How to use arterial pressure to assess Hemodynamics

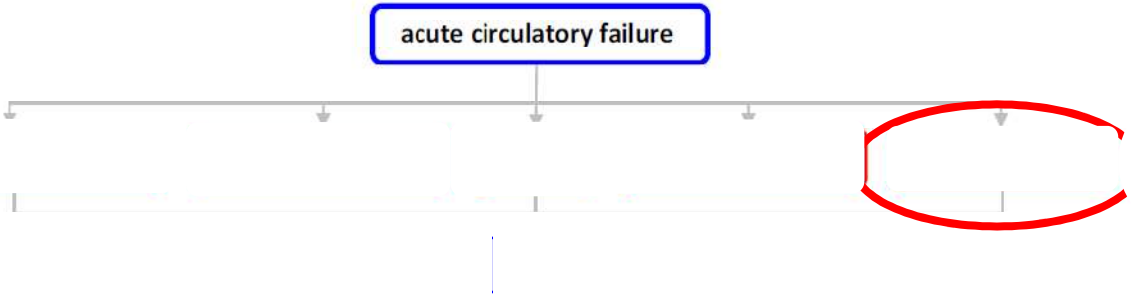
Olfa Hamzaoui
Medical intensive care
Robert Debré Hospital, University hospitals of Reims
France

How to use arterial pressure to assess Hemodynamics

Conflict of interest

- Recieved Honoraria for Lectures from Baxter

Intensive Care Med (2016) 42:1350–1359

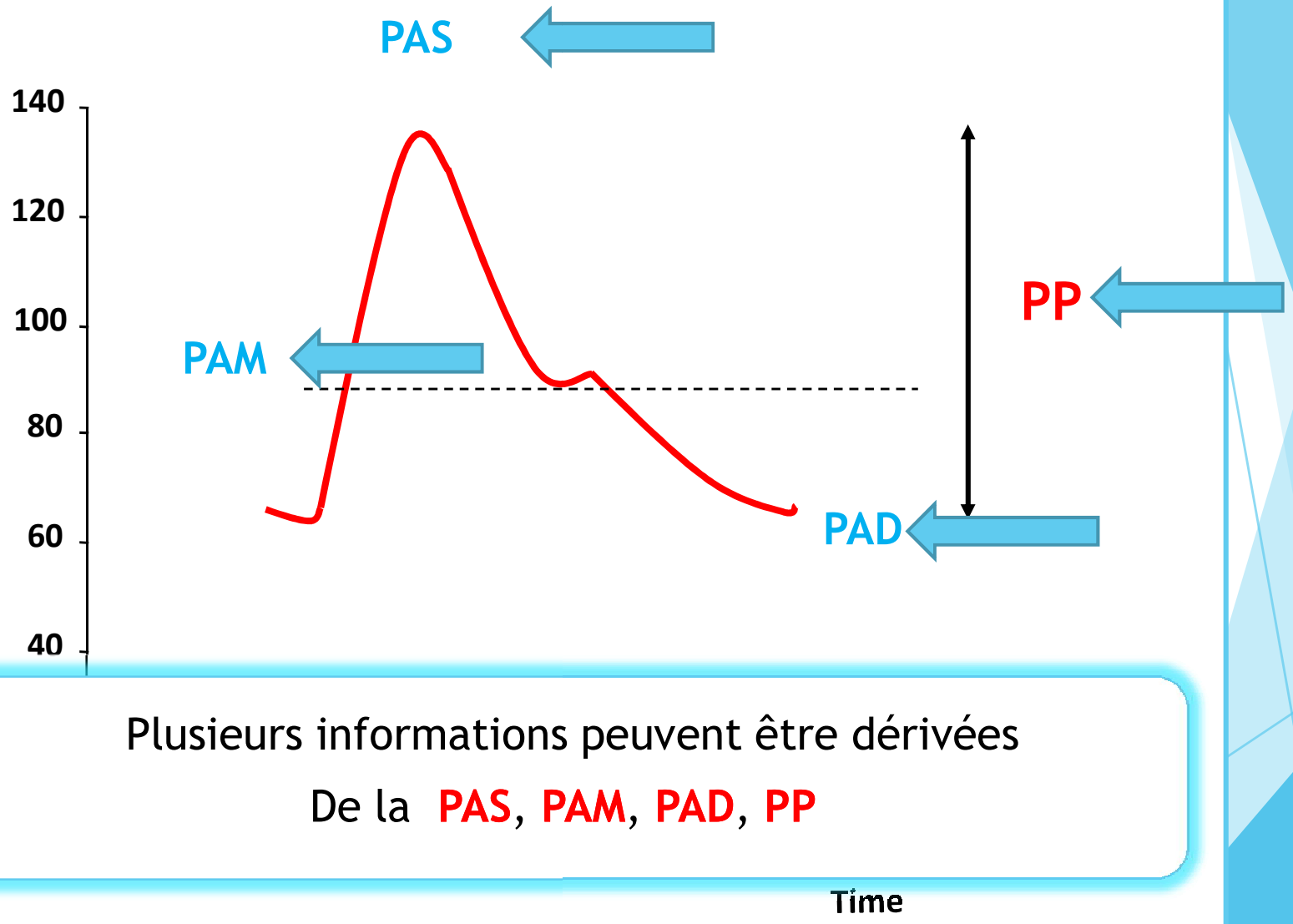


How can we use Arterial pressure?

