Remplissage vasculaire en Réanimation

Quoi de neuf en 2020 ?

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INTRODUCTION

Objectif du remplissage vasculaire ?

Quand faut-il administrer un remplissage vasculaire ?

Efficacité du remplissage vasculaire ?

Quand arrêter le remplissage vasculaire ?

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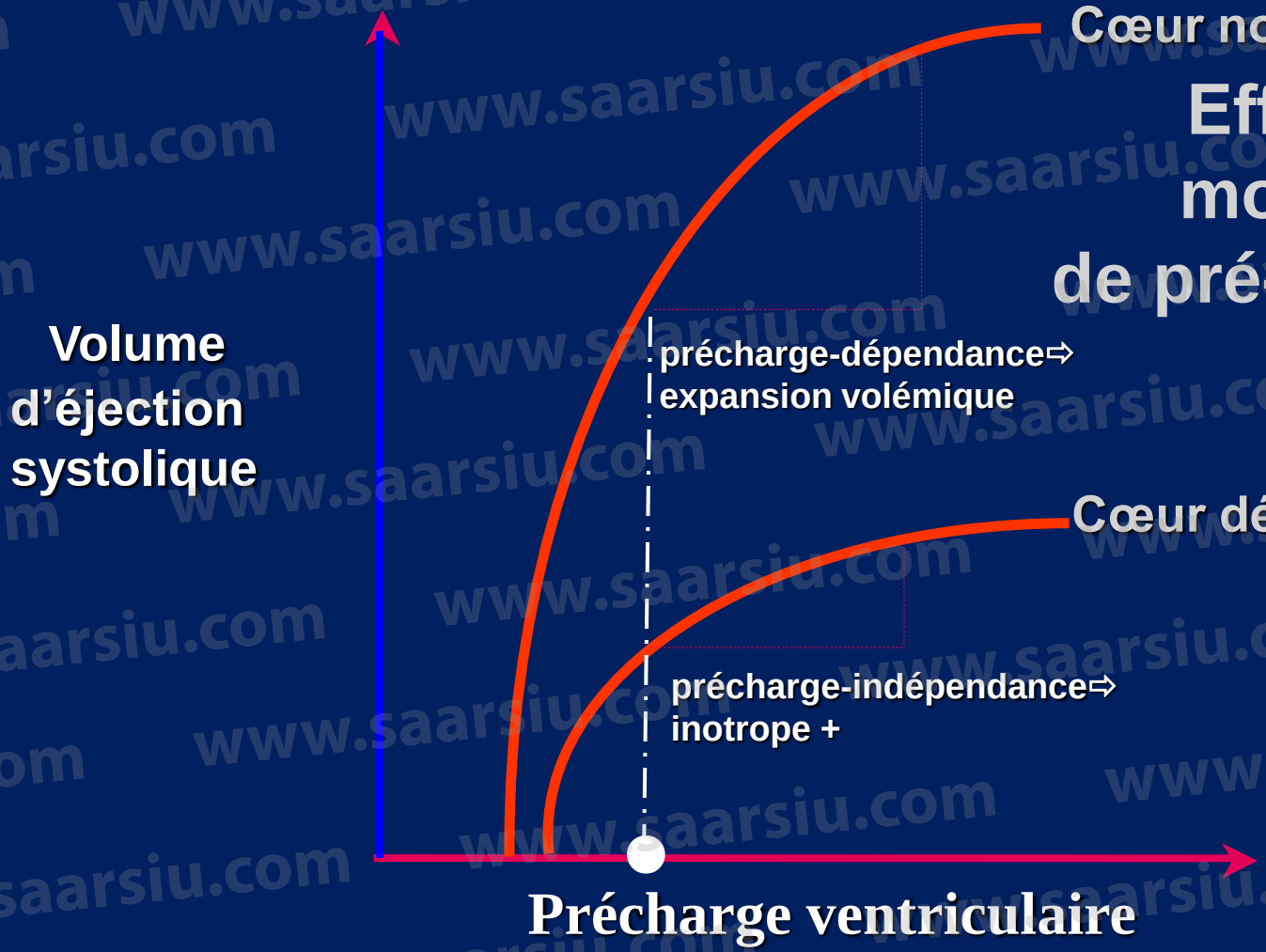
Exploration hémodynamique: la pré-charge

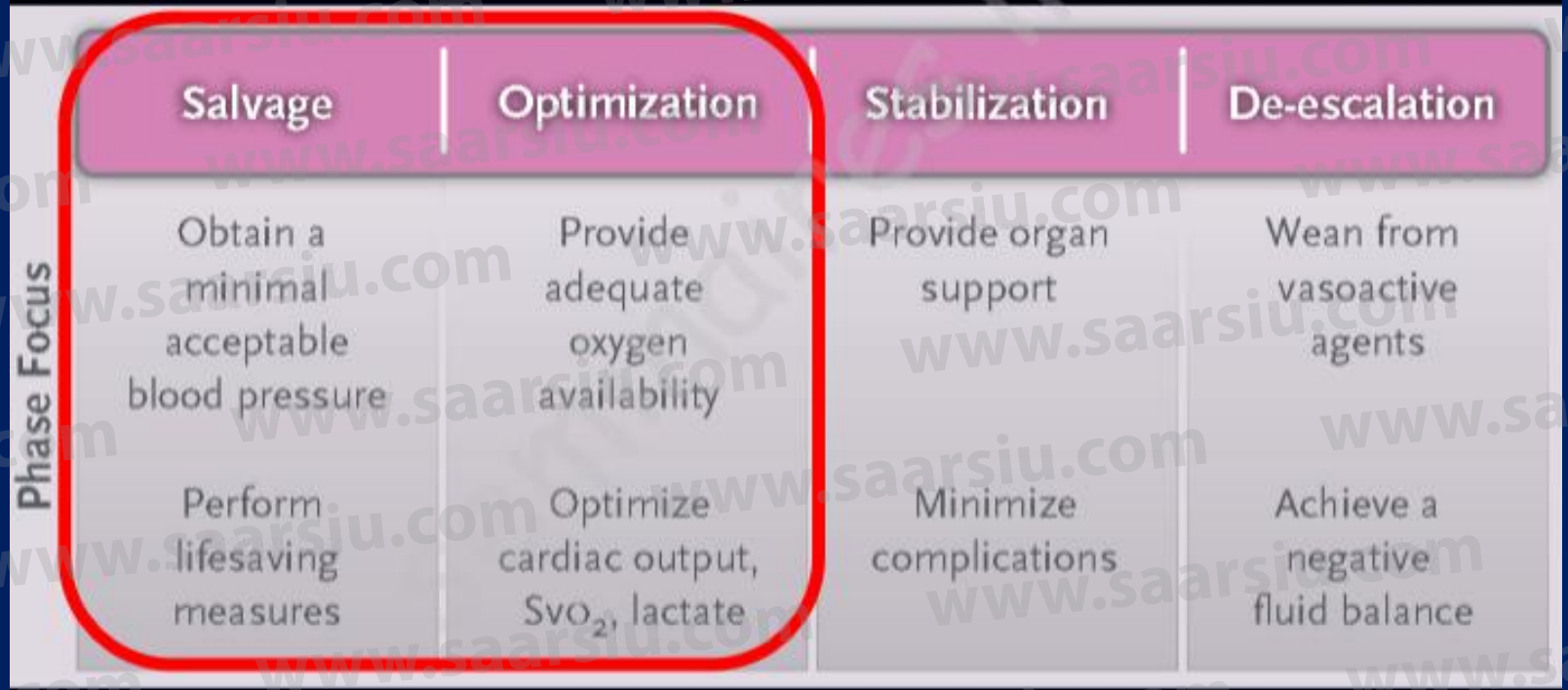


Courbe de fonction systolique de Frank-Starling

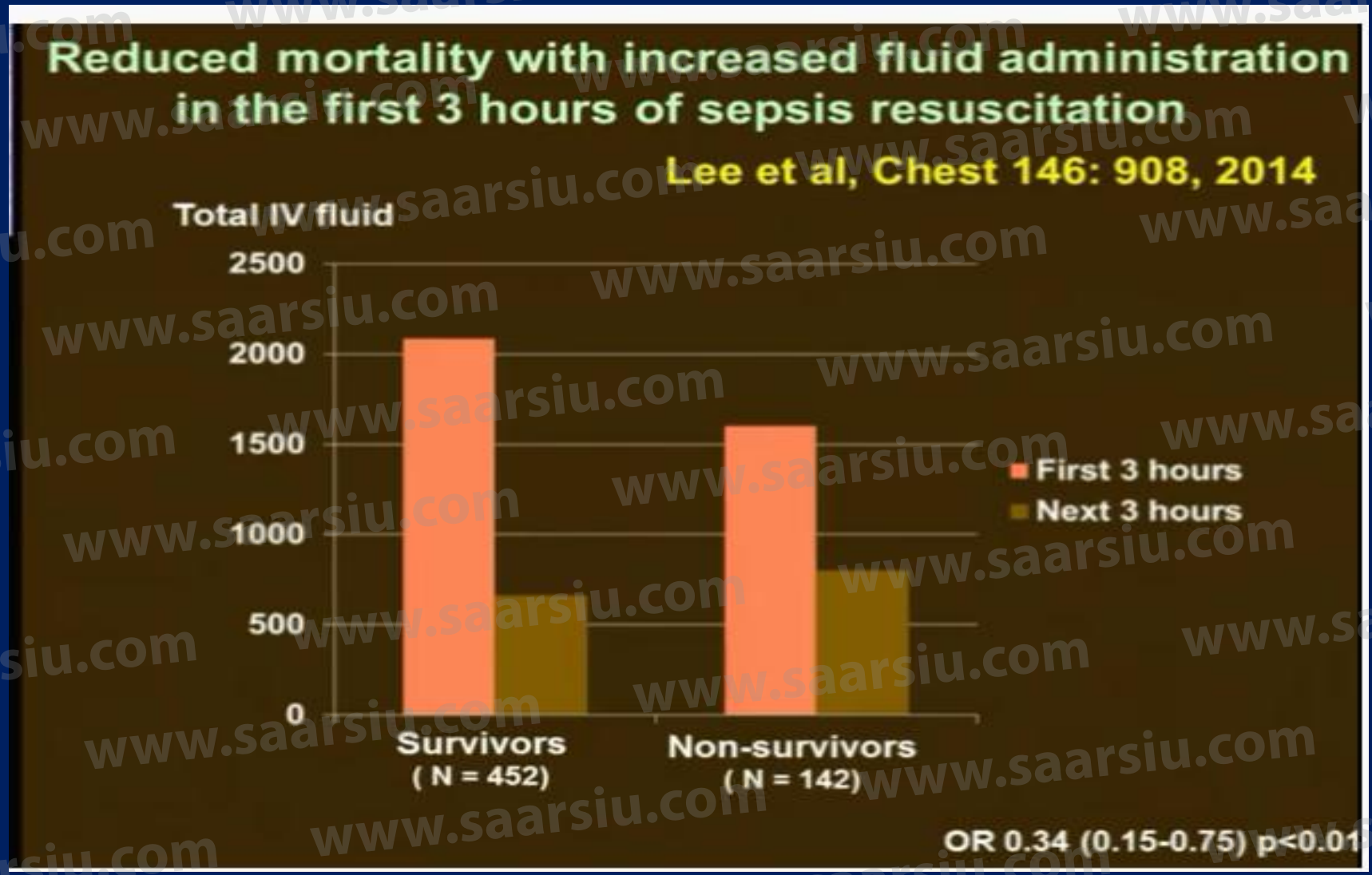
Our resuscitation strategies should be adapted to time

Early phase

Vincent JL and De Backer D
NEJM 369:1726; 2013



Later stages


Reduced mortality with increased fluid administration in the first 3 hours of sepsis resuscitation
Lee et al, Chest 146: 908, 2014
Total IV fluid
2500
2000
1500
1000
500
0
First 3 hours
Next 3 hours
Survivors
(N = 452)
Non-survivors
(N = 142)
OR 0.34 (0.15-0.75) p<0.01

Rhodes et al
ICM 2017
CCM 2017

A. INITIAL RESUSCITATION

1. Sepsis and septic shock are medical emergencies, and we recommend that treatment and resuscitation begin immediately (BPS).
2. We recommend that, in the resuscitation from sepsis-induced hypoperfusion, at least 30 mL/kg of IV crystalloid fluid be given within the first 3 h (strong recommendation, low quality of evidence).
3. We recommend that, following initial fluid resuscitation, additional fluids be guided by frequent reassessment of hemodynamic status (BPS).

