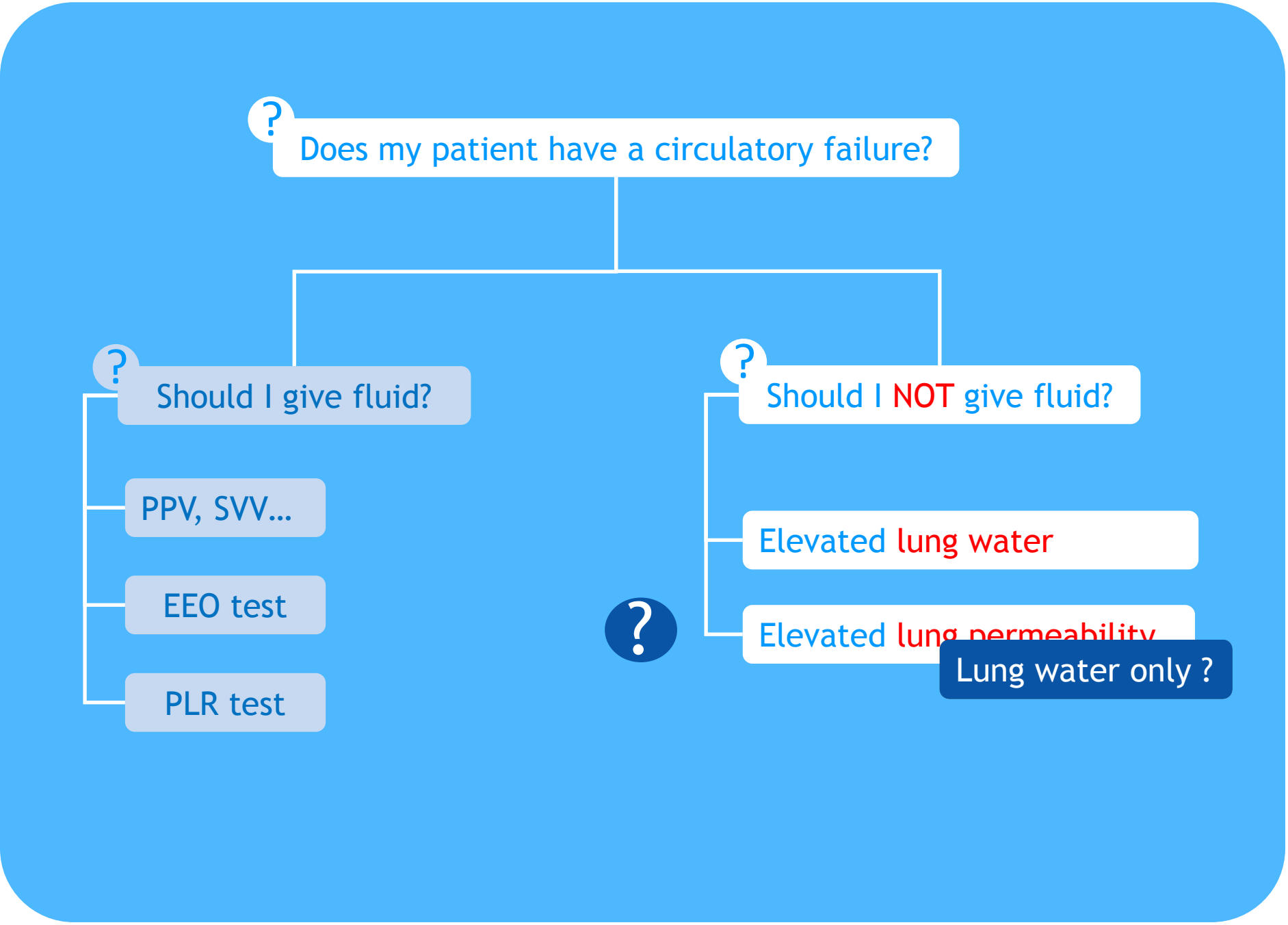
The 4 messages

1. The only way to measure extravascular lung water at the bedside is transpulmonary thermodilution

2. Estimation of lung water by transpulmonary thermodilution is reliable and precise

3. Lung water may help to guide fluid management by indicating the severity of lung oedema

4.


Does my patient have a circulatory failure?
Should I give fluid?
PPV, SVV…
EEO test
PLR test
Should I NOT give fluid?
Elevated lung water
Elevated lung permeability
Lung water only ?