- Analysis of the static values
- Analysis of the dynamic variation of AP values

- Analysis of the static values
- Analysis of the dynamic variation of AP values

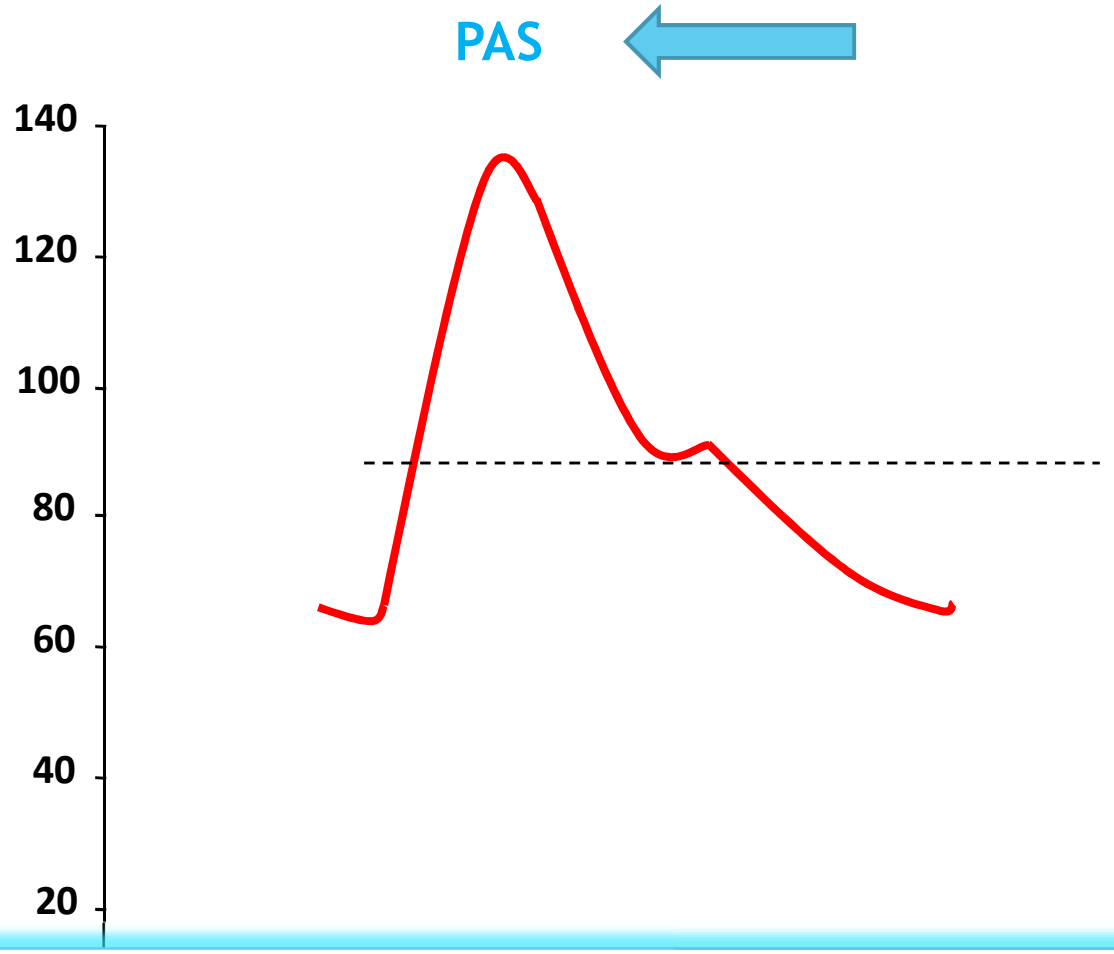
Pression artérielle *(mmHg)*



Plusieurs informations peuvent être dérivées

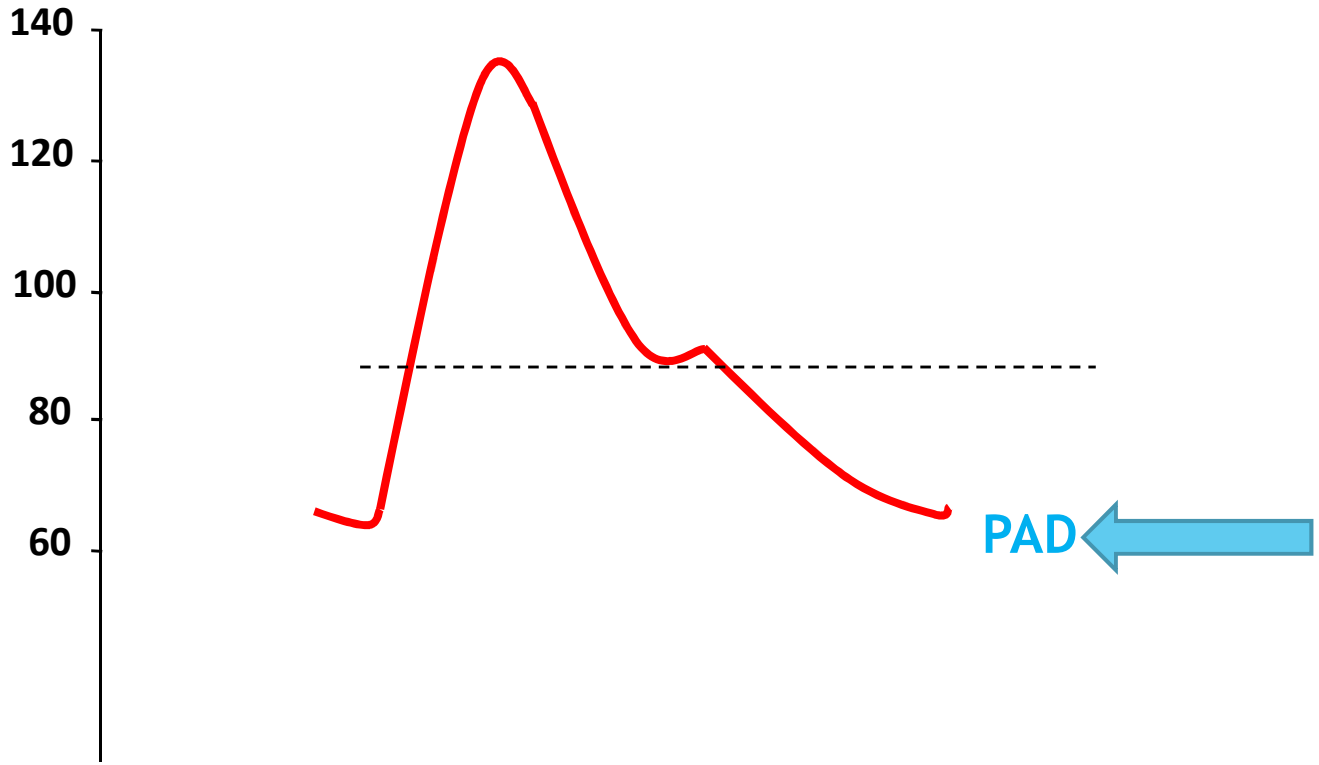
De la **PAS**, **PAM**, **PAD**, **PP**

Pression artérielle *(mmHg)*



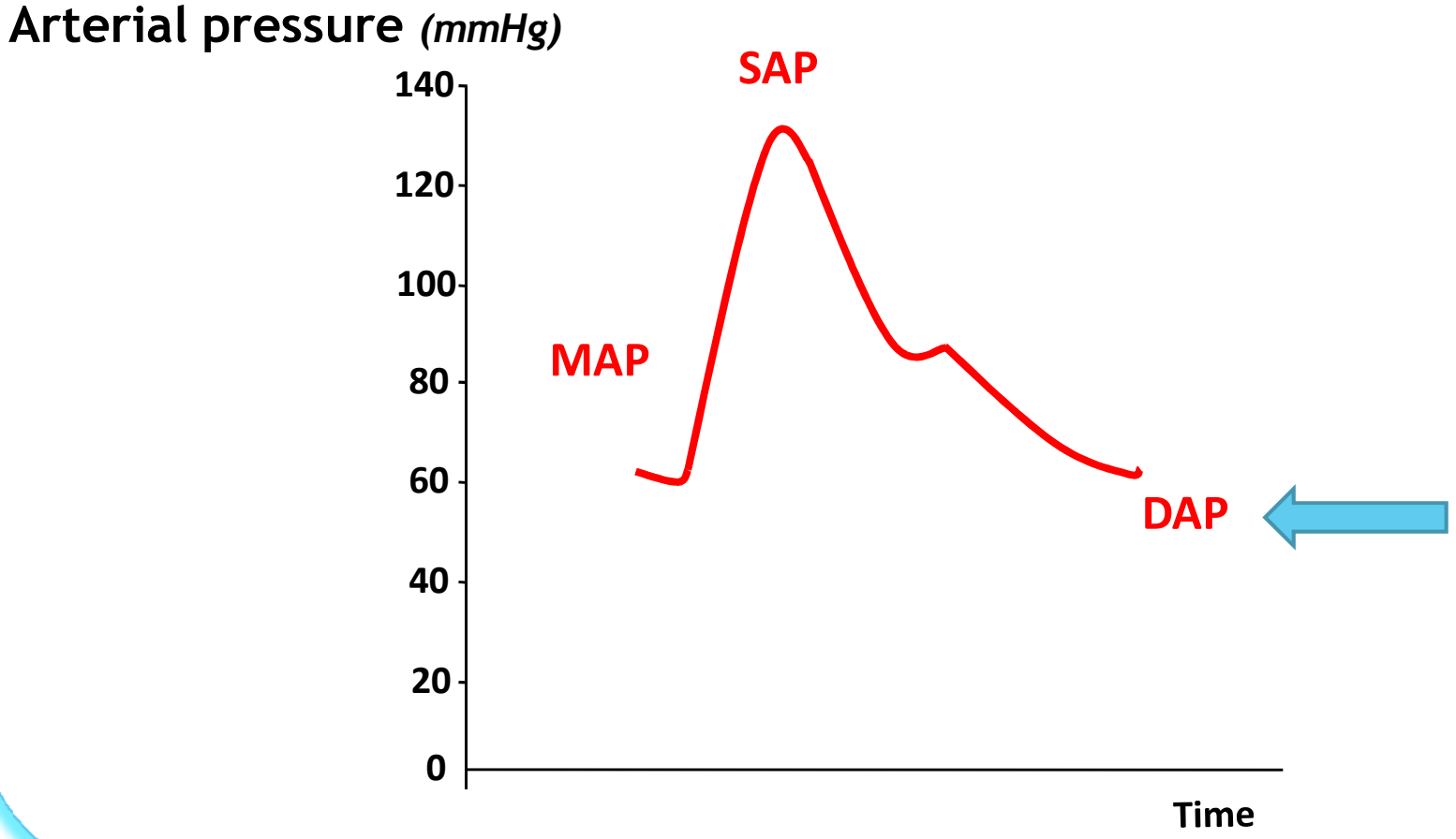
PAS: **Un determinant majeur** de **La post charge**

Pression artérielle*(mmHg)*



Is it important to consider DAP in septic shock ?

DAP is a reflection of vasomotor ne → **a low DAP** is mainly due to a **depressed arterial tone**



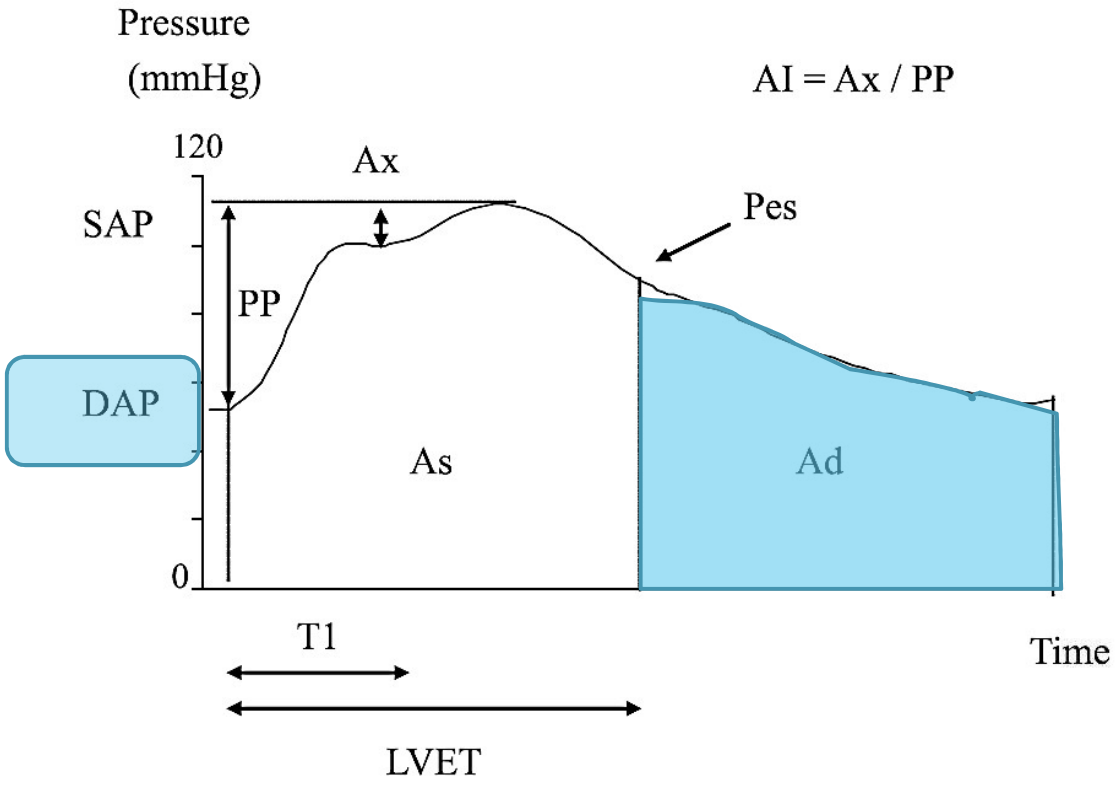
sive Care Med (2007) 33:1931–1937
10.1007/s00134-007-0738-4