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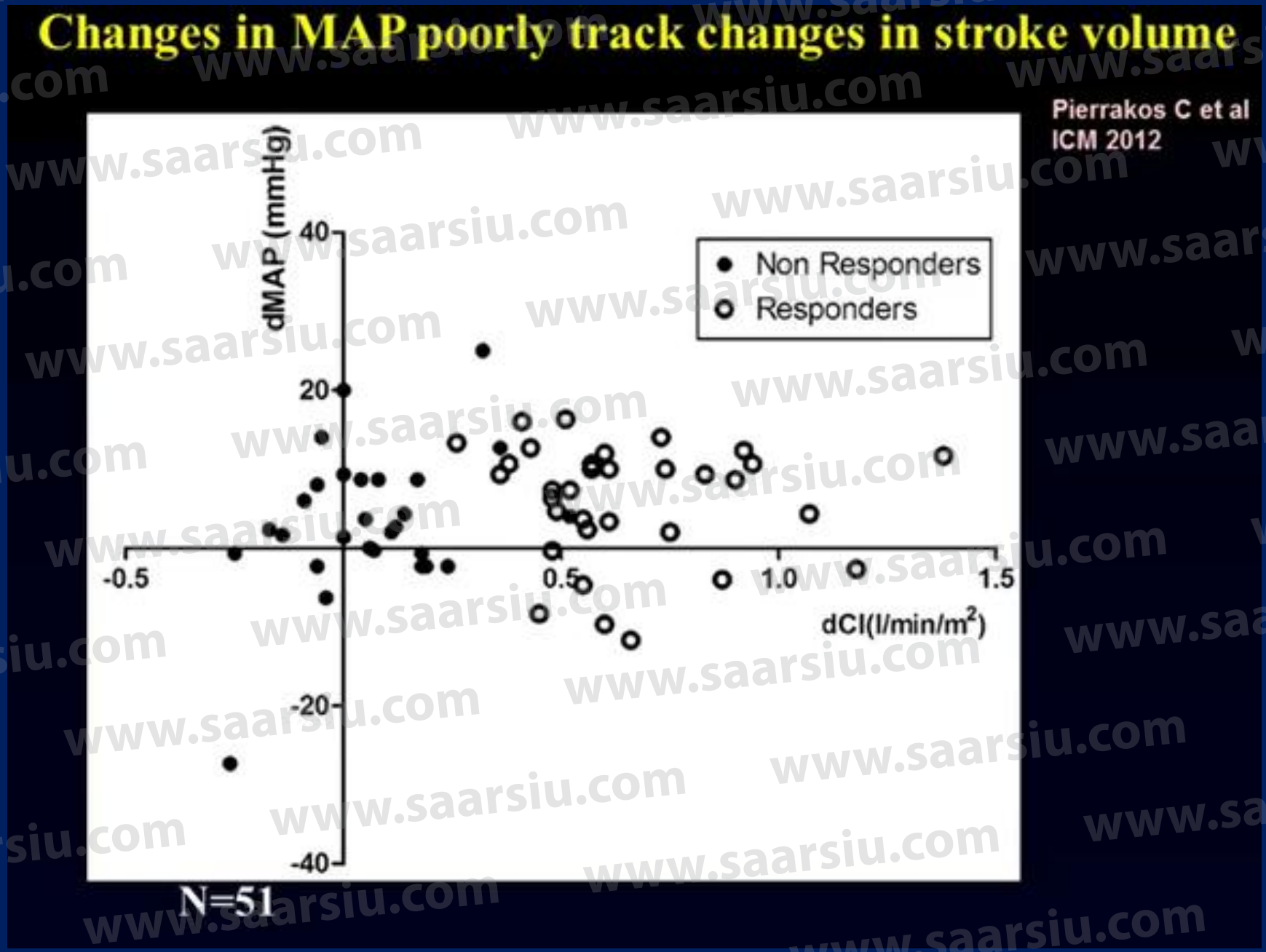
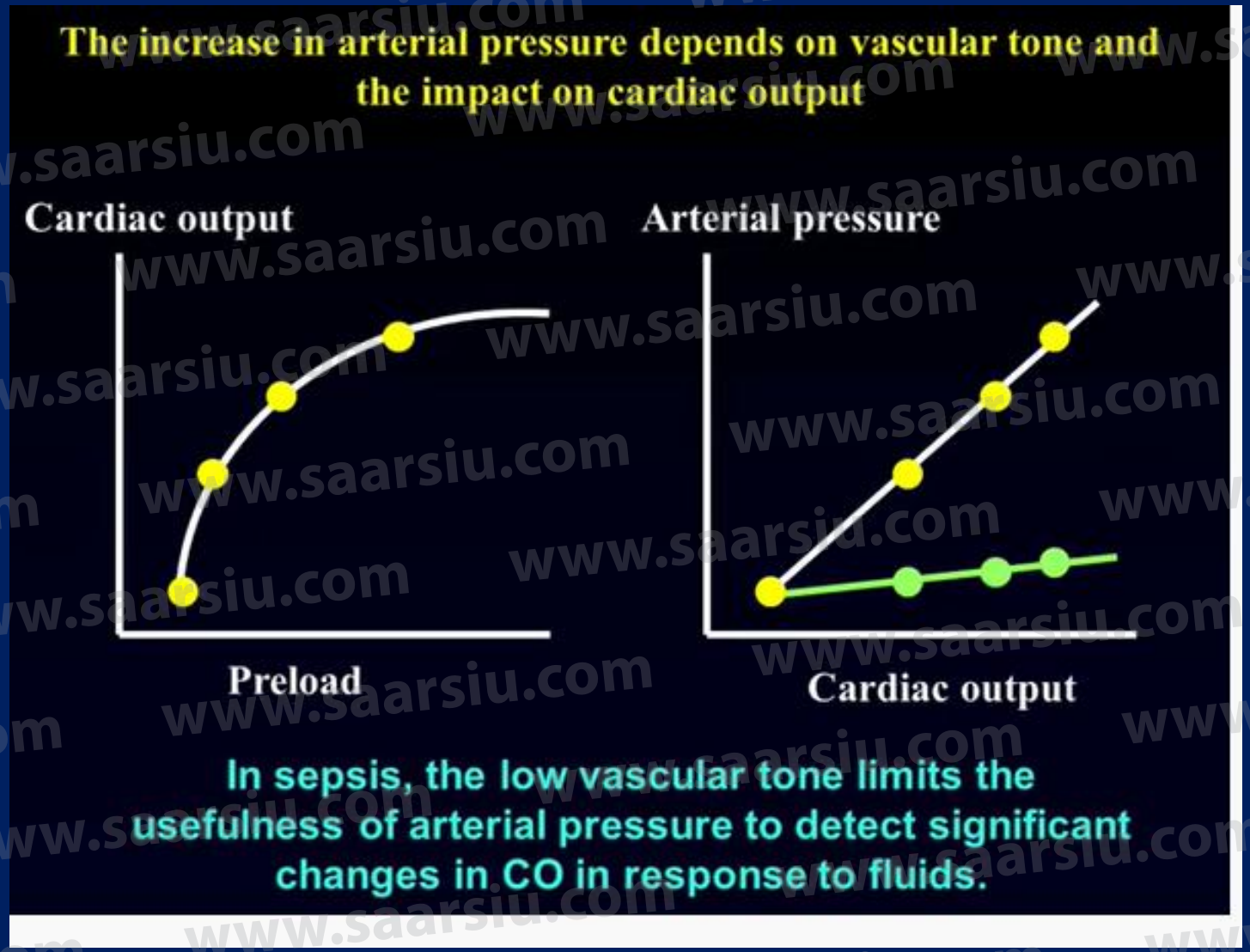
Changes in MAP poorly track changes in stroke volume

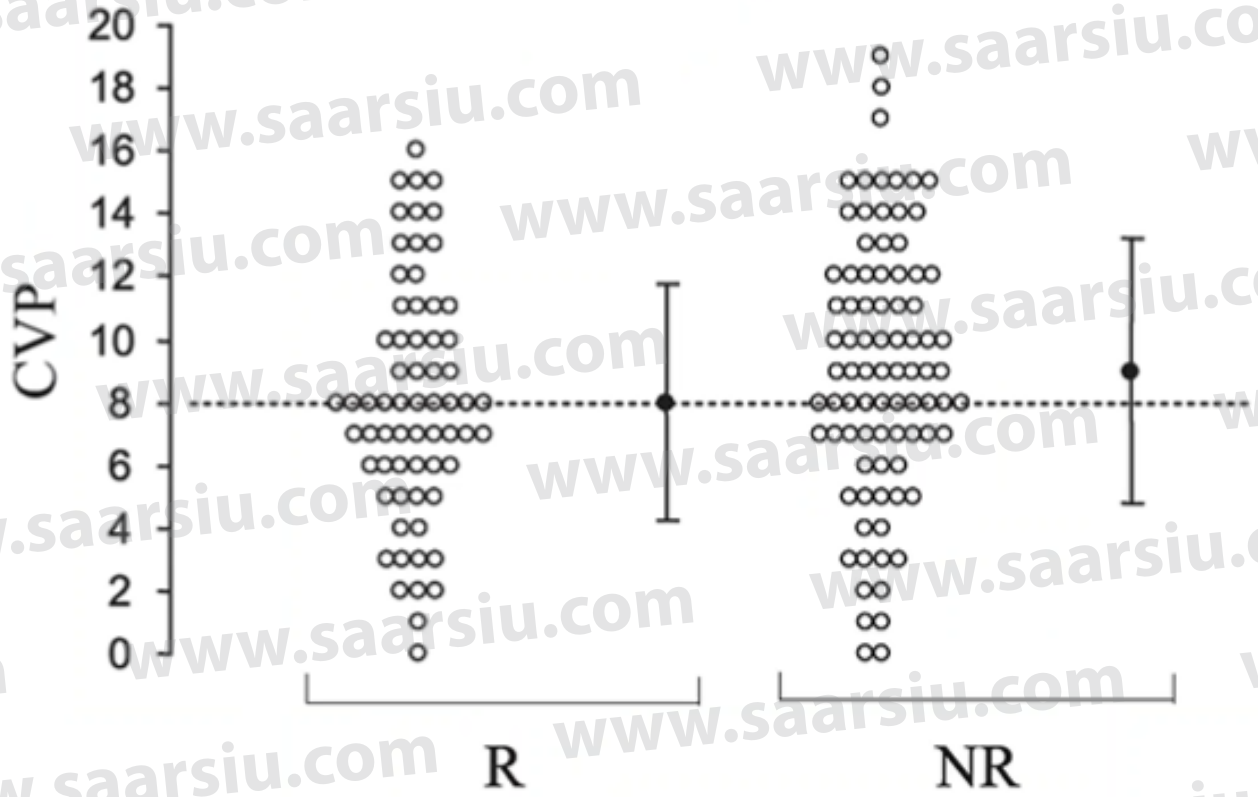



The increase in arterial pressure depends on vascular tone and the impact on cardiac output
Cardiac output
Preload
Arterial pressure
Cardiac output
In sepsis, the low vascular tone limits the usefulness of arterial pressure to detect significant changes in CO in response to fluids.