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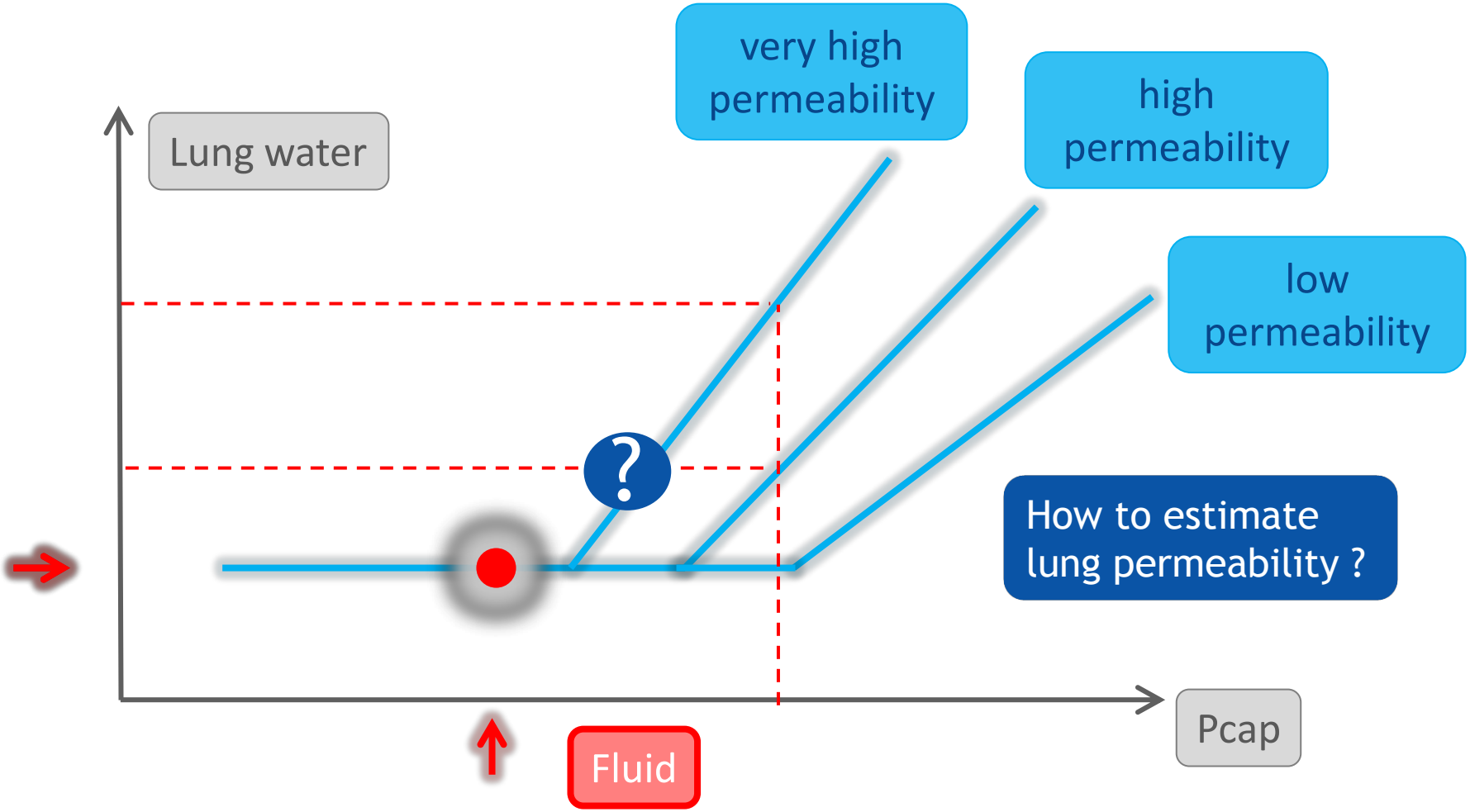
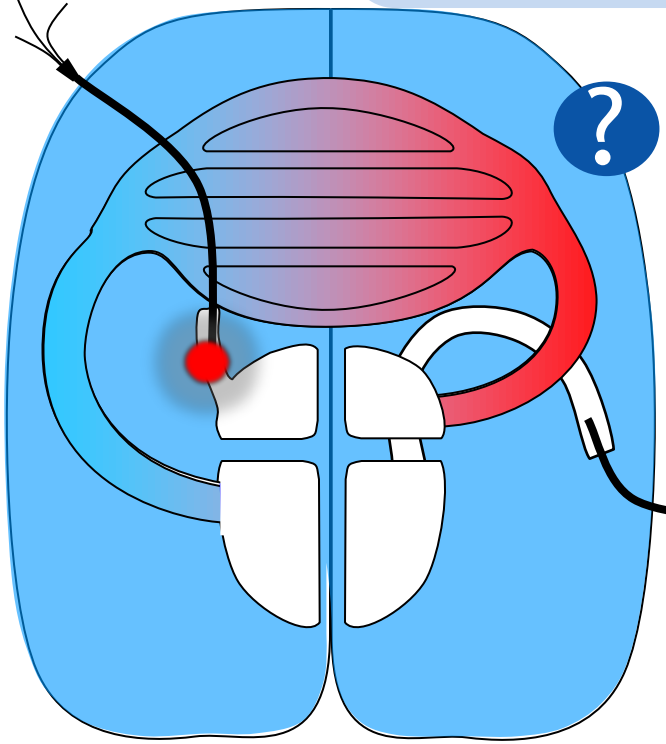