ORIGINAL

chra Lamia
n-Louis Teboul
ier Monnet
id Osman
en Maizel
istian Richard
is Chemla

Contribution of arterial stiffness and stroke volume to peripheral pulse pressure in ICU patients: an arterial tonometry study

67 ICU patients



Peripheral **resistance**

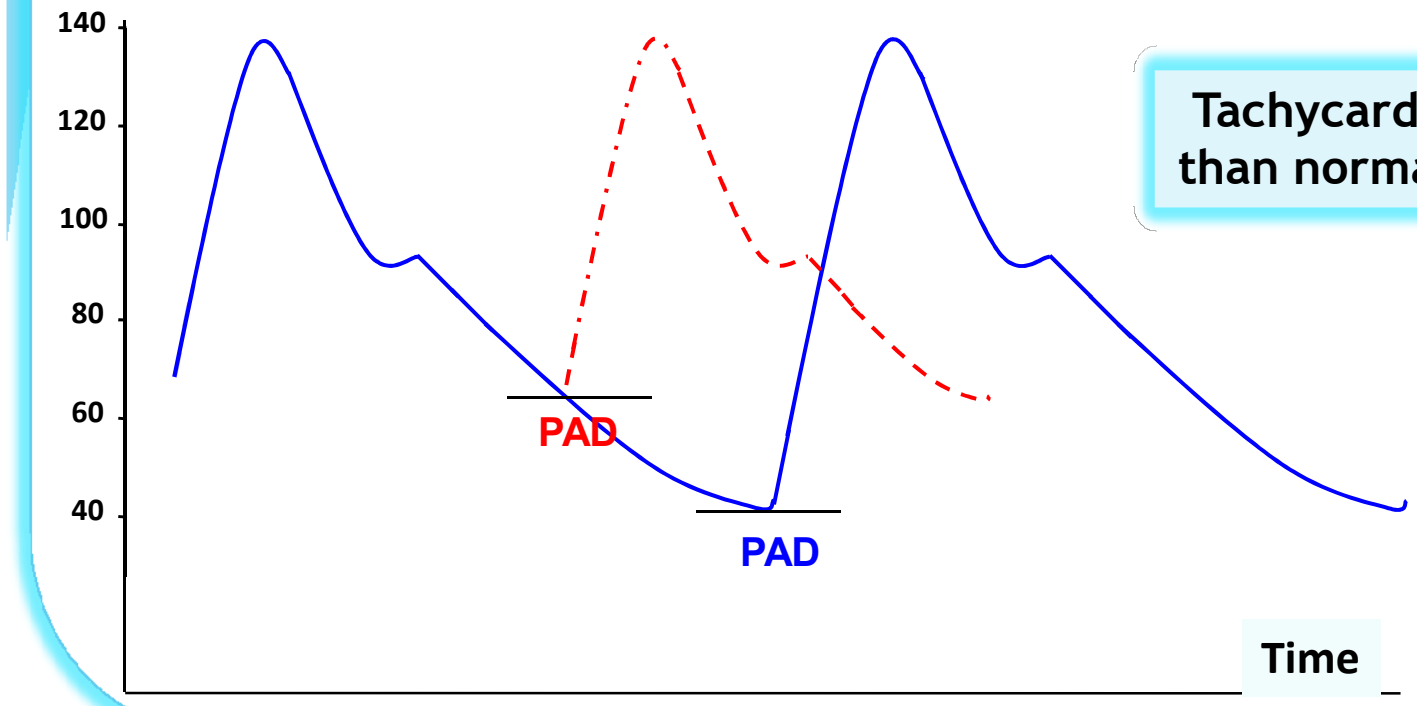
- **related** to peripheral **DAP** (**r = 0.71**) ($p<0.001$)
- but **not related** to peripheral **SAP** ($r^2 = 0.04$) and **PP** ($r^2 = 0.02$)

Is it important to consider DAP in septic shock ?

DAP is a reflection of vasomotor tone → **a low DAP** is mainly due to a **depressed** **terial tone**

BUT

Always consider heart rate



Tachycardia should theoretically result **in a high** **than normal DAP**

Is it important to consider DAP in septic shock ?

DAP is a reflection of vasomotor tone

a low DAP is mainly due to a **depressed arterial ton**

→ **a low DAP** may be seen during **Bradycardia**

Is it important to consider DAP in septic shock ?

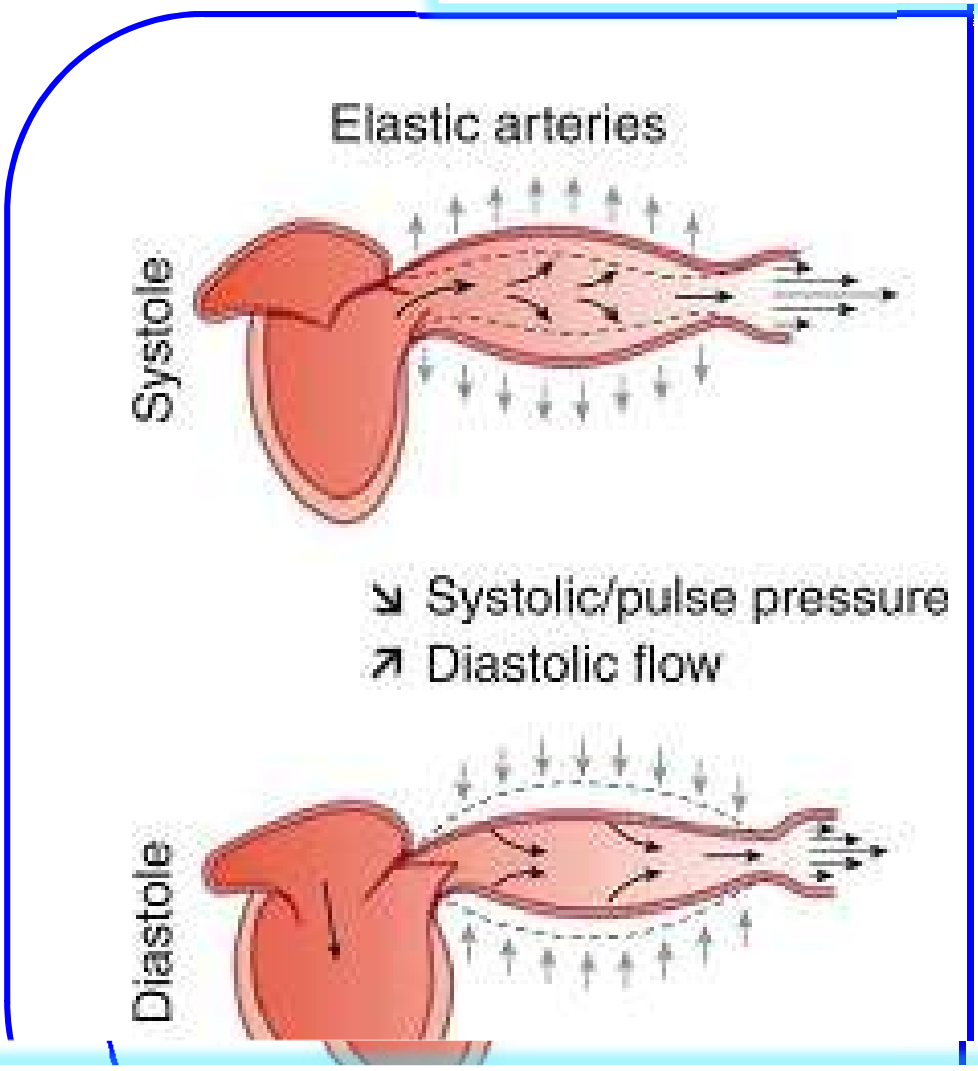
DAP is a reflection of vasomotor tone

a low DAP is mainly due to a **depressed arterial to**

a low DAP may be seen during **Bradycardia**

→ **Arterial stiffness**

The **cardiac pump** generates a **pulsatile flow**



arteries a

In patients **with stiff arteries the diastolic part** of aortic pressure **is reduced**

t of the **stroke volume** during the **systole** and by **restituting** it during the **diastole**

Is it important to consider DAP in septic shock ?