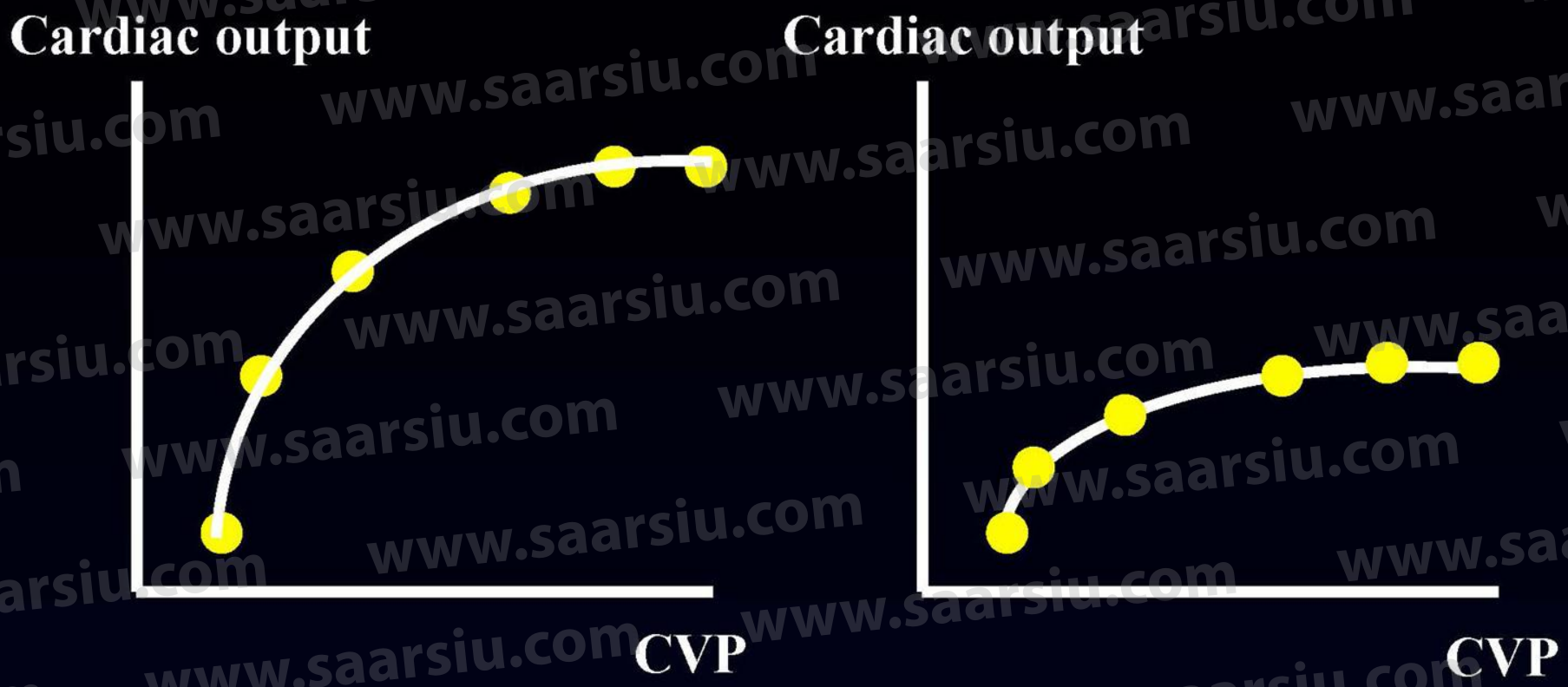
SHOULD WE GUIDE FLUID ADMINISTRATION ON CVP ?

Cardiac filling pressures are not appropriate to predict hemodynamic response to volume challenge*

David Osman, MD; Christophe Ridel, MD; Patrick Ray, MD; Xavier Monnet, MD, PhD; Nadia Anguel, MD; Christian Richard, MD; Jean-Louis Teboul, MD, PhD



The increase in CVP does not imply that cardiac output increased, it only reflects that preload effectively increased



The increase in CVP is the price to pay, not a goal in itself !

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Précharge

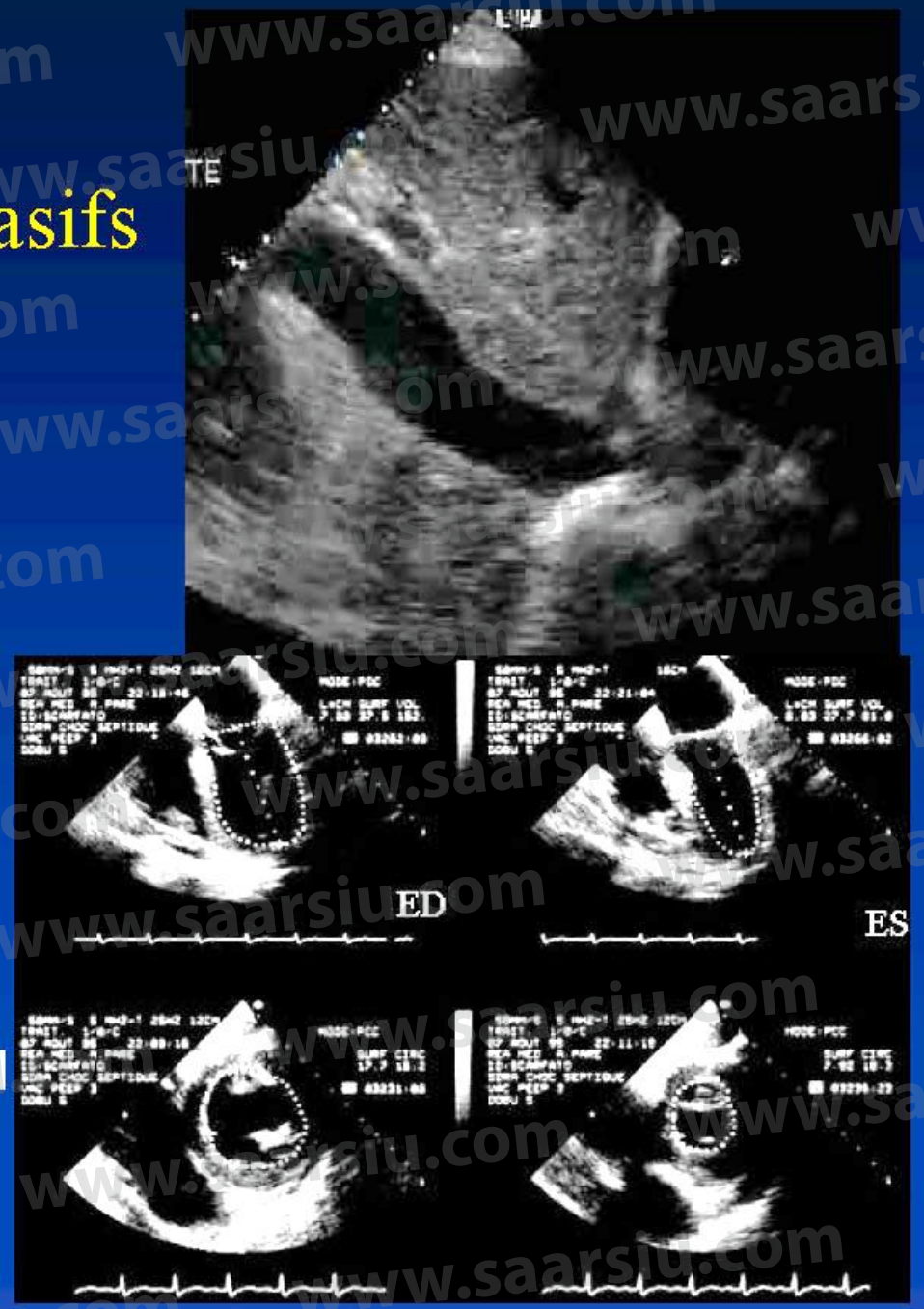
critères statiques non invasifs

Echocardiographie

Hypovolémie

- Diamètre Veine cave
- Surface Ventricule Gauche < 5 cm2/m2 très spécifique

- Mauvais indicateurs prédictifs de réponse au remplissage vasculaire



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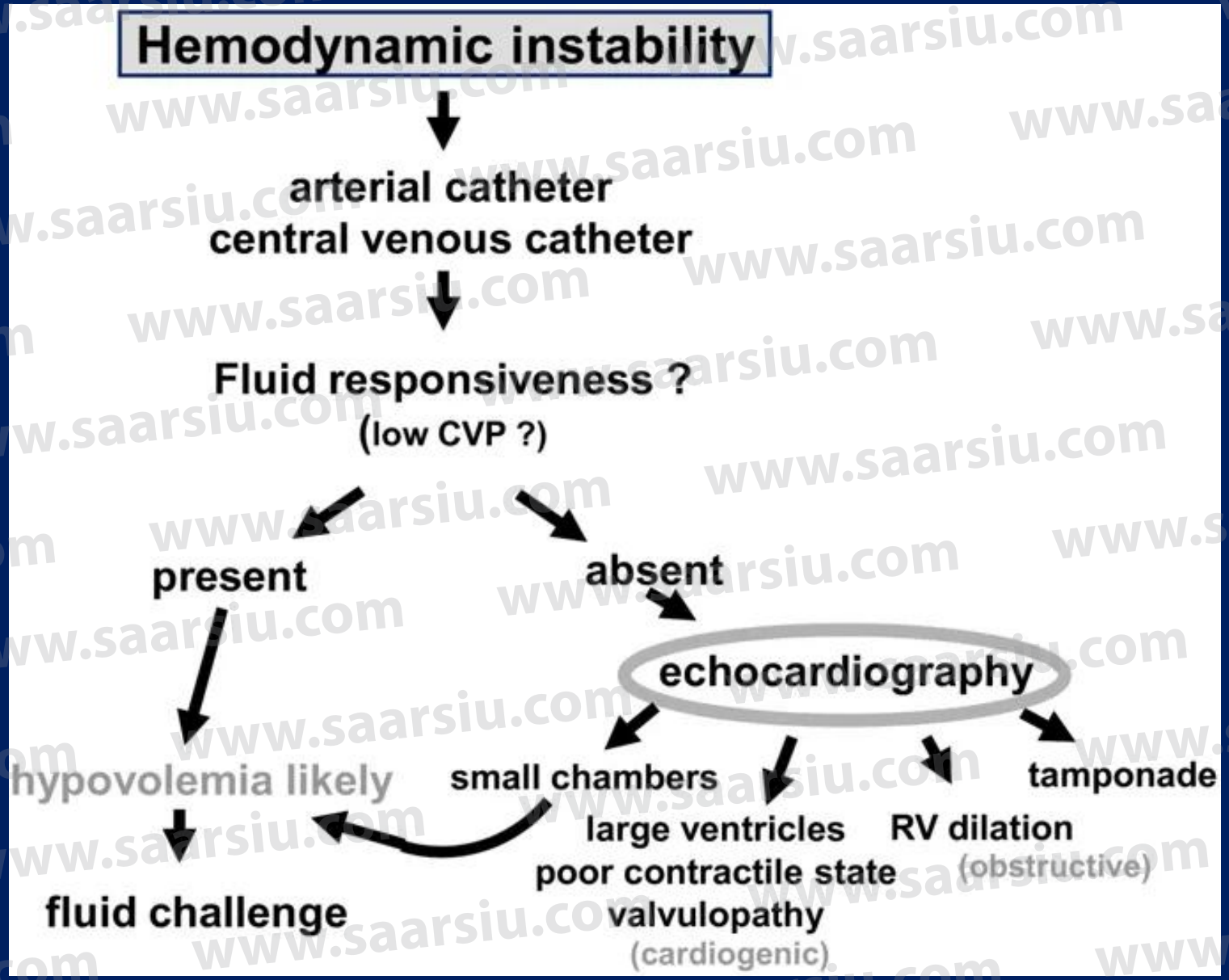

JL Vincent et al. Diagnostic algorithm based on use of echocardiography

Exploration hémodynamique

Les indices dynamiques

La VM induit des variations cycliques du volume d'éjection seulement chez patients « précharge-dépendant »

La réponse au remplissage doit être corrélée avec l'amplitude des variations cycliques du volume d'éjection sous VM