How to estimate the risk of fluid administration ?

Pulmonary vascular permeability index = Out of the vessels / In the vessels

Cold bolus



Does it really reflect lung permeability ?

PiCCO

VolumeView

How to estimate the risk of fluid administration ?

Intensive Care Med 2007

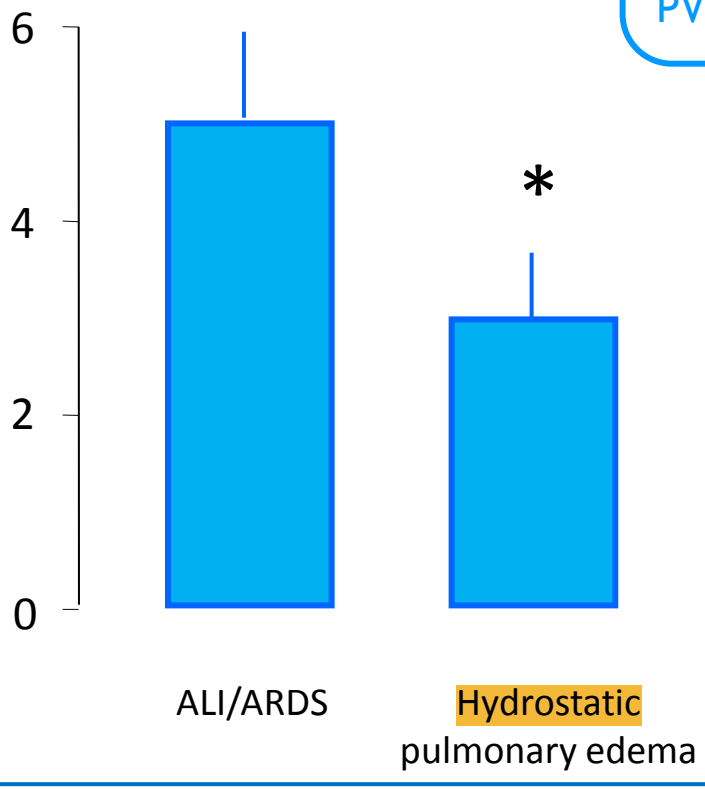
Xavier Monnet
Nadia Anguel
David Osman
Olfa Hamzaoui
Christian Richard
Jean-Louis Teboul