DAP is a reflection of vasomotor tone

Septic shock is caracterised by vasodilation and a low vasomotor tone: DAP may help the diagnosis at the bedside

The NEW ENGLAND JOURNAL of MEDICINE

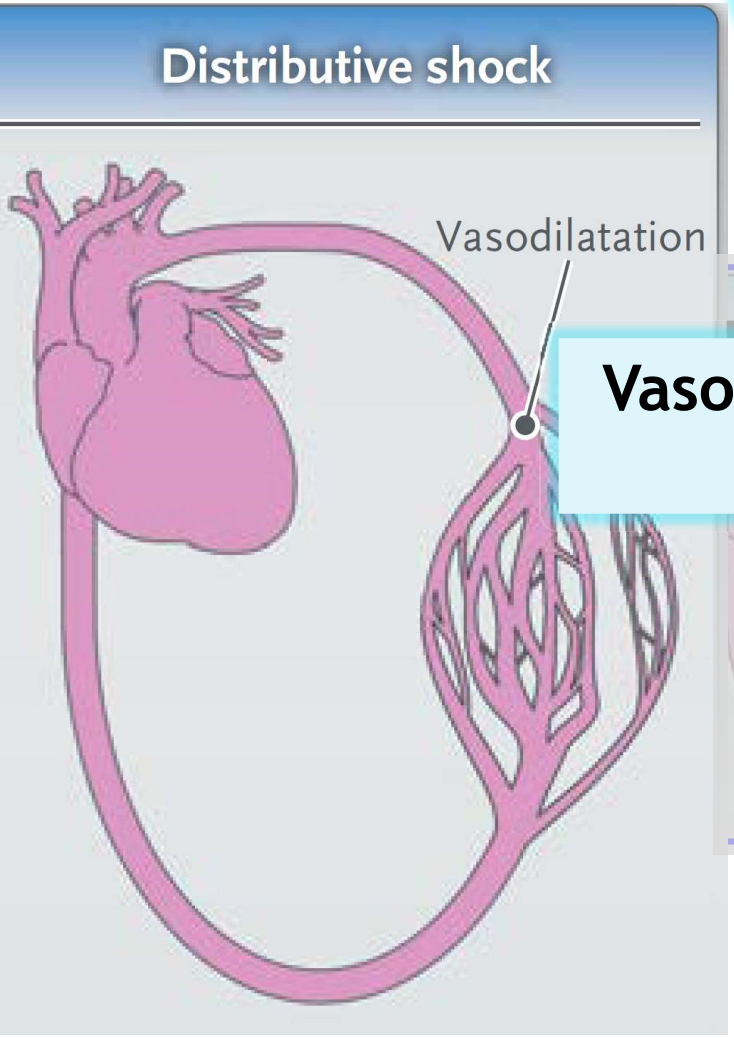
REVIEW ARTICLE

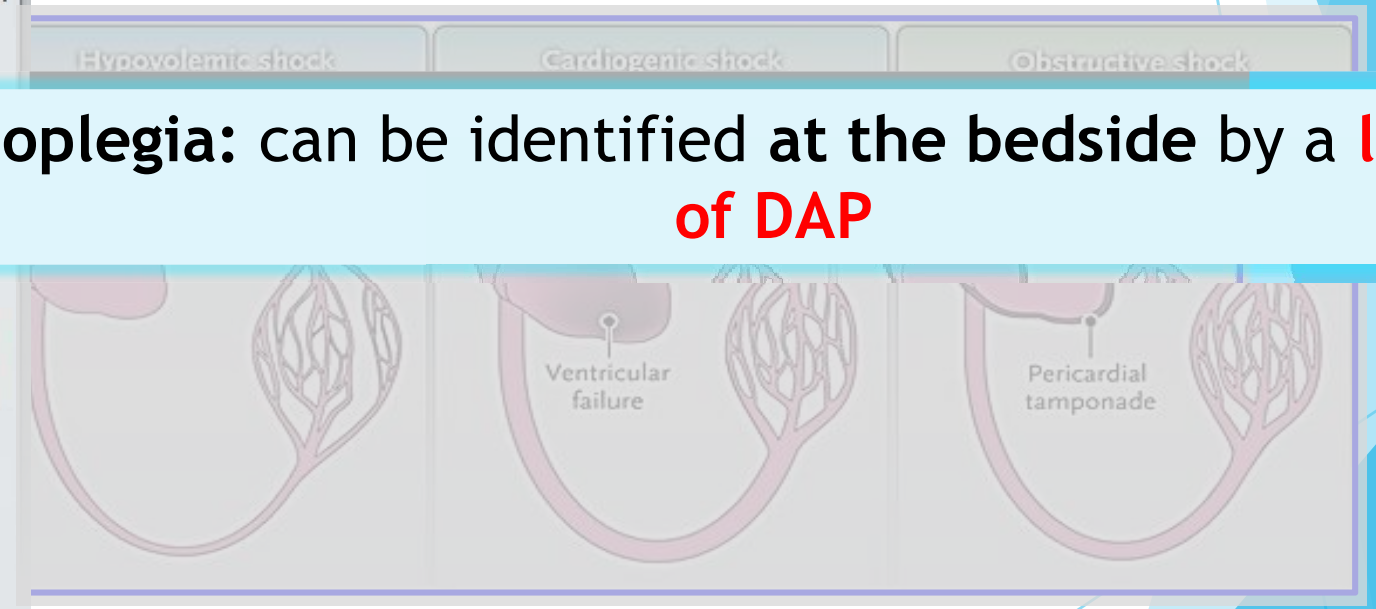
CRITICAL CARE MEDICINE

Simon R. Finfer, M.D., and Jean-Louis Vincent, M.D., Ph.D., *Editors*

Circulatory Shock

Jean-Louis Vincent, M.D., Ph.D., and Daniel De Backer, M.D., Ph.D.





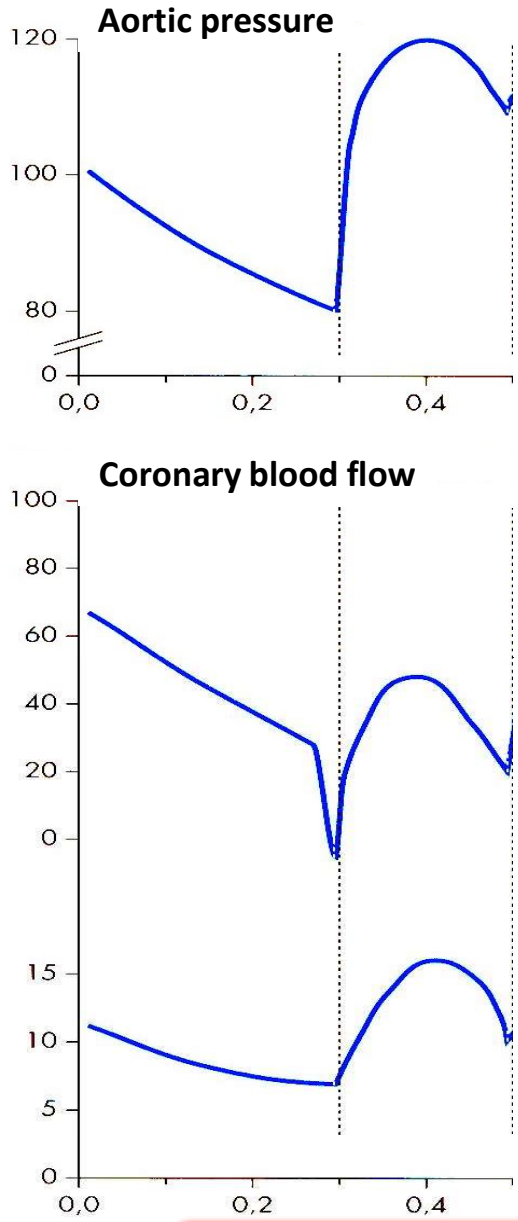
Vasoplegia: can be identified **at the bedside** by a **low va**
of DAP

Is it important to consider DAP in septic shock ?

DAP is a reflection of vasomotor tone

Septic shock is caracterised by vasodilation and a low vasomotor tone

DAP is the upstream pressure for LV coronary perfusion



DAP is the upstream pressure for LV coronary perfusion

Is it important to consider DAP in septic shock ?

DAP is a reflection of vasomotor tone

Septic shock is caracterised by vasodilation and a low vasomotor tone

DAP is the upstream pressure for LV coronary perfusion

DAP is associated to outcome

Diastolic Arterial Blood Pressure: A Reliable Early Predictor of Survival in Human Septic Shock

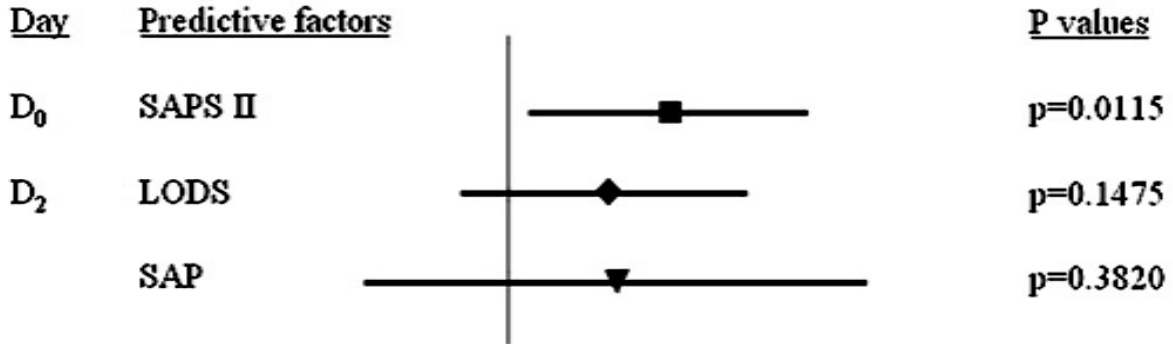
Samir Benchekroune, MD, Peter C. J. Karpati, MD, Christine Berton, MD†, Cédric Nathan, MD, Joaquim Mateo, MD, Mansour Chaara, MD, Florence Riché, MD, Marie-Josèphe Laisné, MD, Didier Payen, MD, PhD, and Alexandre Mebazaa, MD, PhD