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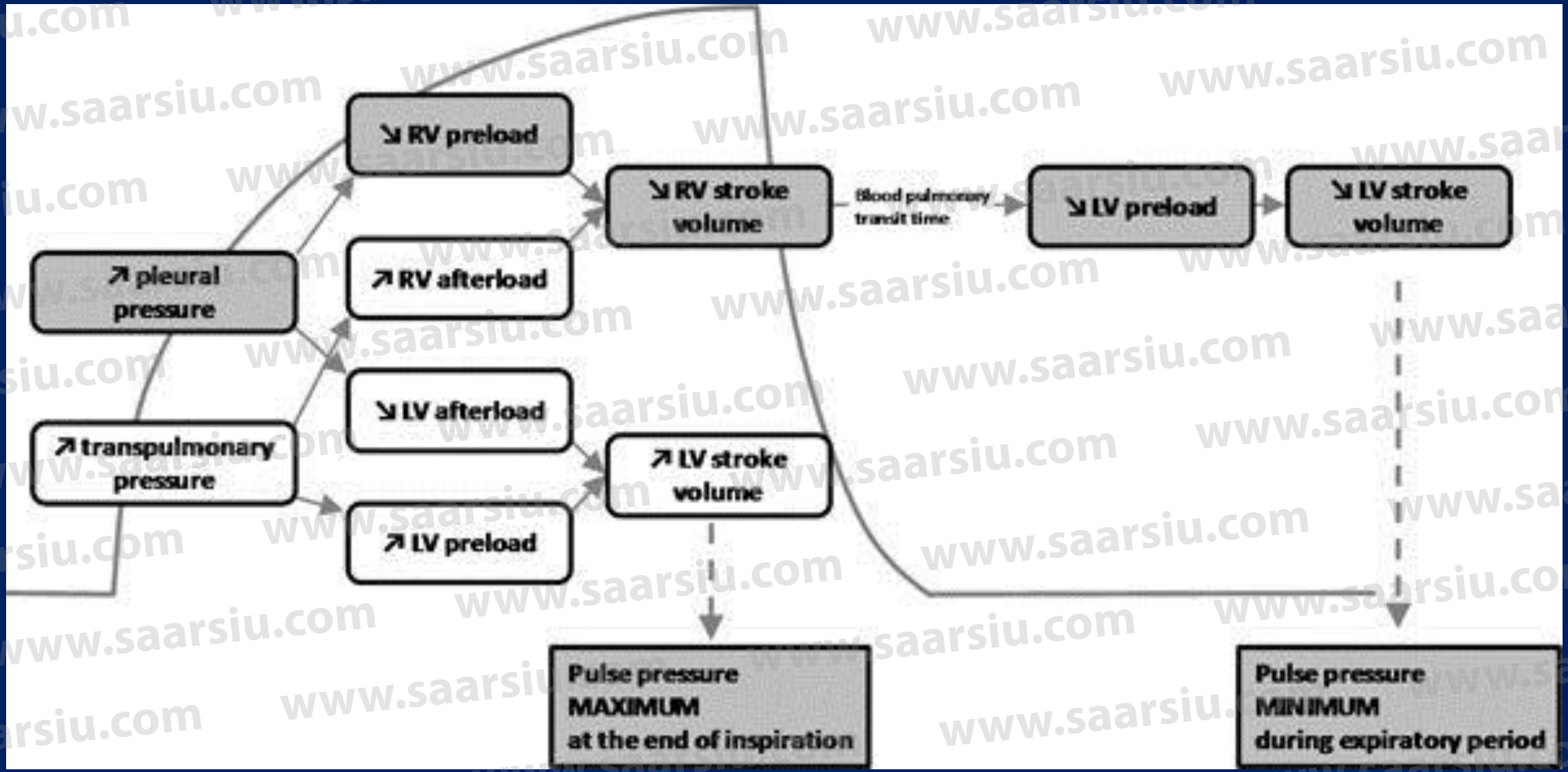


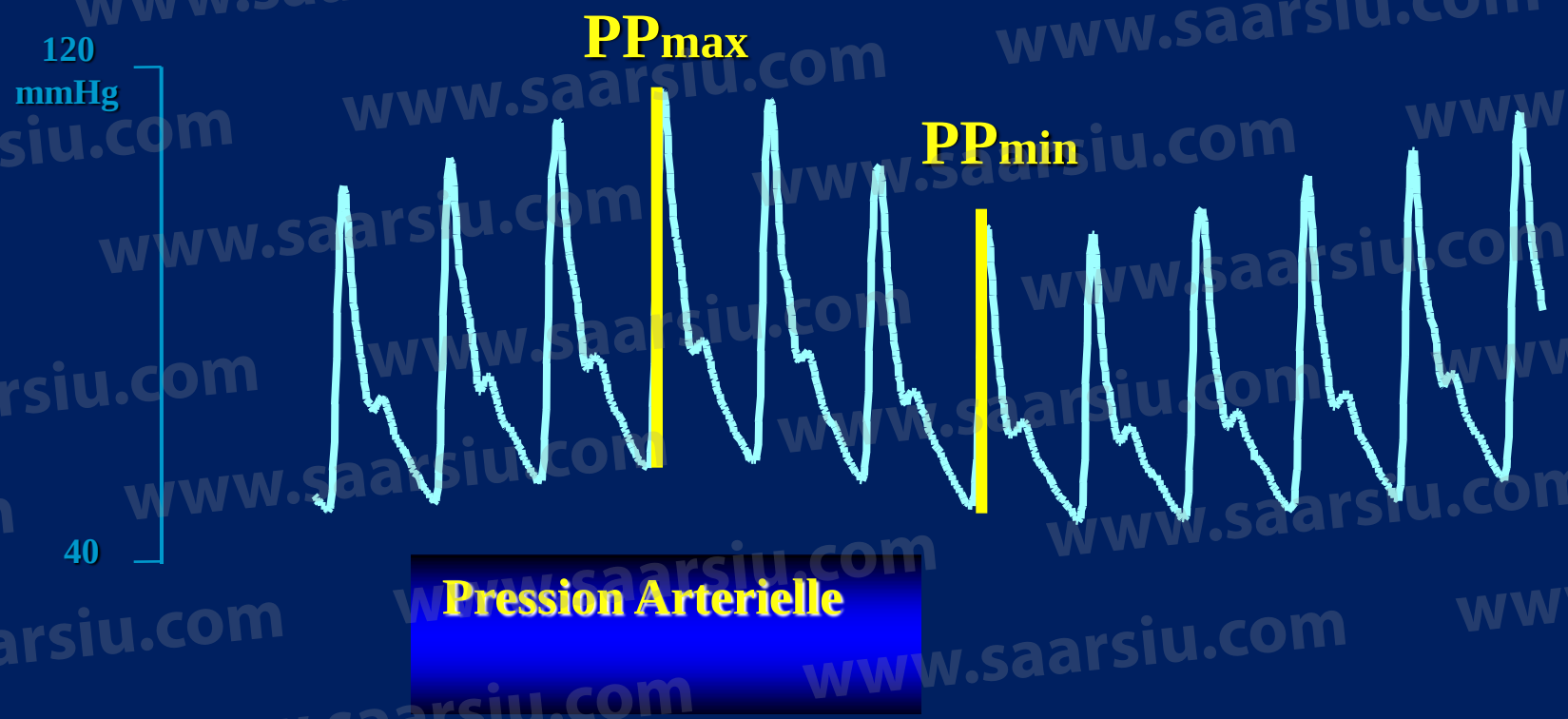
Heart-lung interactions. Hemodynamic effects of mechanical ventilation. The cyclic changes in left ventricular (LV) stroke volume are mainly related to the expiratory decrease in LV preload due to the inspiratory decrease in right ventricular (RV) filling

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

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

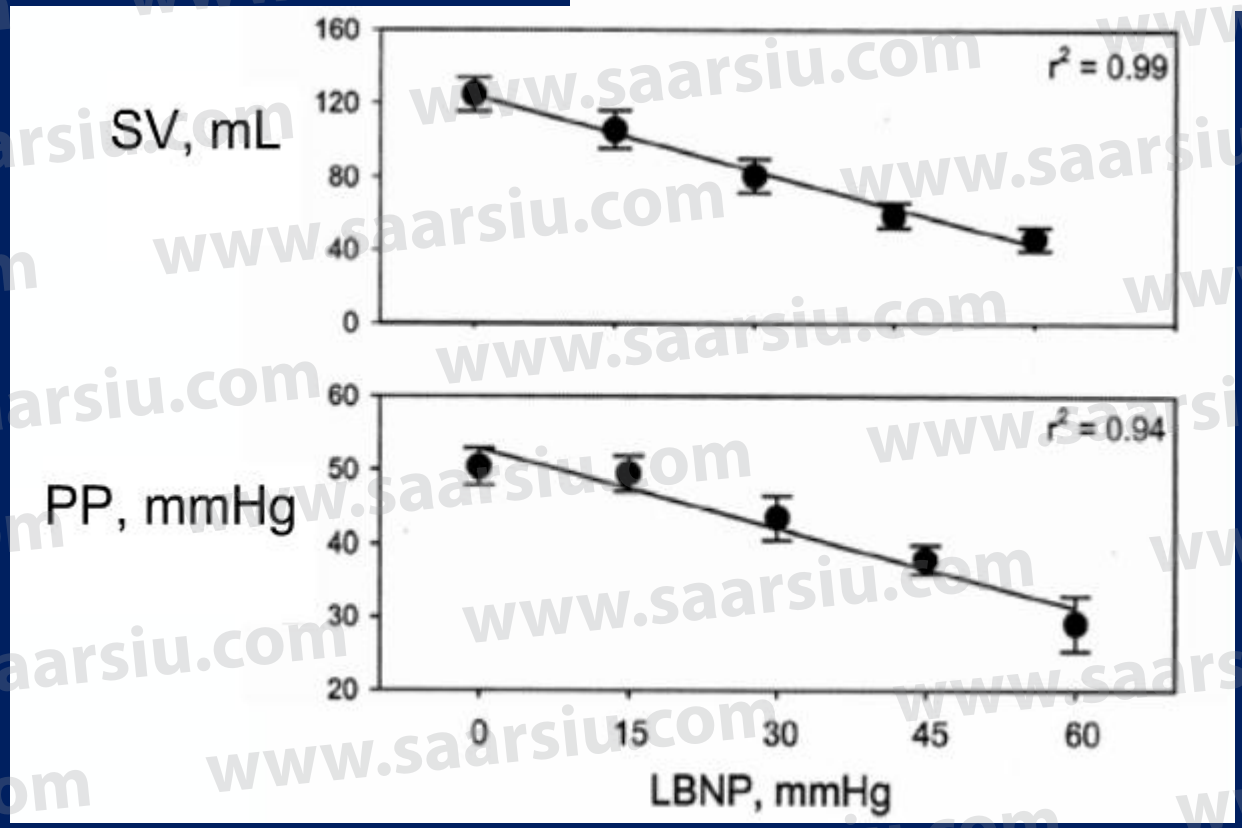


Exploration hémodynamique: la pression artérielle invasive pulsée

Arterial Pulse Pressure and Its Association With Reduced Stroke Volume During Progressive Central Hypovolemia