ORIGINAL

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

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

Pulmonary vascular permeability index



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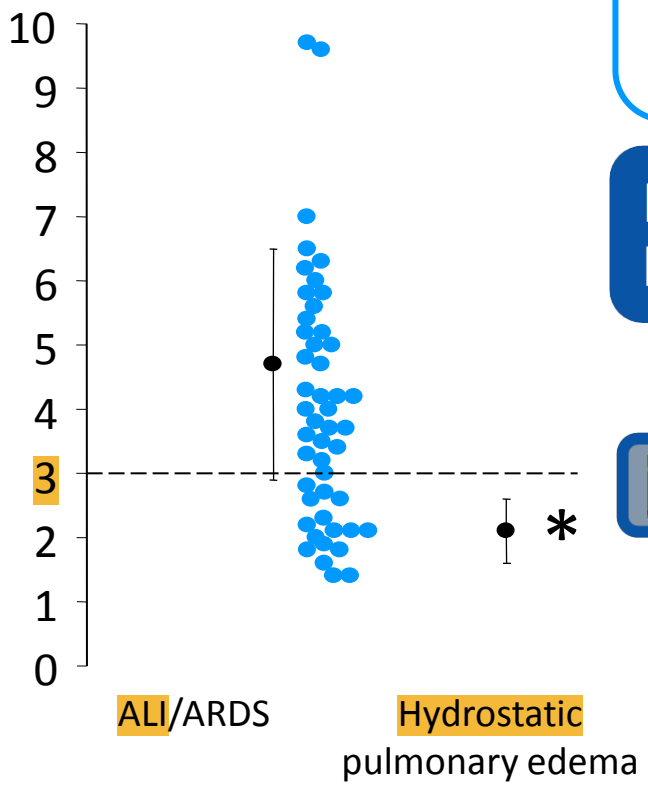

PVPI for diagnosing hydrostatic lung edema

Threshold = 3

Se = 85%
Sp = 100%

How to estimate the risk of fluid administration ?

Intensive Care Med 2007

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Nadia Anguel
David Osman
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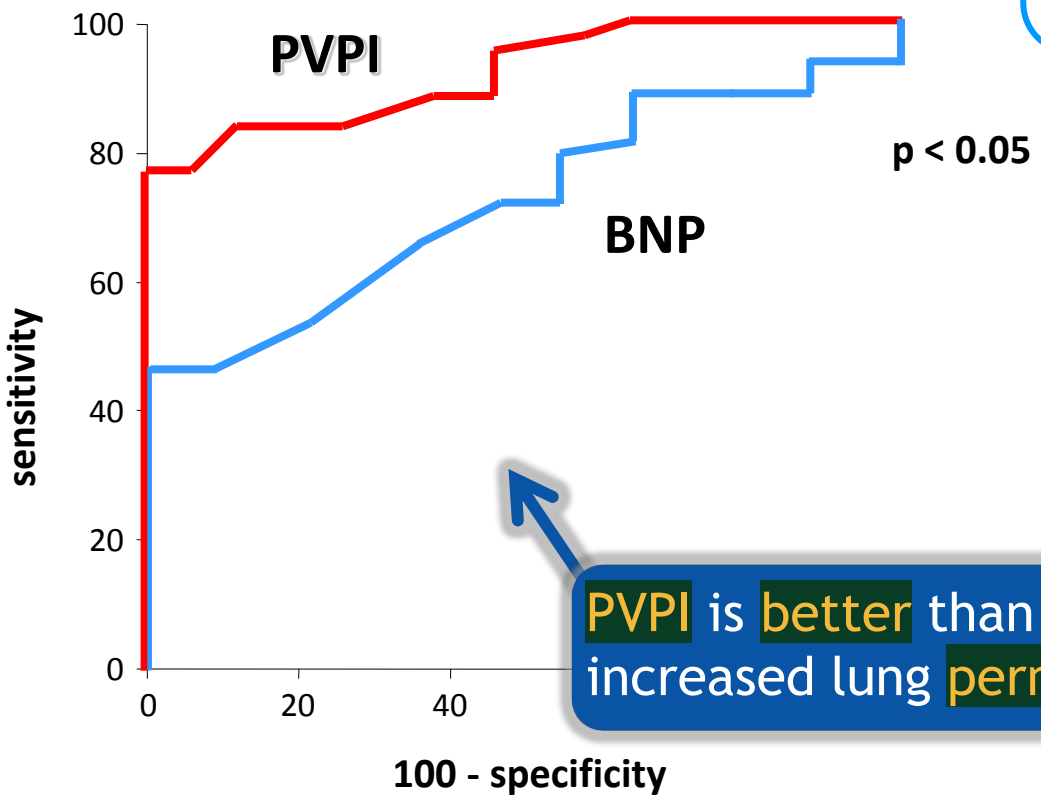