J Trauma. 2008;64:1188–1195

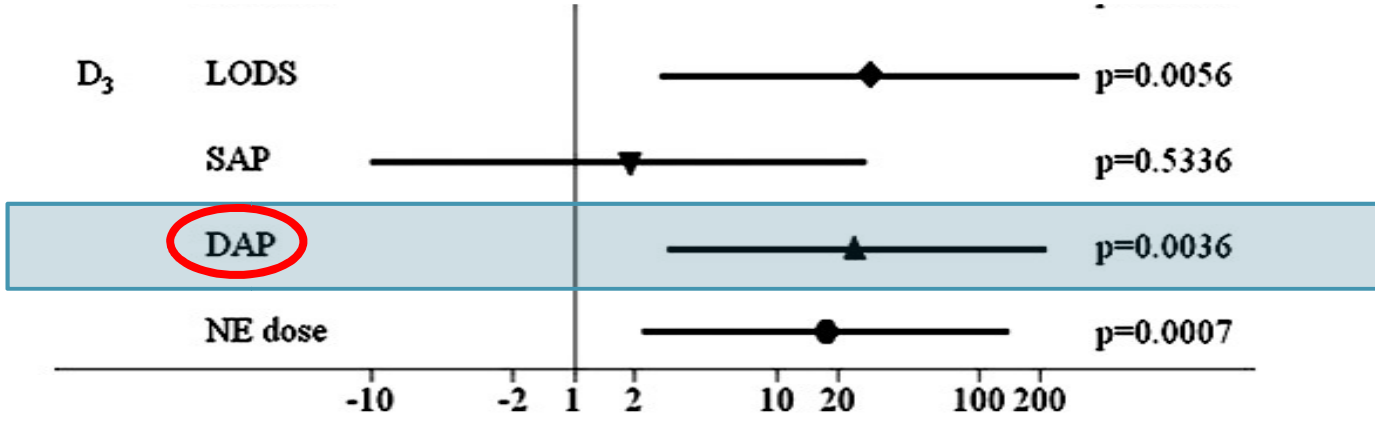
8 septic shock patients

Receiving NE for at least 72 hrs

Observational study



At D_3 low DAP (and not low SAP) was a predictor of mortalit



of Intensive Care (2023)

RESEARCH Open Access

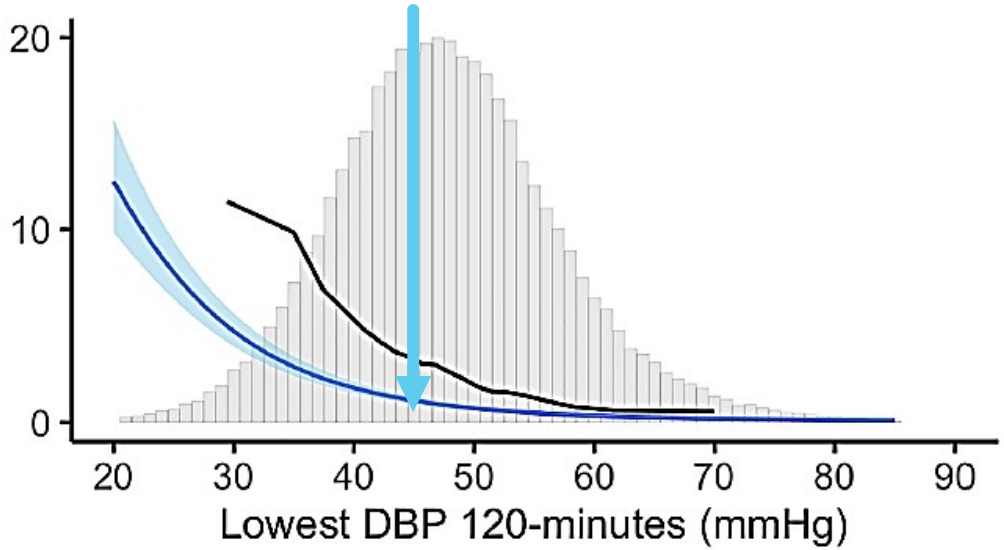
Association of systolic, diastolic, mean, and pulse pressure with morbidity and mortality in septic ICU patients: a nationwide observational study

Ashish K. Khanna[1,2*], Takahiro Kinoshita[3], Annamalai Natarajan[3], Emma Schwager[3], Dustin D. Linn[3], Junzi Dong[3], Erina Ghosh[3], Francesco Vicario[3] and Kamal Maheshwari[4]

- **Retrospective observational** study, **77,328** septic patients in 364 ICUs in the eICU
- **Primary exposure** was **the lowest cumulative** value of each component; mean, systolic,diastolic, and pulse pressure, sustained for at **least 120 min** during ICU stay

Predicted Probability of ICU Mortality in Septic Shock Patients (%)

44 mmHg



In **septic ICU patients**, **lower level of all blood pressure** components including mean, systolic, diastolic and pulse pressure **were associated with higher mortality**, acute kidney injury and myocardial injury

Is it important to consider DAP in septic shock ?

DAP is a reflection of vasomotor tone

Septic shock is caracterised by vasodilation and a low vasomotor tone

DAP is the upstream pressure for LV coronary perfusion

DAP is associated to outcome

DAP may be used as a trigger when managing septic shock patients

Diastolic arterial pressure is important in septic shock: PRO

Olfa Hamzaoui Jean-Louis Teboul

Journal of Critical Care 51 (2019) 238–240

Patient of **70** years old and history of CAD

with **tachycardia** (heart rate: 100 beats/min)

and clinical signs of **septic shock** in spite of initial fluid resuscitation

Situation A

Situation B

DAP may be a trigger to start norepinephrine

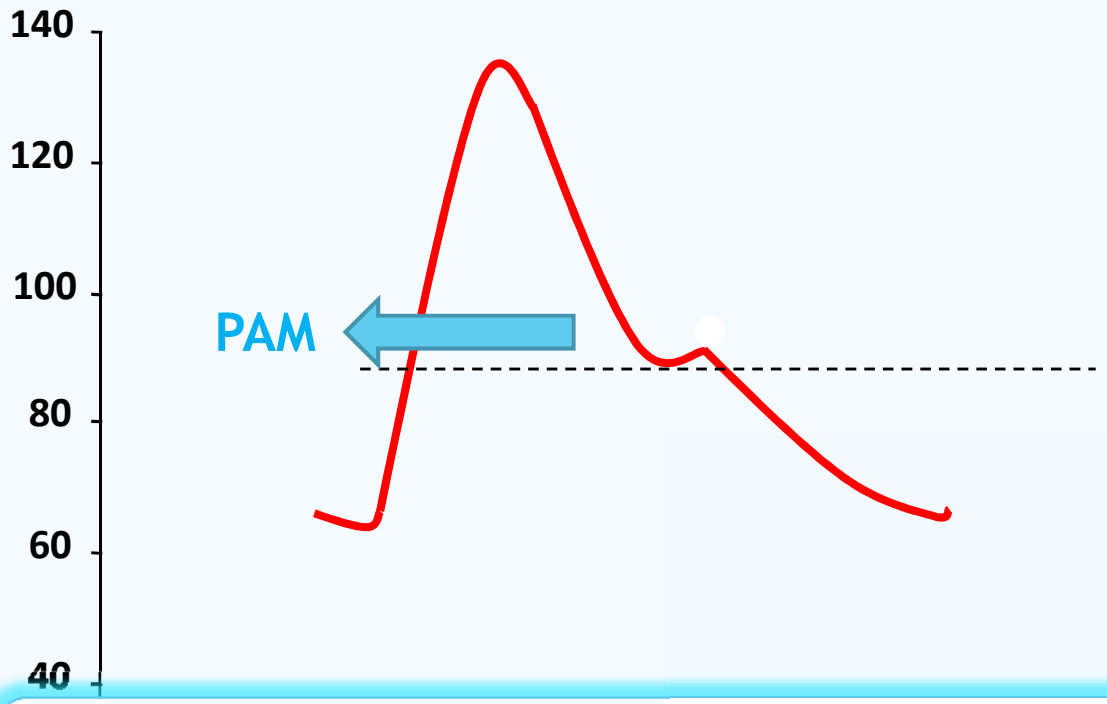
Surviving Sepsis Campaign: International Guidelines for Management of Severe Sepsis and Septic Shock: 2012

R. Phillip Dellinger, MD[1]; Mitchell M. Levy, MD[2]; Andrew Rhodes, MB BS[3]; Djillali Annane, MD[4]; Herwig Gerlach, MD, PhD[5]; Steven M. Opal, MD[6]; Jonathan E. Sevransky, MD[7]; Charles L. Sprung, MD[8]; Ivor S. Douglas, MD[9]; Roman Jaeschke, MD[10]; Tiffany M. Osborn, MD, MPH[11]; Mark E. Nunnally, MD[12]; Sean R. Townsend, MD[13]; Konrad Reinhart, MD[14]; Ruth M. Kleinpell, PhD, RN-CS[15]; Derek C. Angus, MD, MPH[16]; Clifford S. Deutschman, MD, MS[17]; Flavia R. Machado, MD, PhD[18]; Gordon D. Rubenfeld, MD[19]; Steven A. Webb, MB BS, PhD[20]; Richard J. Beale, MB BS[21]; Jean-Louis Vincent, MD, PhD[22]; Rui Moreno, MD, PhD[23]; and the Surviving Sepsis Campaign Guidelines Committee including the Pediatric Subgroup*

Rationale. Vasopressor therapy is required to sustain life and maintain perfusion in the face of life-threatening hypotension, even when hypovolemia has not yet been resolved.