Victor A. Convertino, PhD, William H. Cooke, PhD, and John B. Holcomb, MD

J trauma 2006:61; 629-634



La PP varie parallèlement au VES

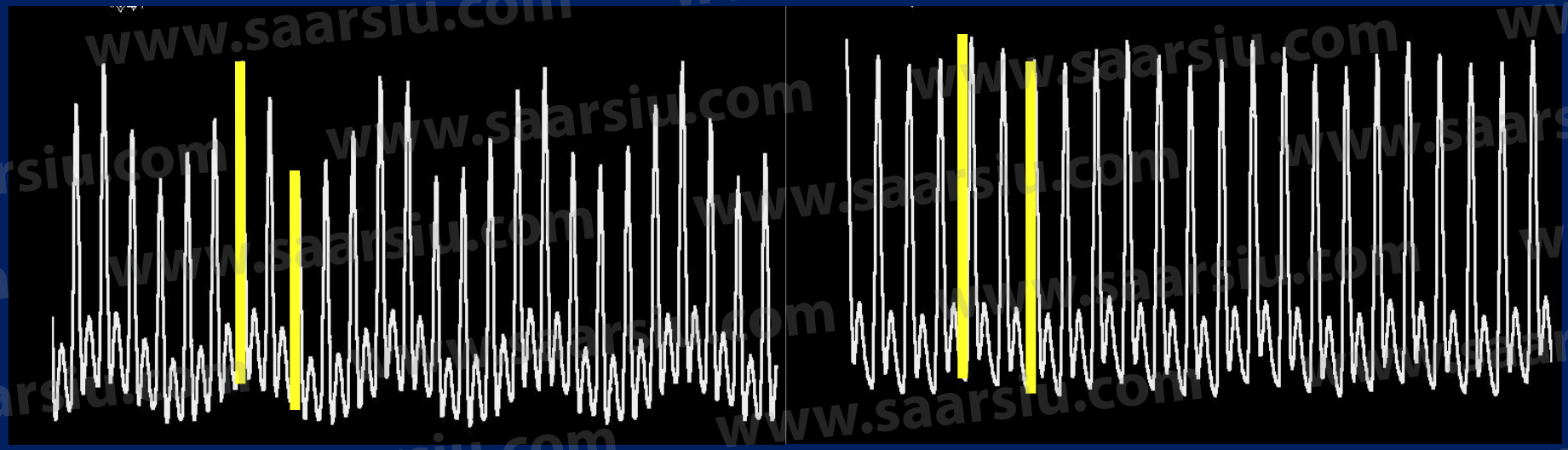
Responder patient

ΔPP = 32 %

Before fluid loading

ΔPP = 5 %

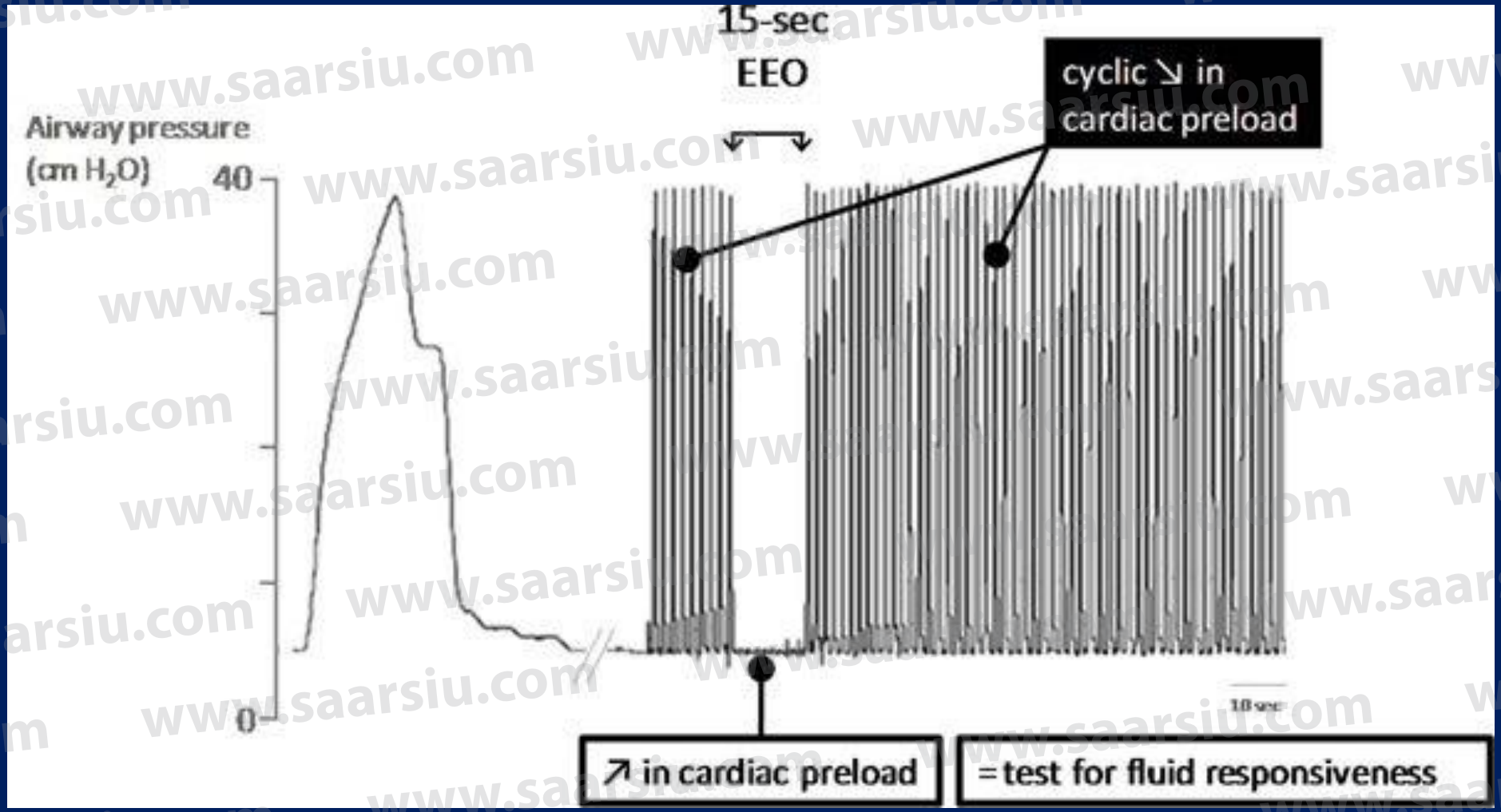
After fluid loading

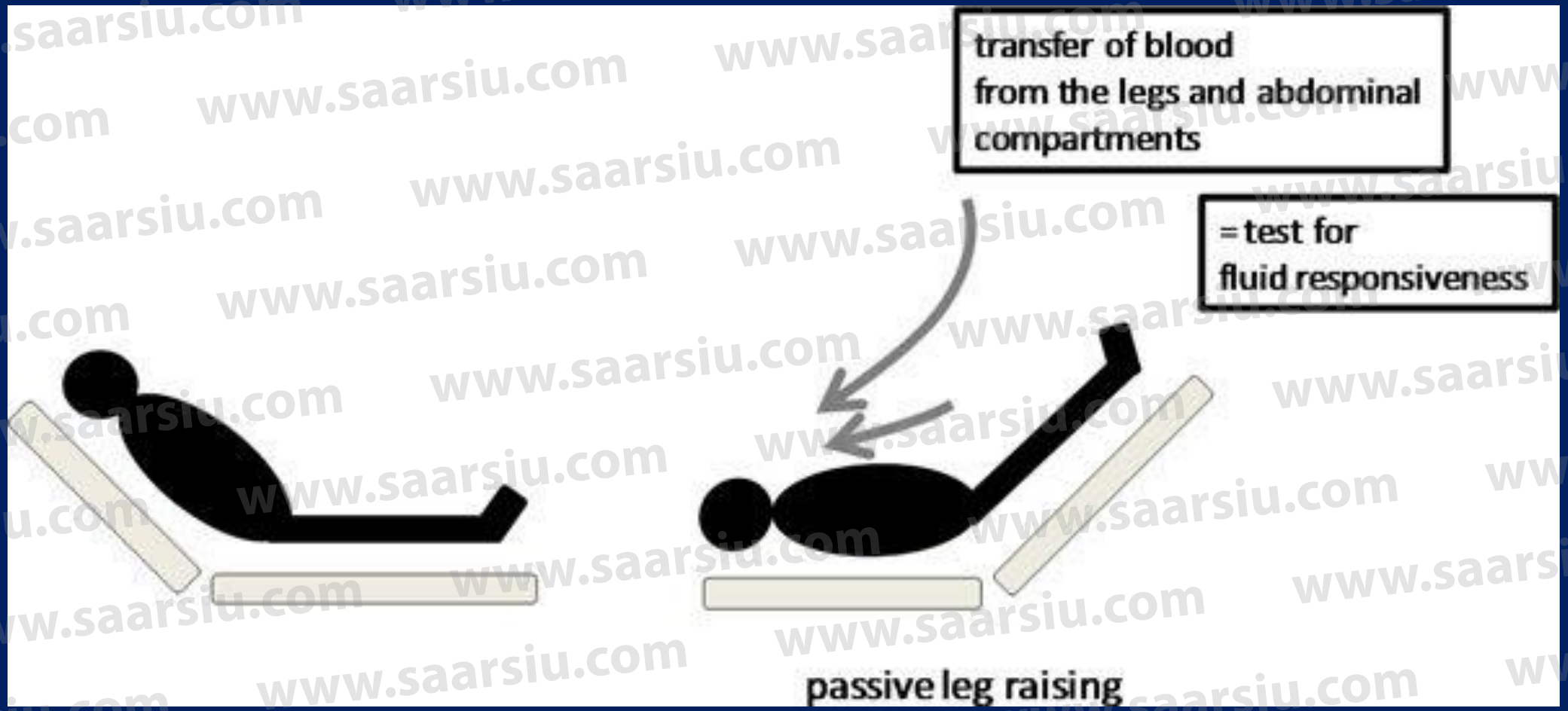


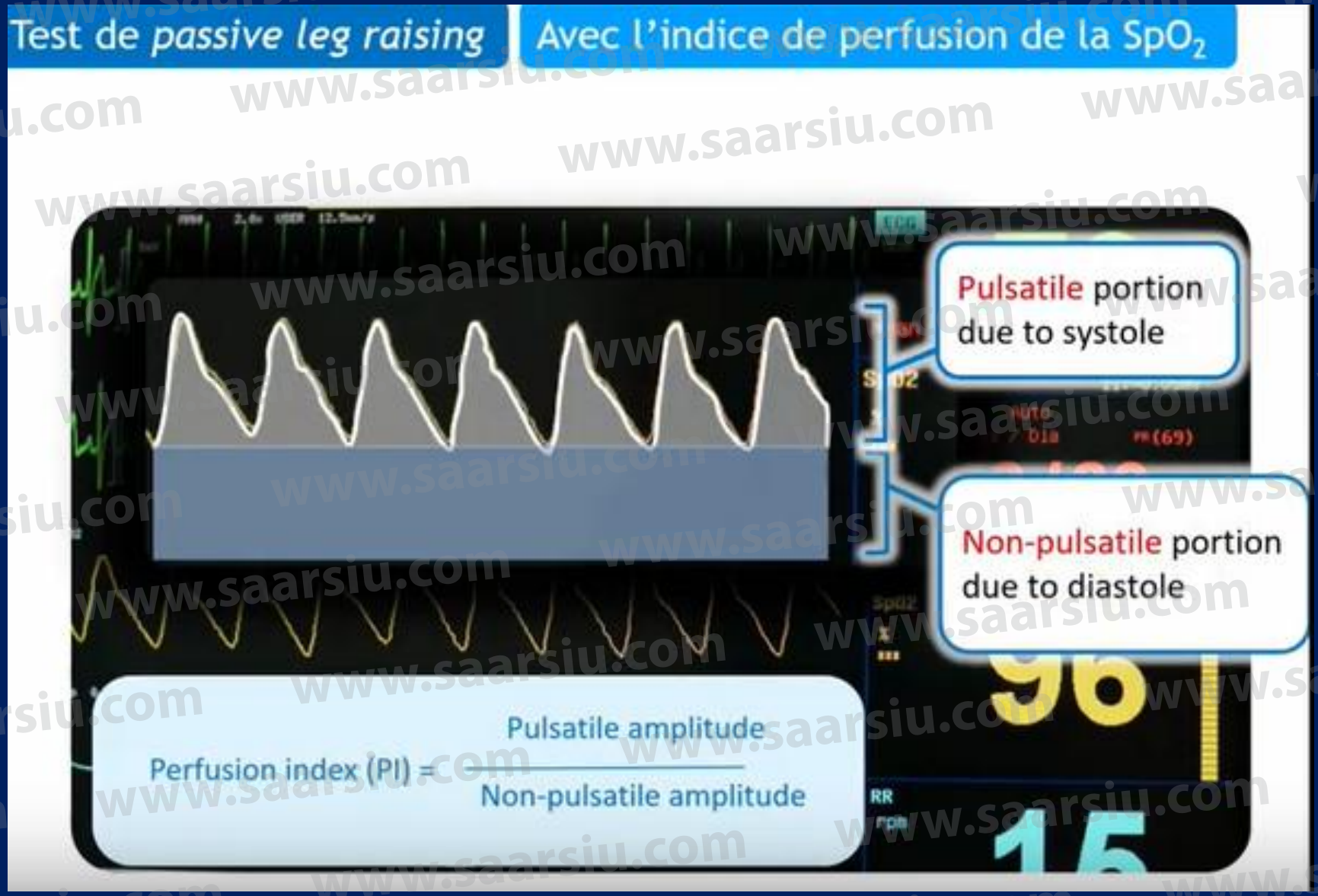
L' amplitude de la variabilité respiratoire de la PA permet de préjuger directement de l' importance de la réponse au remplissage vasculaire

∀ΔPP est le plus performant, et ne nécessite pas d' intervention sur le respirateur