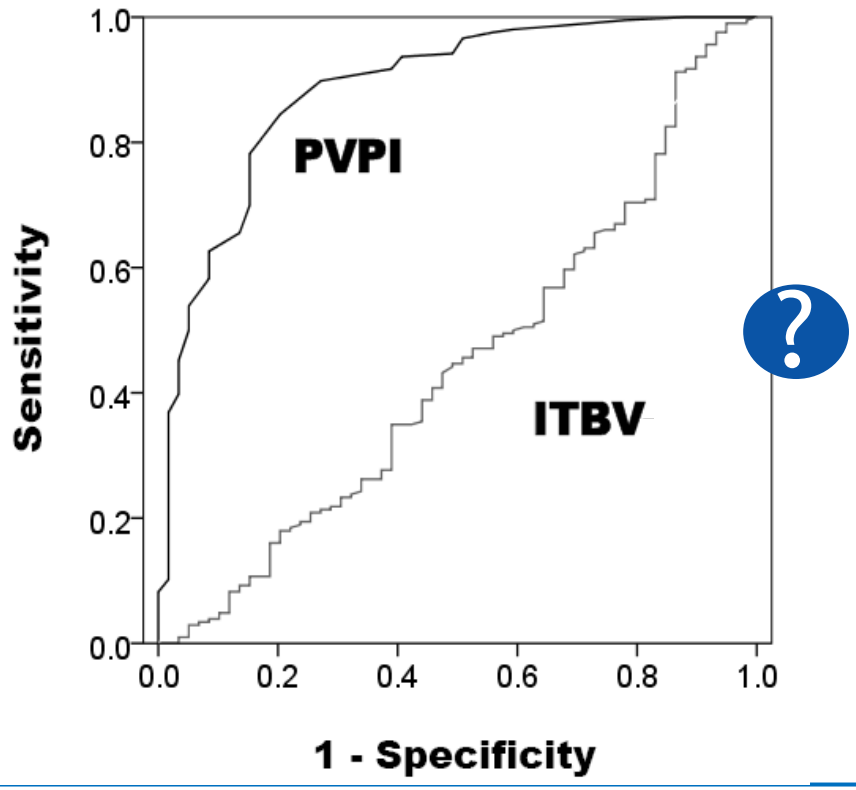
PVPI is better than BNP to detect increased lung permeability

How to estimate the risk of fluid administration ?

The clinical usefulness of extravascular lung water and pulmonary vascular permeability index to diagnose and characterize pulmonary edema: a prospective multicenter study on the quantitative differential diagnostic definition for acute lung injury/acute respiratory distress syndrome

Shigeki Kushimoto[1*], Yasuhiko Taira[2], Yasuhide Kitazawa[3], Kazuo Okuchi[4], Teruo Sakamoto[5], Hiroyasu Ishikura[6], Tomoyuki Endo[7], Satoshi Yamanouchi[1], Takashi Tagami[8,9], Junko Yamaguchi[10], Kazuhide Yoshikawa[11], Manabu Sugita[12], Yoichi Kase[13], Takashi Kanemura[14], Hiroyuki Takahashi[15], Yuichi Kuroki[16], Hiroo Izumino[17], Hiroshi Rinka[18], Ryutarou Seo[19], Makoto Takatori[20], Tadashi Kaneko[21], Toshiaki Nakamura[22], Takayuki Irahara[23], Nobuyuki Saito[24] and Akihiro Watanabe[8], for The PiCCO Pulmonary Edema Study Group

Critical Care 2012



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

How to use it in practice ?

How to estimate the risk of fluid administration ?