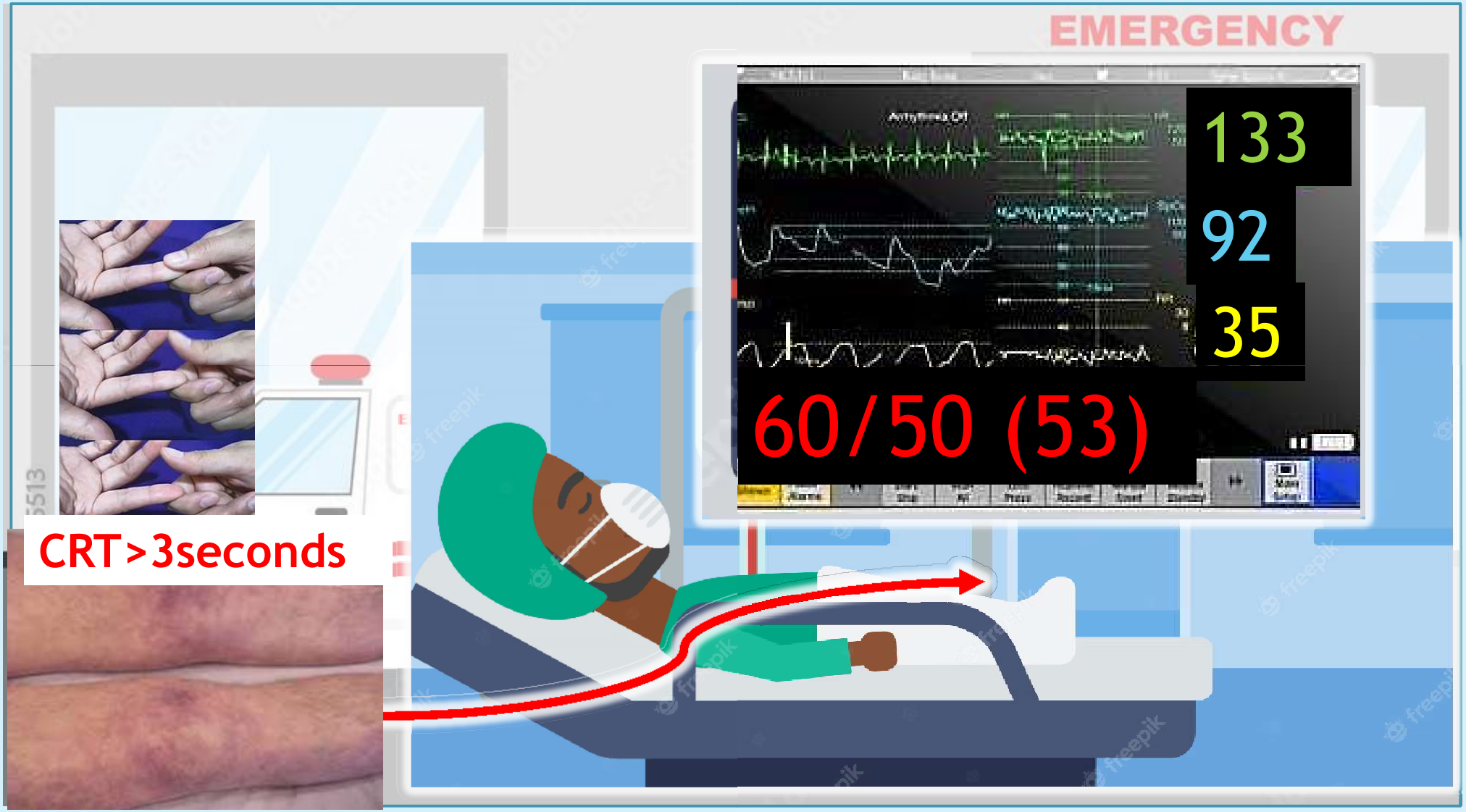
Adequate fluid resuscitation is a fundamental aspect of the hemodynamic management of patients with septic shock and should ideally be achieved before vasopressors and inotropes are used; however, using vasopressors early as an emergency measure in patients with severe shock is frequently necessary, as when diastolic blood pressure is too low.