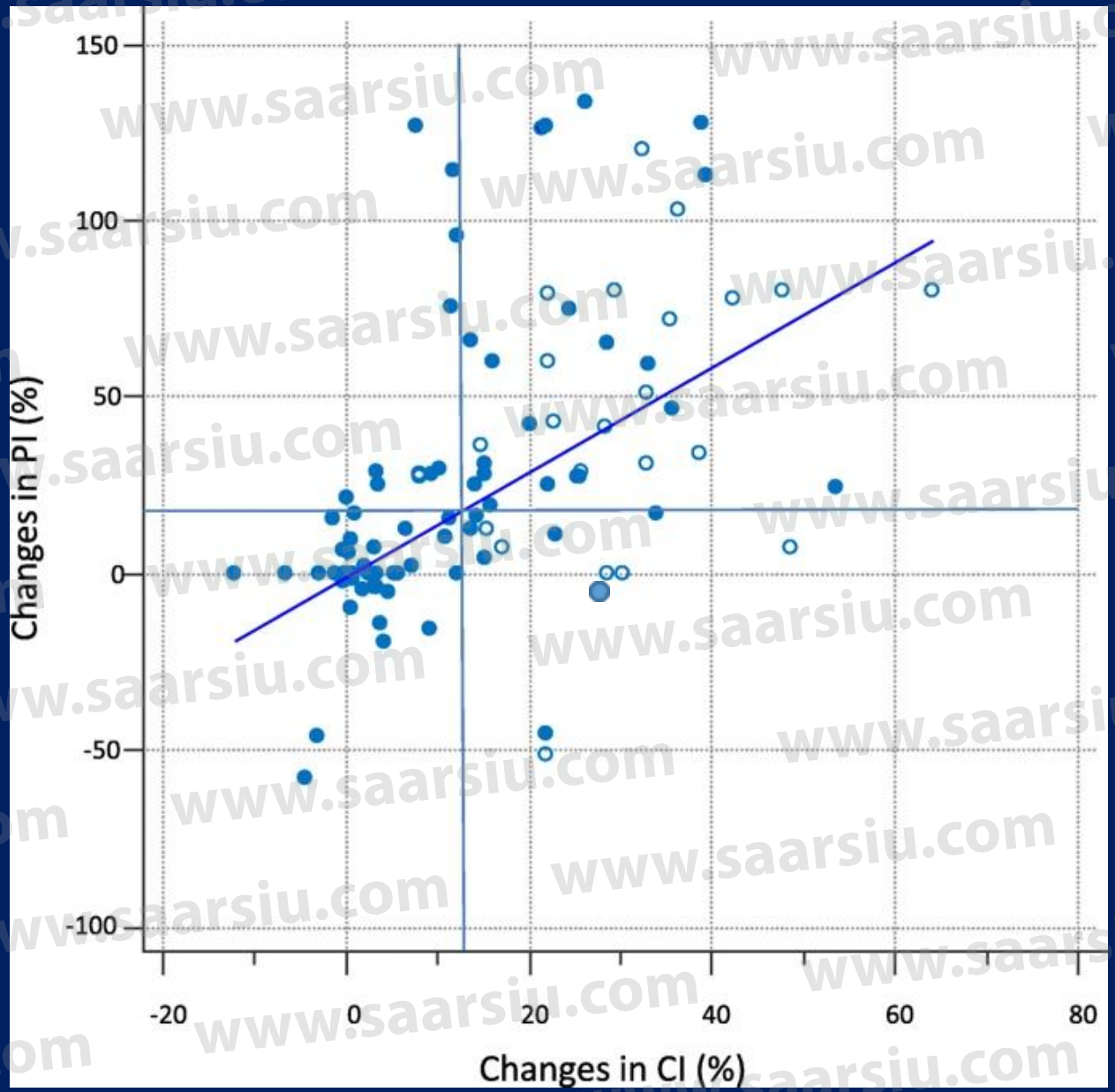
- Valeur seuil =13% pour une sens et spé optimales de prédiction de réponse au RV


15-sec
EEO
cyclic ↘ in
cardiac preload
Airway pressure
(cm H_2O)
40
0
10 sec
↗ in cardiac preload
= test for fluid responsiveness


transfer of blood
from the legs and abdominal
compartments
= test for
fluid responsiveness
passive leg raising



A. Beurton. The effects of passive leg raising may be detected by the plethysmographic oxygen saturation signal in critically ill patients . Crit Care 2019



Correlation between perfusion index (PI) changes and cardiac index (CI) changes during passive leg raising and volume expansion

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FLUID CHALLENGE

- Teste la capacité du système circulatoire à augmenter le débit cardiaque après un remplissage vasculaire à minima.
- 200-250ml de cristalloïdes en 5 à 10 minutes
- Monitorage de la variation du volume d’ éjection systolique après FC
- Non si hypovolémie évidente à la phase aigue d’ un état de choc

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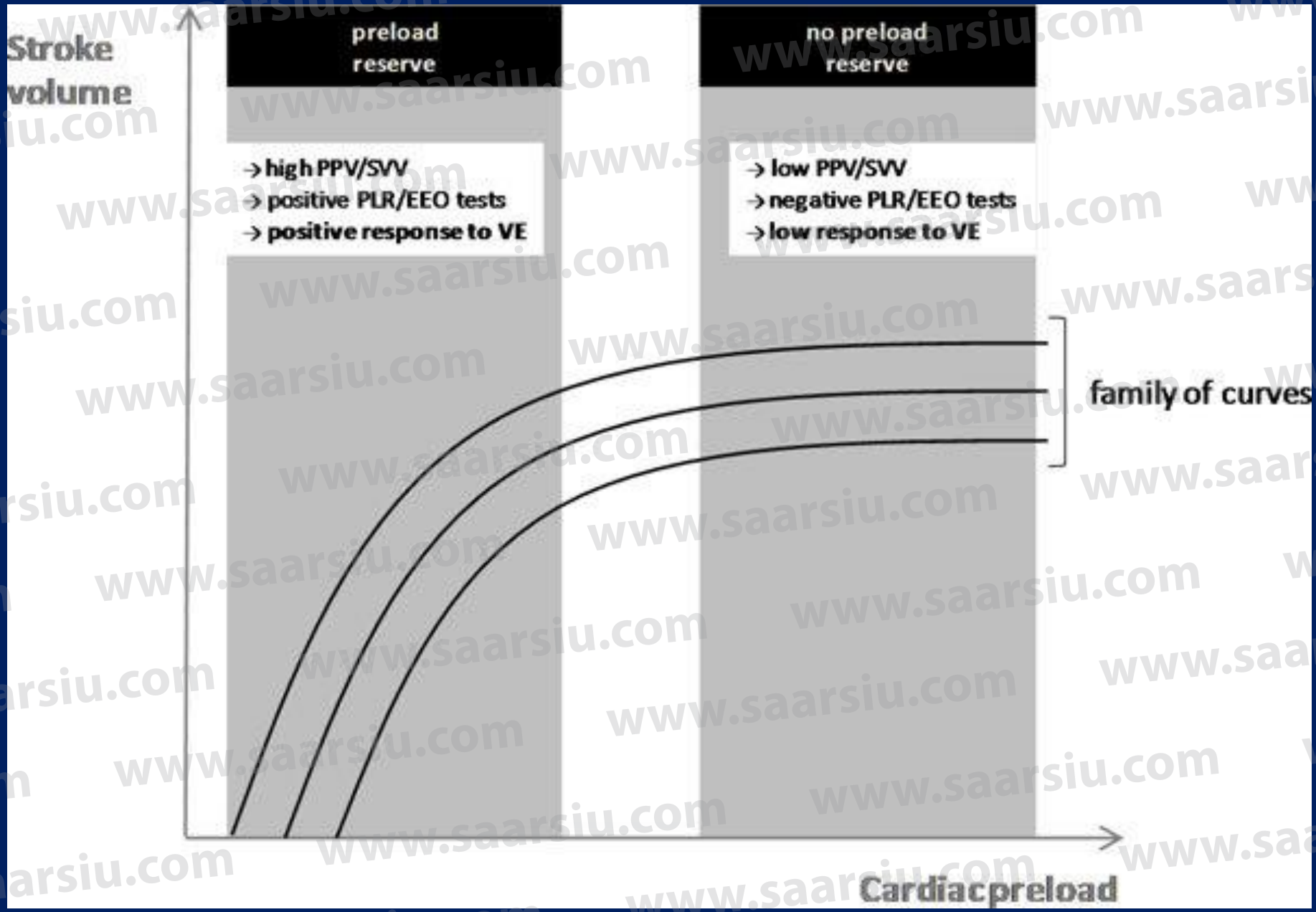

FRANK STARLING CURVE

Use of PEEP to detect fluid responsiveness during operative period in patients undergoing digestive surgery

M. Benlabed (1) MD PhD , S. Nedjari (2) MD, R. Gaudy(1) MD , A. Ladjouze (2) MD S. Aissaoui (2) MD, F. Ouanes MD (2).

(1) Anesthesiology and Intensive care, Lille University, Lille, France

(2) Algiers University Hospital, Algiers , Algeria

Hemodynamic Parameters to Guide Fluid Therapy

Method	Technology	Area under the curve (95% CI)
Pulse pressure variation	Arterial wave form	0.94 (0.93-0.95)
Systolic pressure variation	Arterial wave form	0.86 (0.82-0.90)
Stroke volume variation	Pulse contour analysis	0.88 (0.78-0.88)
LV end-diastolic area	Echocardiography	0.64 (0.53-0.74)
Global end-diastolic volume	Transpulmonary hemodilution	0.56 (0.37-0.67)
Central venous pressure	Central venous catheter	0.55 (0.18-0.62)

From Marik PE et al. Crit Care Med 37:2642-7, 2009.

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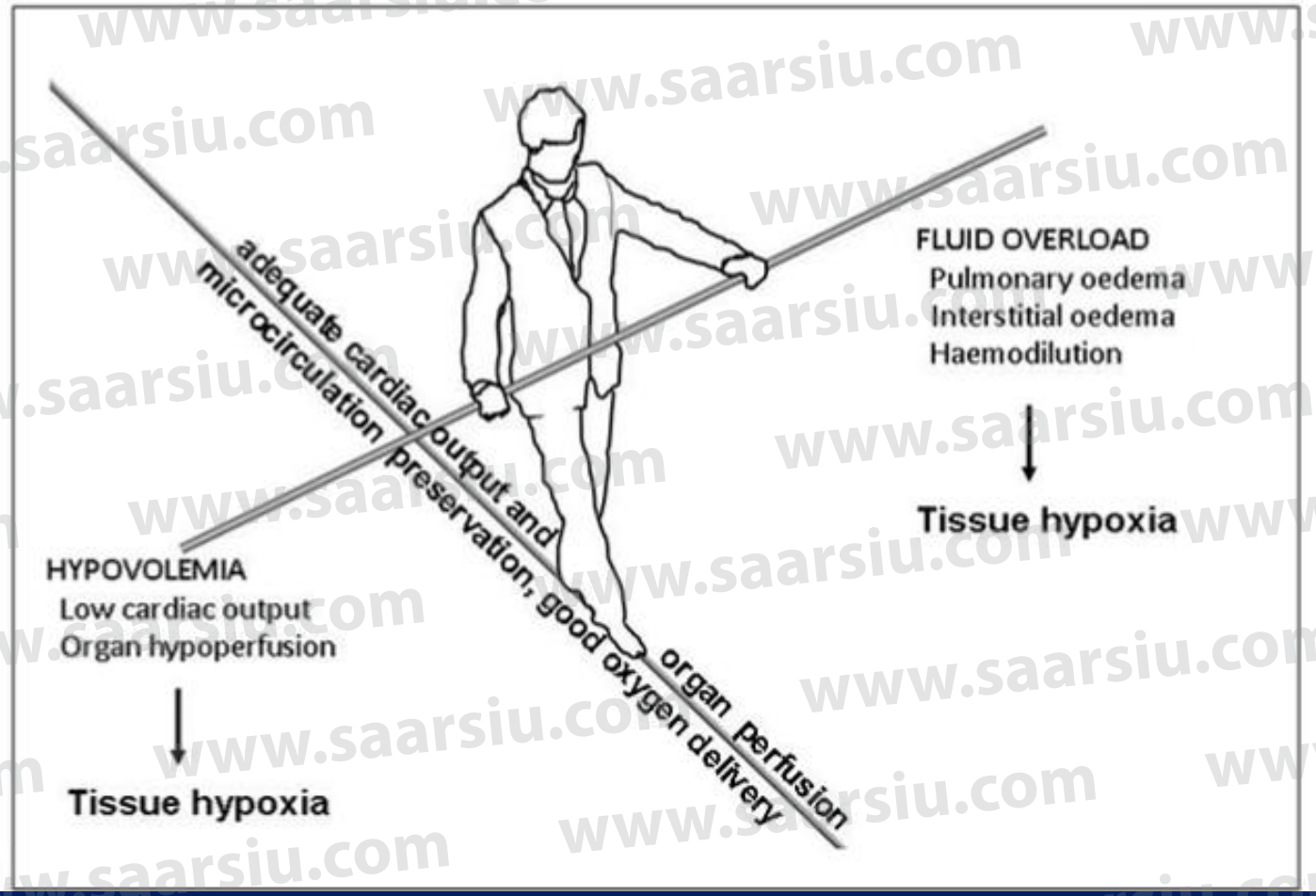
CHALLENGE