Patient #1

ARDS

AP = 90 / 40 mmHg

Cardiac index = 2.0 L/min/m²

PaO_2/FiO_2 = 180 mmHg

PLR test : positive

Lung water = 12 mL/kg
Permeability index = 4

Volume expansion

Patient #2

ARDS

AP = 90 / 40 mmHg

Cardiac index = 2.0 L/min/m²

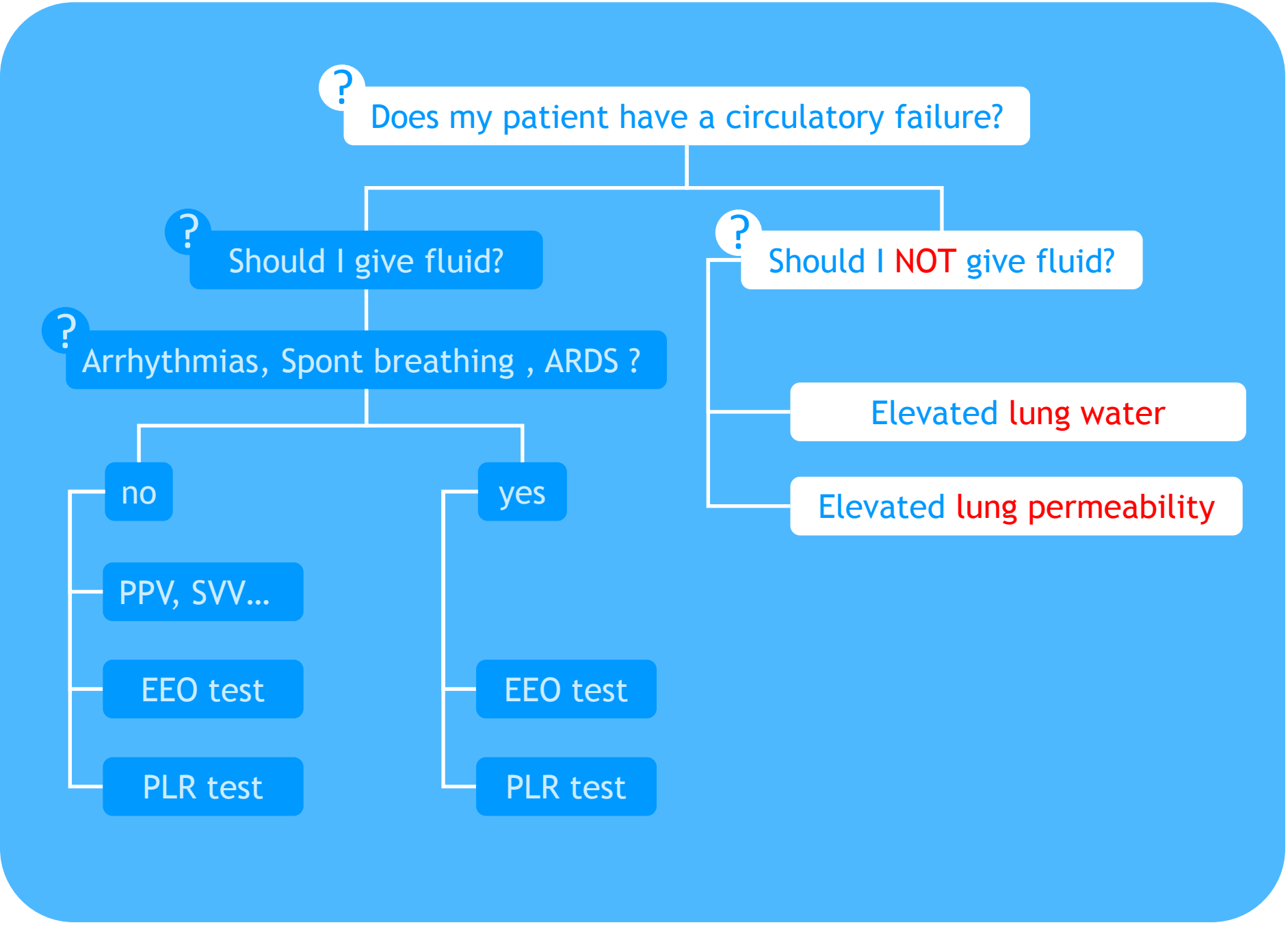
PaO_2/FiO_2 = 180 mmHg

PLR test : positive

Lung water = 20 mL/kg
Permeability index = 8

Volume expansion?

Vasopressor ?


Does my patient have a circulatory failure?
Should I give fluid?
Should I NOT give fluid?
Arrhythmias, Spont breathing , ARDS ?
Elevated lung water
Elevated lung permeability
no
yes
PPV, SVV…
EEO test
PLR test
EEO test
PLR test

The 4 messages

1. The only way to measure extravascular lung water at the bedside is transpulmonary thermodilution
2. Estimation of lung water by transpulmonary thermodilution is reliable and precise
3. Lung water may help to guide fluid management by indicating the severity of lung oedema
4. Lung permeability is a direct indicator of the risk of excessive fluid loading

Extravascular lung water and pulmonary permeability

Prof. Xavier MONNET

Medical Intensive Care Unit

Paris-Sud University Hospitals

xavier.monnet@aphp.fr