Pression artérielle *(mmHg)*



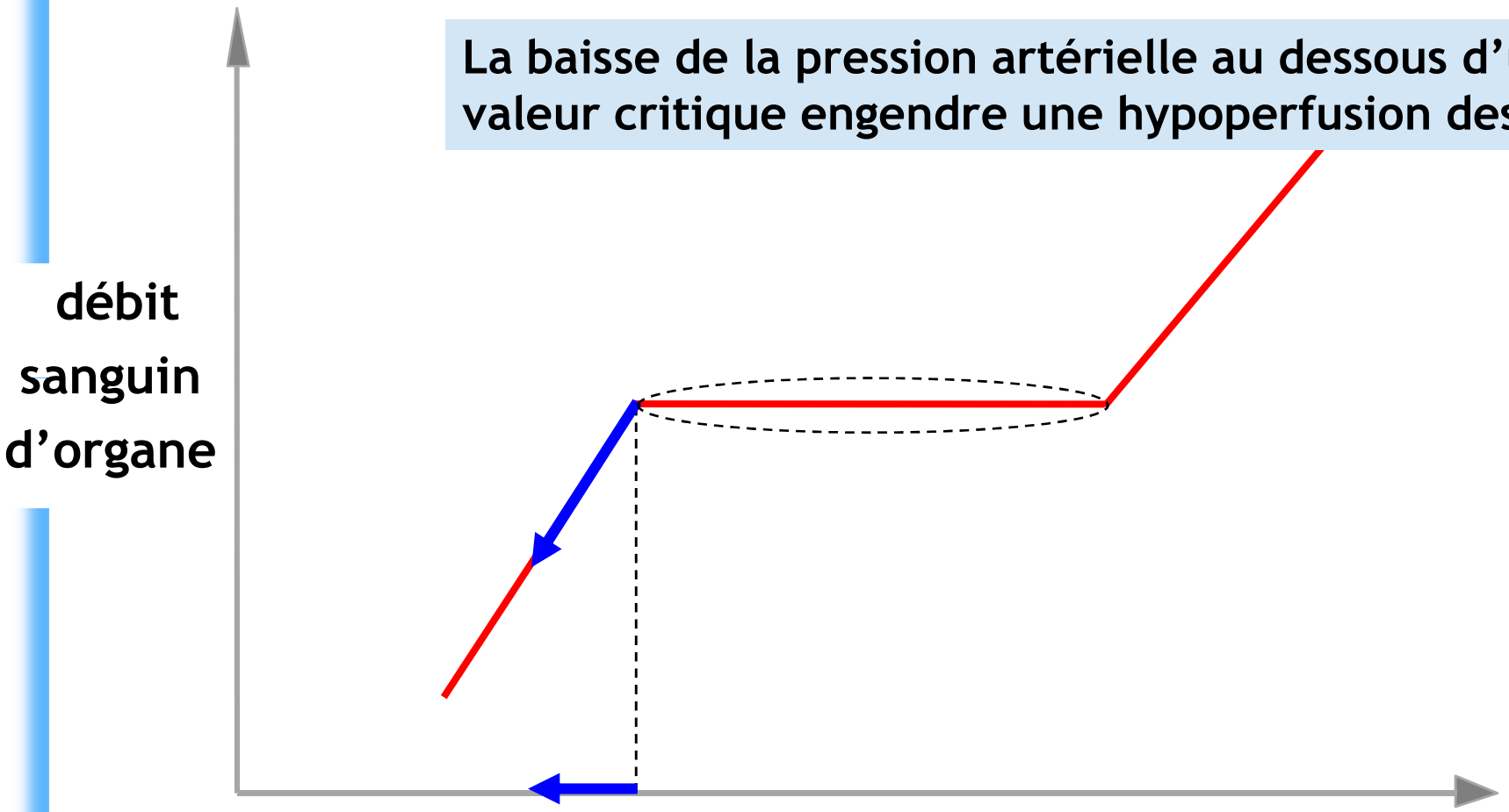
PAM : pression de perfusion des organes

PAM : cible thérapeutique


EMERGENCY
133
92
35
60/50 (53)
CRT>3seconds

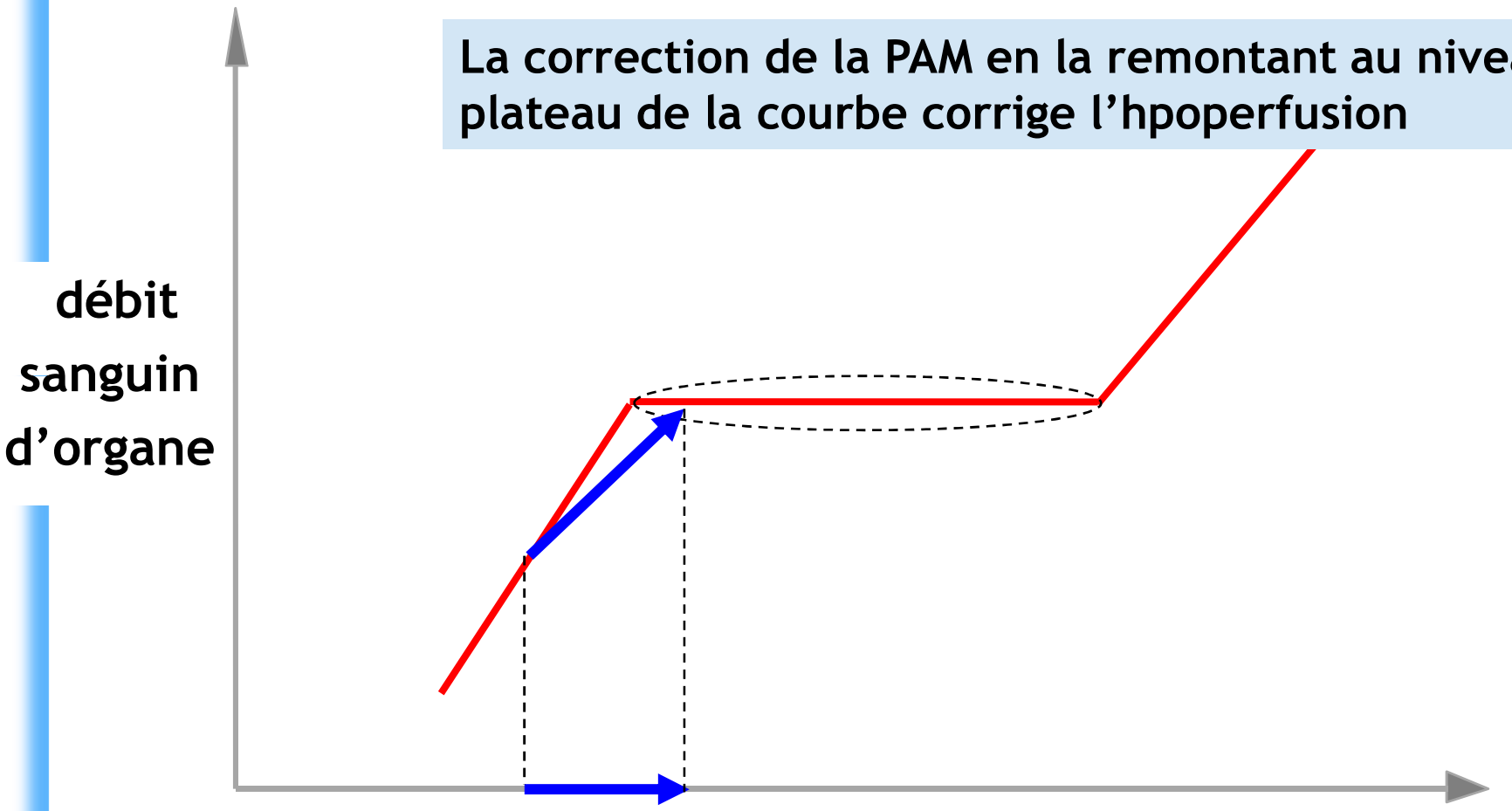
Autoregulation du débit sanguin

La baisse de la pression artérielle au dessous d'une valeur critique engendre une hypoperfusion des organes



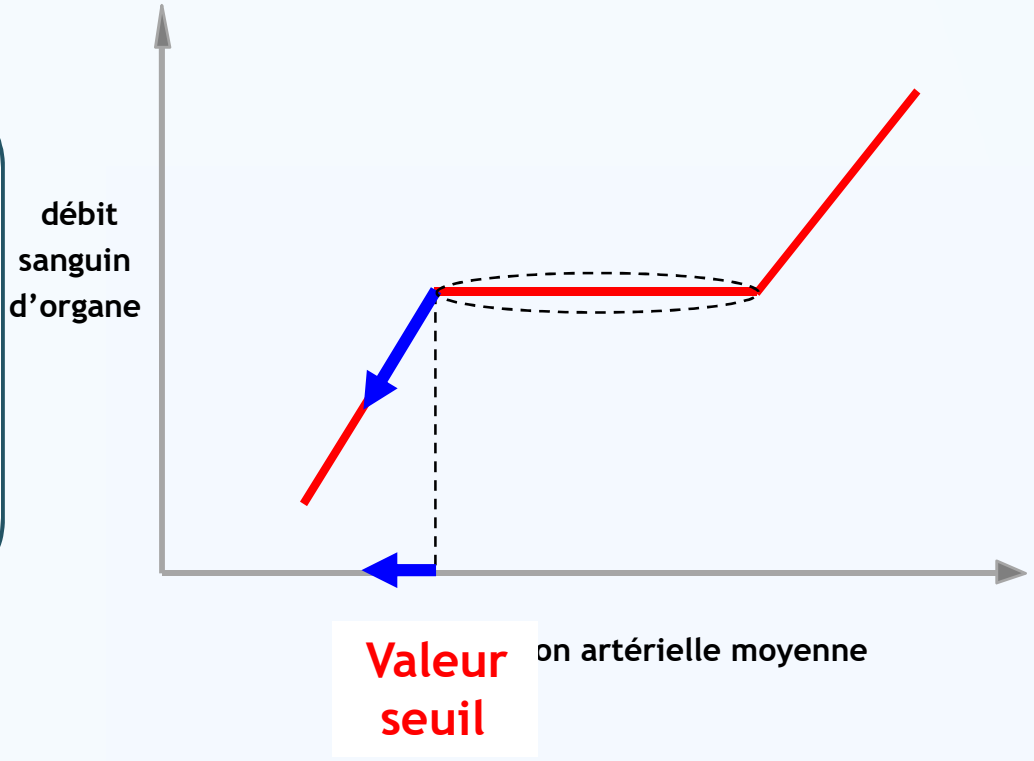
Autoregulation du débit sanguin

La correction de la PAM en la remontant au niveau du plateau de la courbe corrige l'hpoperfusion



PAM: Cible thérapeutique

Quelle valeur seuil ?



GUIDELINES

Surviving sepsis campaign: international guidelines for management of sepsis and septic shock 2021

Intensive Care Med (2021) 47:1181–1247

MEAN ARTERIAL PRESSURE

MODERATE

9 For adults with septic shock on vasopressors, we **recommend** an initial target mean arterial pressure (MAP) of 65 mm Hg over higher MAP targets.

Intensive Care Med (2005) 31:1066–1071
DOI 10.1007/s00134-005-2688-z

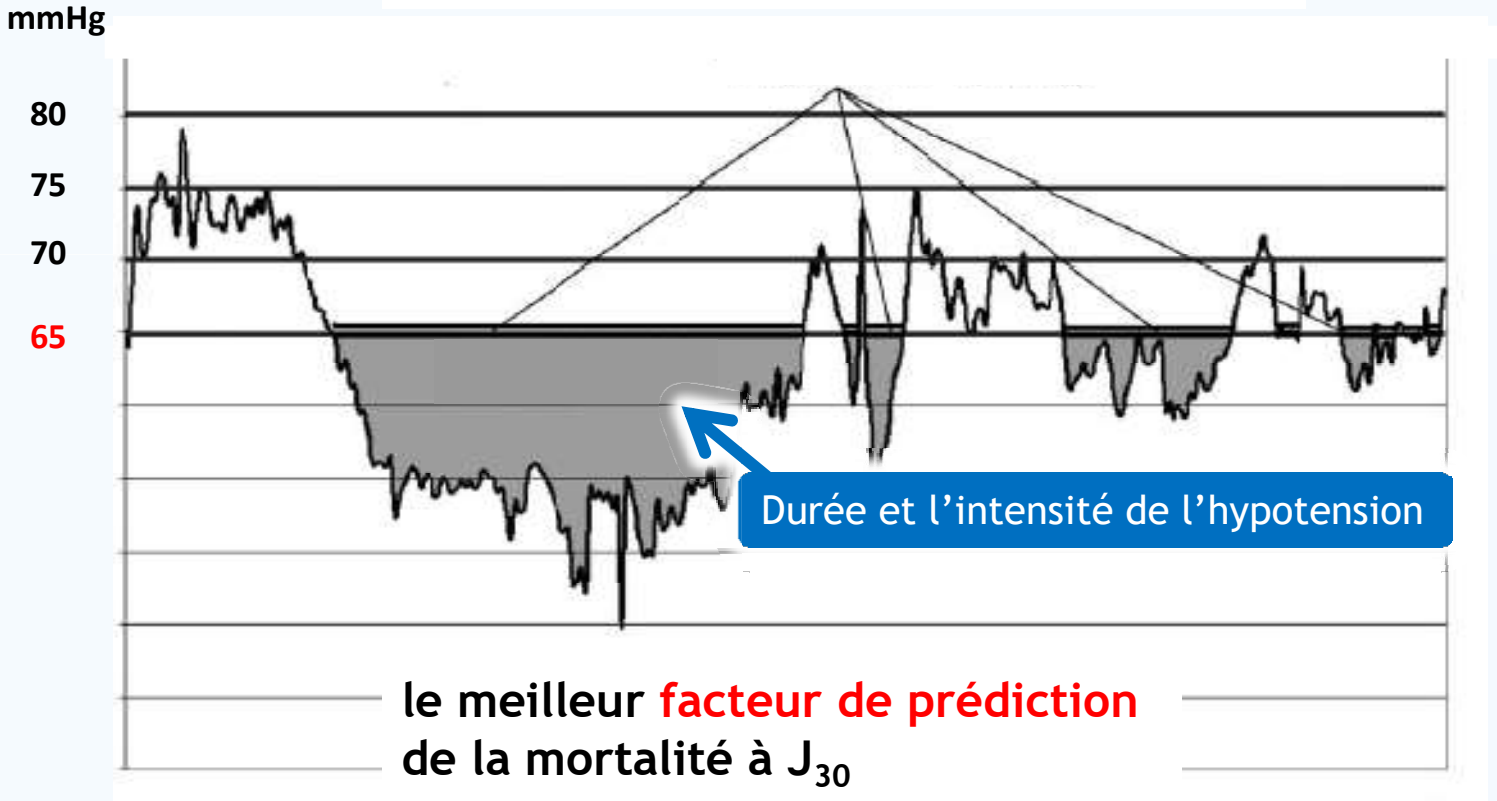
ORIGINAL

Marjut Varpula
Minna Tallgren
Katri Saukkonen
Liisa-Maria Voipio-Pulkki
Ville Pettilä