Thierry Boulain and Maurizio Cecconi

Intensive Care Medicine 2015



Risque lié à 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

The risk of fluid overload

Acheampong and Vincent Critical Care (2015) 19:251
DOI 10.1186/s13054-015-0970-1

CRITICAL CARE

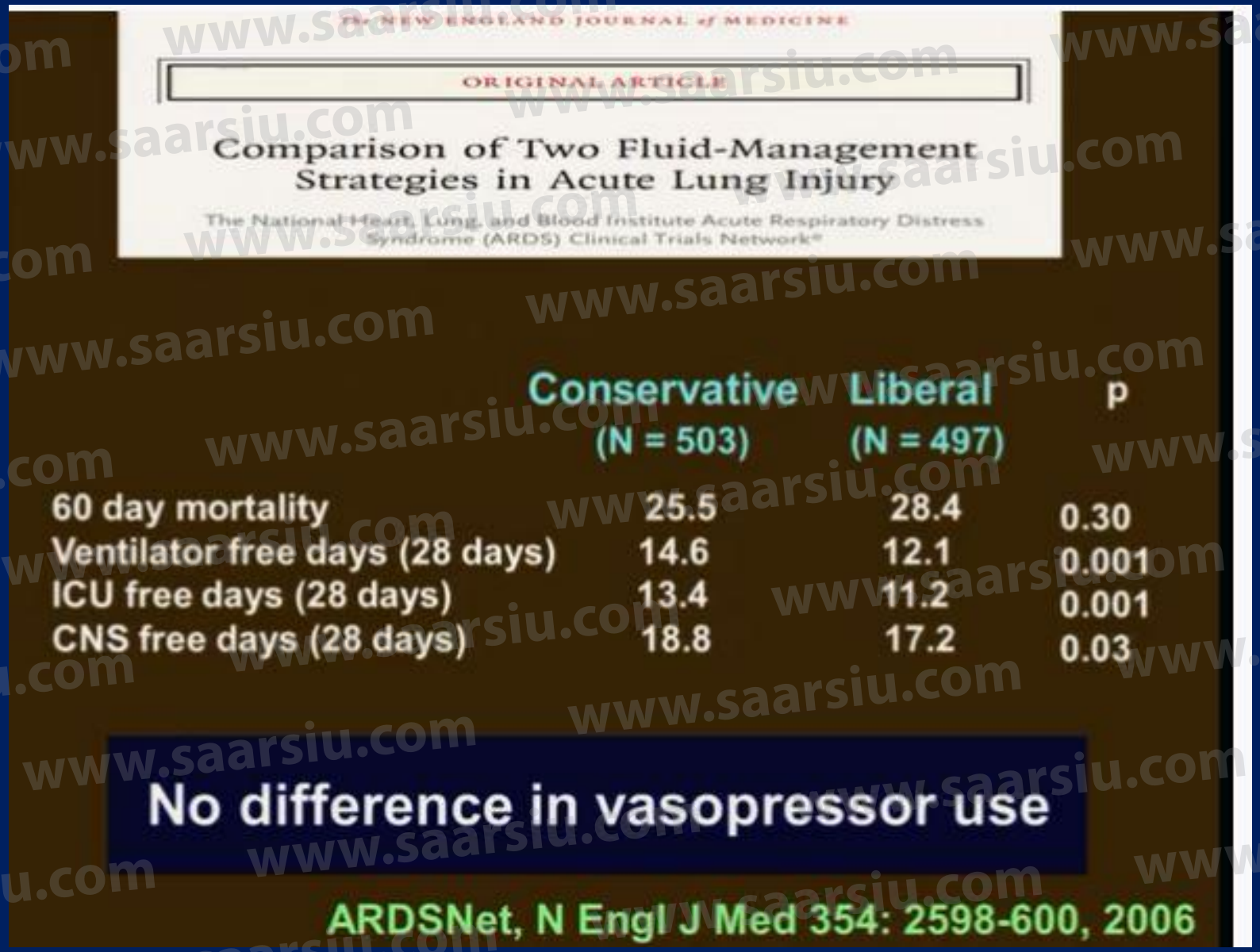
RESEARCH Open Access

A positive fluid balance is an independent prognostic factor in patients with sepsis

Angela Acheampong and Jean-Louis Vincent*

173 patients with sepsis

Survivors had a lower fluid balance


THE NEW ENGLAND JOURNAL of MEDICINE
ORIGINAL ARTICLE
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*
Conservative (N = 503)
Liberal (N = 497)
p
60 day mortality 25.5 28.4 0.30
Ventilator free days (28 days) 14.6 12.1 0.001
ICU free days (28 days) 13.4 11.2 0.001
CNS free days (28 days) 18.8 17.2 0.03
No difference in vasopressor use
ARDSNet, N Engl J Med 354: 2598-600, 2006

The Endothelial Glycocalyx: the Double-barrier Concept of Vascular Permeability

✓Healthy endothelium is coated by the endothelial glycolalyx, a layer of membrane-bound proteoglycans and glycoproteins

Endothelial glycocalyx binds plasma proteins and fluids with a functional thickness of more than 1 µm. The amount of plasma not participating to the normal blood circulation is about 700-1000 mL in humans

✓By exerting a vital role on the physiologic endothelial permeability barrier, and preventing leucocyte and platelet adhesion, it mitigates inflammation and tissue edema

From Chappell D et al. Anesthesiology 109:724-740, 2008.

Fluid Resuscitation in ICU Patients

- ✓ Iatrogenic acute hypervolemia triggers atrial natriuretic peptide release, which has the power to degrade the endothelial glycocalyx

Kamp-Jensen M et al. Br J Anaesth 64:606-610, 1990.
Bruegger D et al. Am J Physiol Heart Circ Physiol 289:H1993-9, 2005.

- ✓ Degradation of the endothelial glycocalyx leads to platelet aggregation, leukocyte adhesion, and tissue oedema through increased endothelial permeability

Vink H et al. Circulation 101:1500-2, 2000.
Michel CC. Exp Physiol 82:1-30, 1997.
Chappell D et al. Anesthesiology 107-776-84, 2007.

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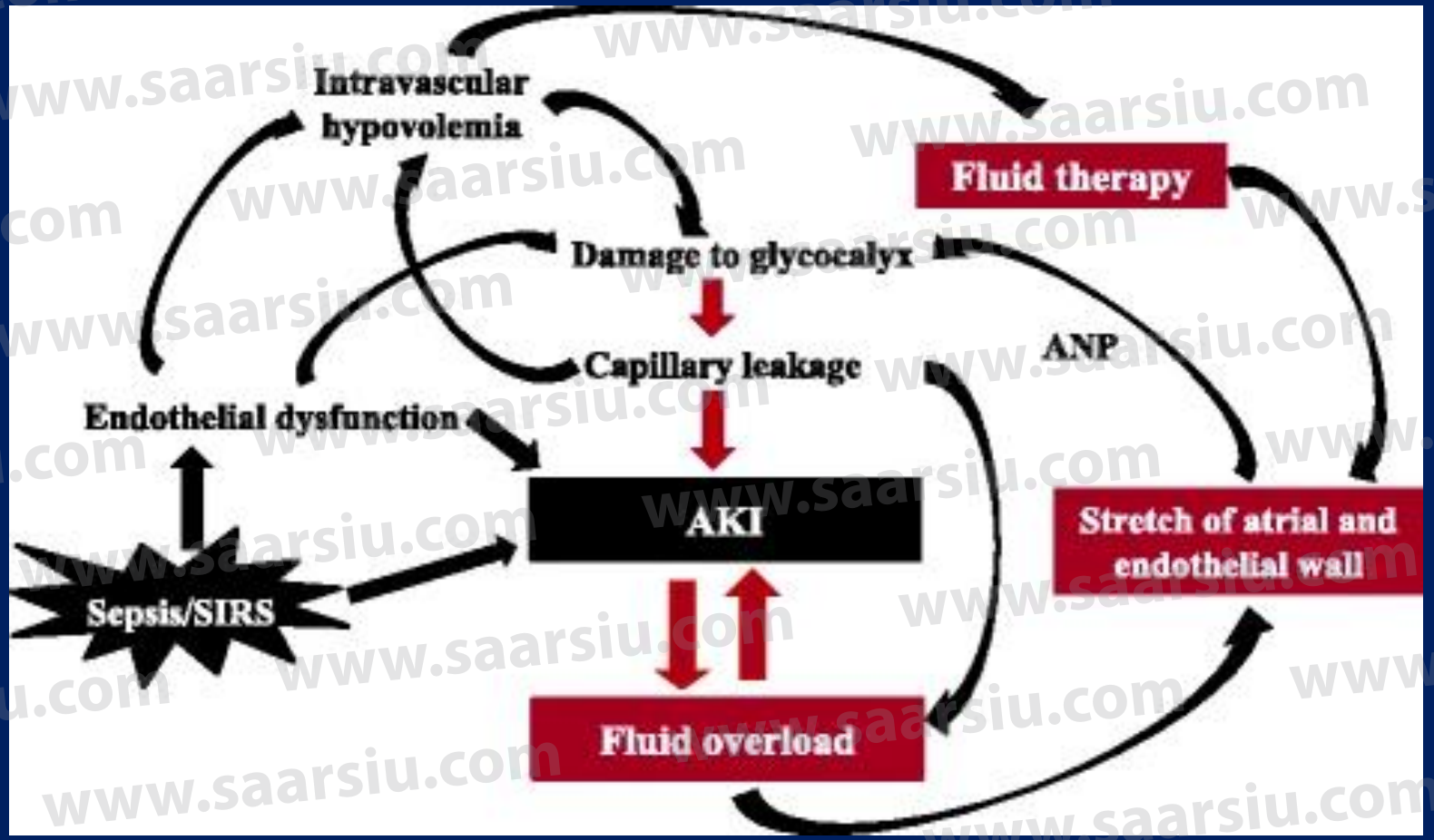


Interconnected relationship between acute kidney injury and fluid overload . Ostermann et al. Critical Care. 2015

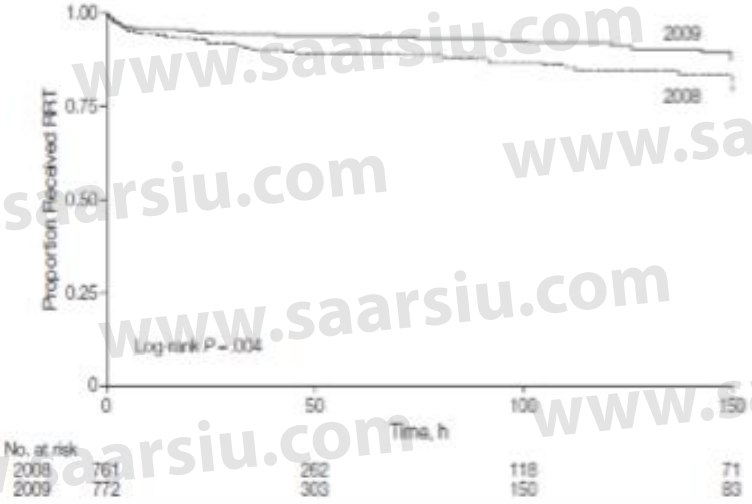
Association Between a Chloride-Liberal vs Chloride-Restrictive Intravenous Fluid Administration Strategy and Kidney Injury in Critically Ill Adults

- ✓ Prospective open-label sequential period pilot study
  - ICU patients 02-08/2008: standard IV fluids (N=760)
  - ICU patients 02-08/2009: chloride restrictive IV fluids (N=773)
- ✓ Primary objectives: peak creat level and AKI (RIFLE)

Table 3. Incidence of Acute Kidney Injury Stratified by Risk, Injury, Failure, Loss, and End-Stage (RIFLE) Serum Creatinine Criteria

	No. (%) [95% CI] of Patients[a]		
	Control Period (n = 760)	Intervention Period (n = 773)	*P* Value
RIFLE class			
Risk	71 (9.0) [7.2-11.0]	57 (7.4) [5.5-9.0]	.16
Injury	48 (6.3) [4.5-8.1]	23 (3.0) [1.8-4.2]	.002
Failure	57 (7.5) [5.6-9.0]	42 (5.4) [3.8-7.1]	.10
Injury and failure	105 (14) [11-16]	65 (8.4) [6.4-10.0]	<.001

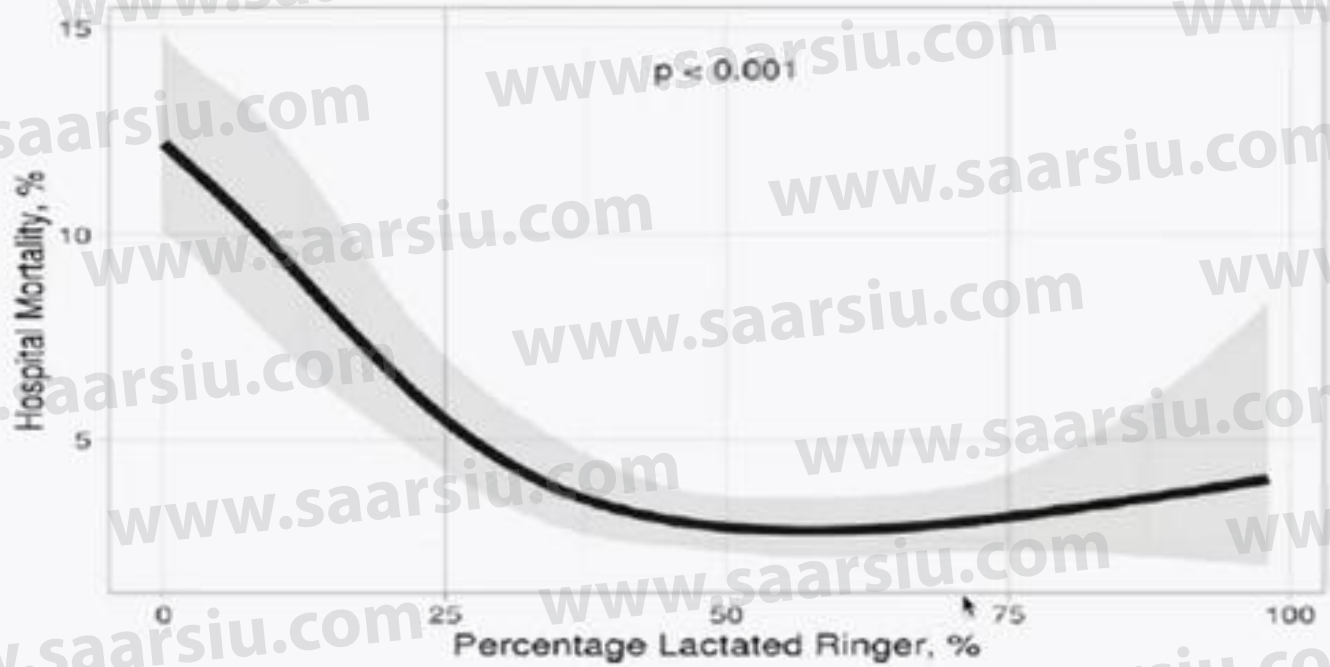
Figure 2. Renal Replacement Therapy (RRT) in the Intensive Care Unit (ICU)



From Yunos NM et al. JAMA 308:1566-72, 2012.

Lactated Ringer Is Associated With Reduced Mortality and Less Acute Kidney Injury in Critically Ill Patients: A Retrospective Cohort Analysis*

10,249 patients were included



Zampieri et al Crit Care Med 2016

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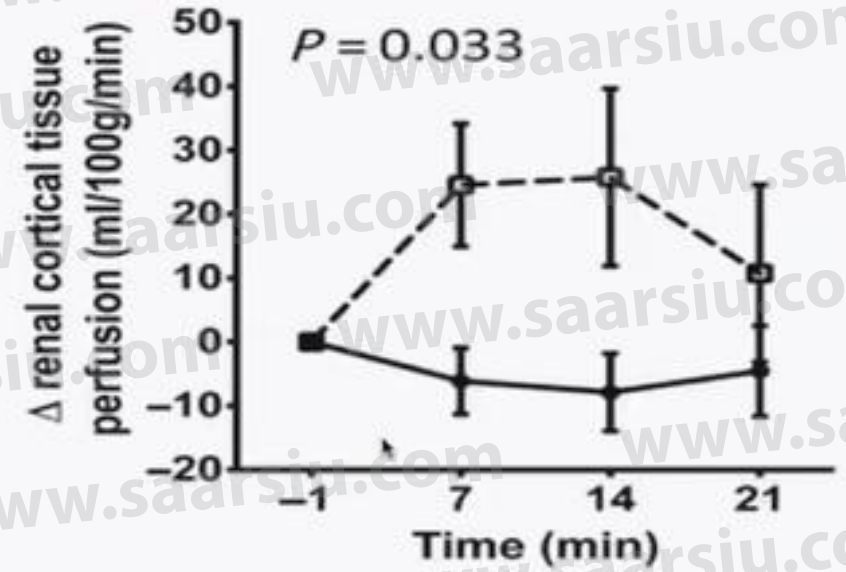
Hyperchlorémie - fonction rénale:

Vasoconstriction rénale ?



Chowdury et al Ann Surg 2014

CONCLUSION

- EFFICACITE DU REMPLISSAGE VASCULAIRE : DC , SVCO2 , LACTATES
- INDICES DYNAMIQUES DE PREFERENCE
- FLUID CHALLENGE OU MINI FLUID CHALLENGE
- RISQUE DU REMPLISSAGE VASCULAIRE (surcharge, choix du soluté)

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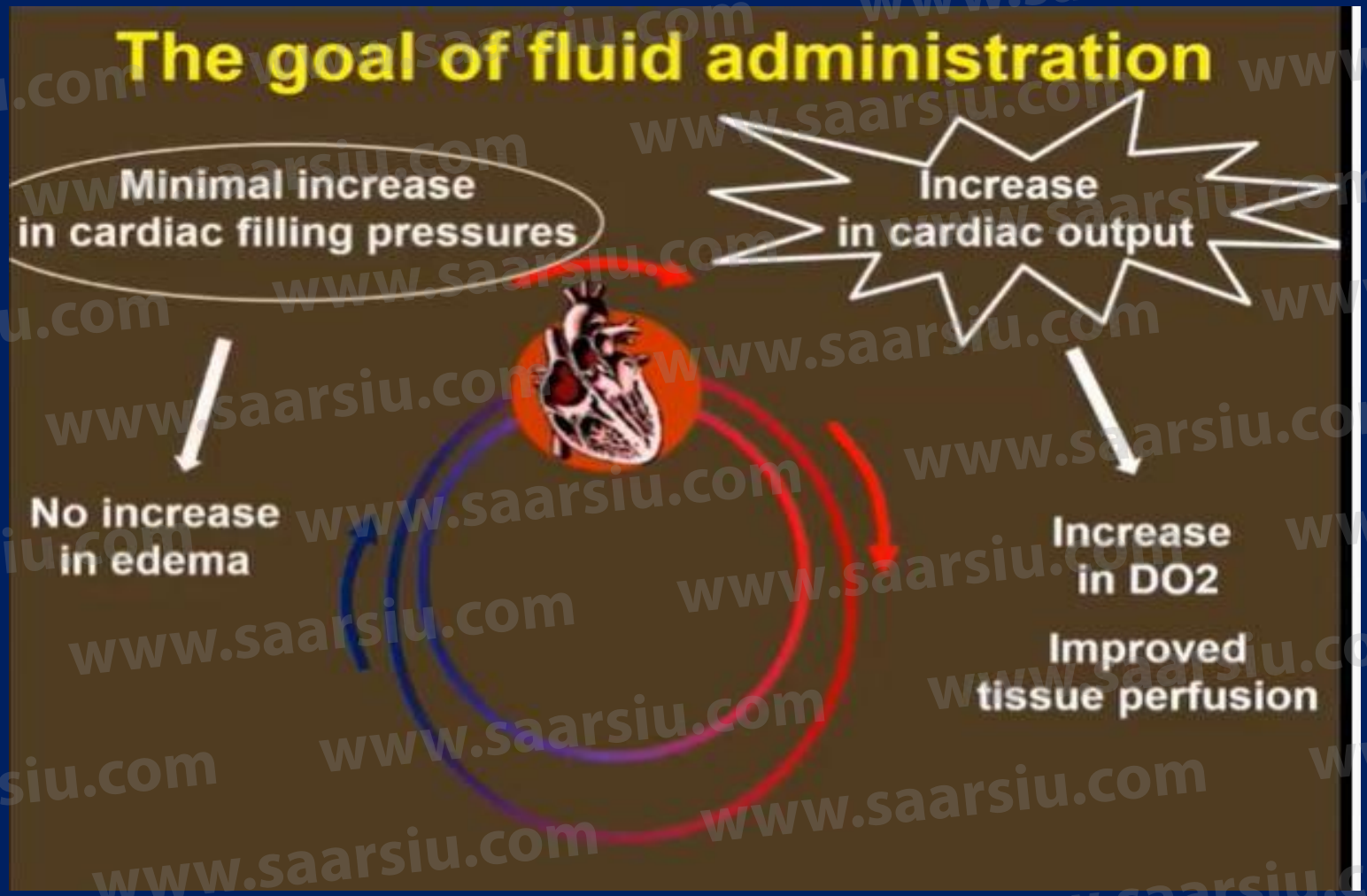
CONCLUSION


The goal of fluid administration
Minimal increase
in cardiac filling pressures
Increase
in cardiac output
No increase
in edema
Increase
in DO2
Improved
tissue perfusion

Risque lié à l'expansion volémique ?

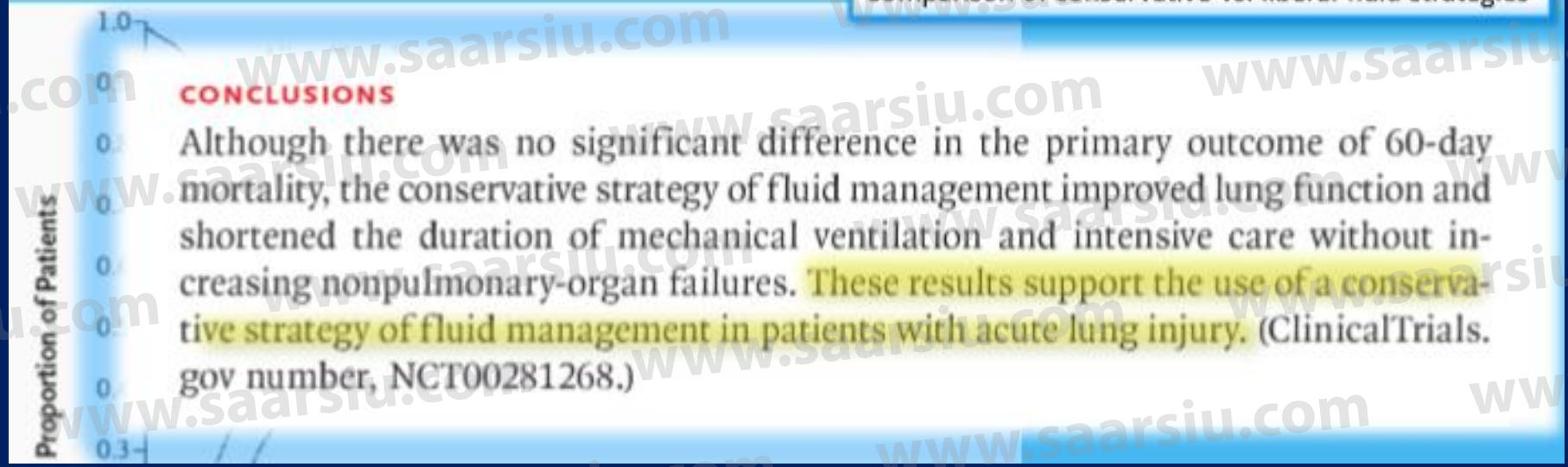
THE NEW ENGLAND JOURNAL of MEDICINE

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.)