Hemodynamic variables related to outcome in septic shock

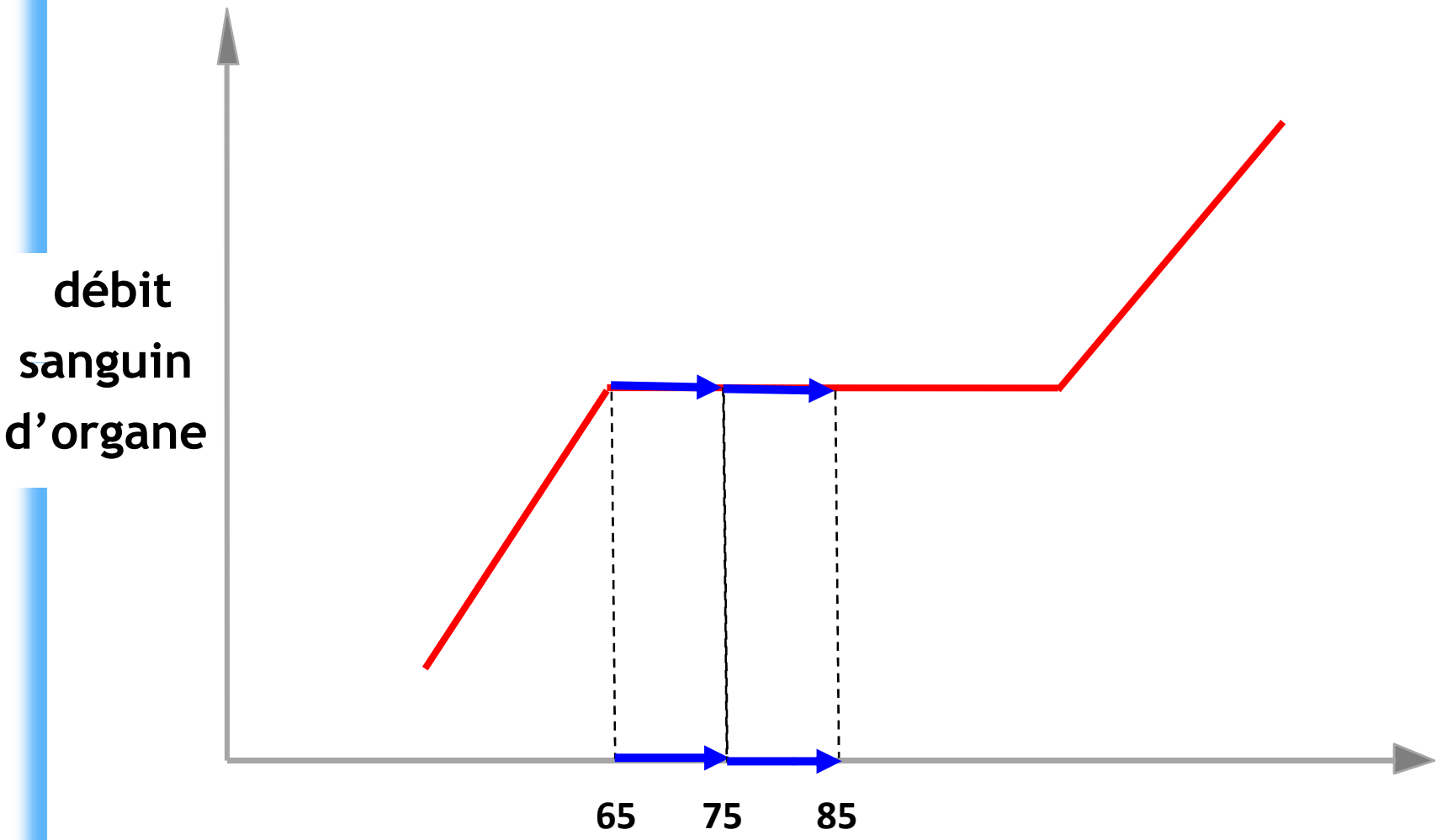
Cohorte Retrospective
111 patients en choc septique
Mortalité à J30

Durée passée sous PAM 65 mmHg



le meilleur facteur de prédiction
de la mortalité à J_{30}

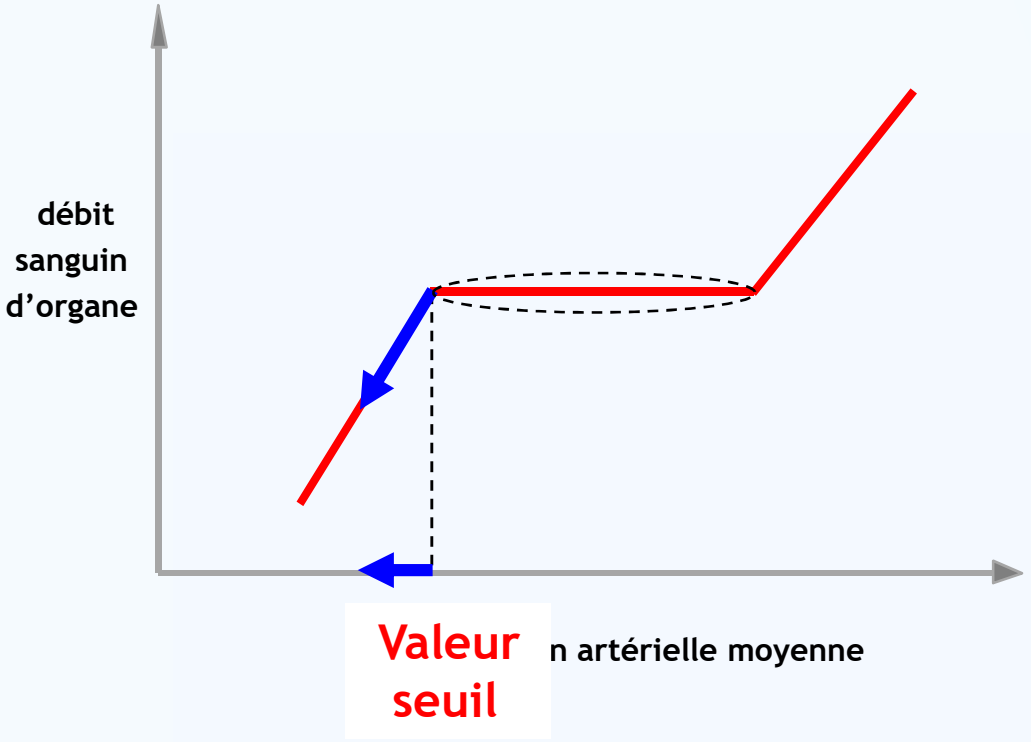
Autoregulation du débit sanguin



PAM: Cible thérapeutique

Quelle valeur seuil ?

Est-elle la même chez tous les patients?

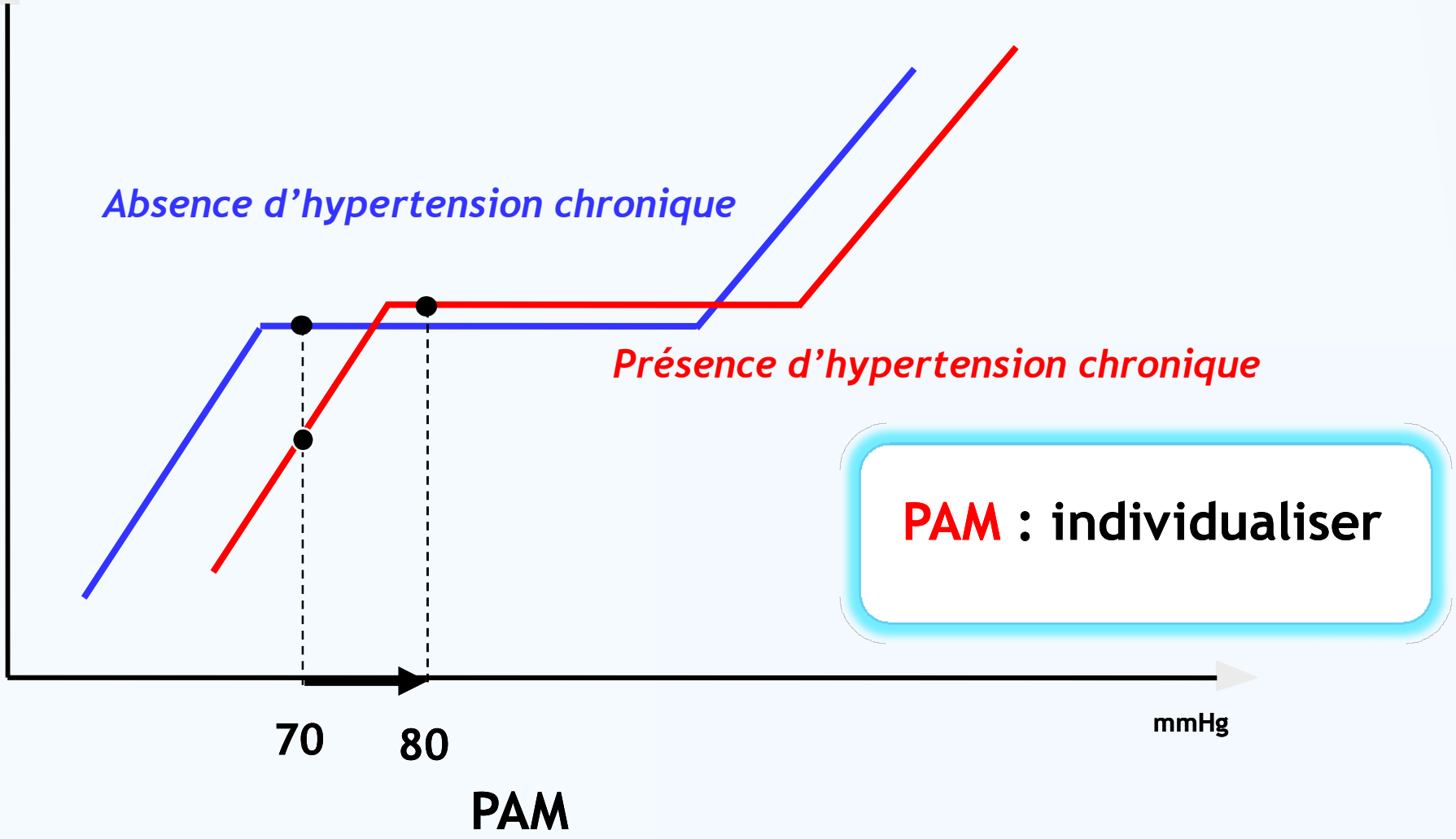


Autoregulation of Brain Circulation in Severe Arterial Hypertension

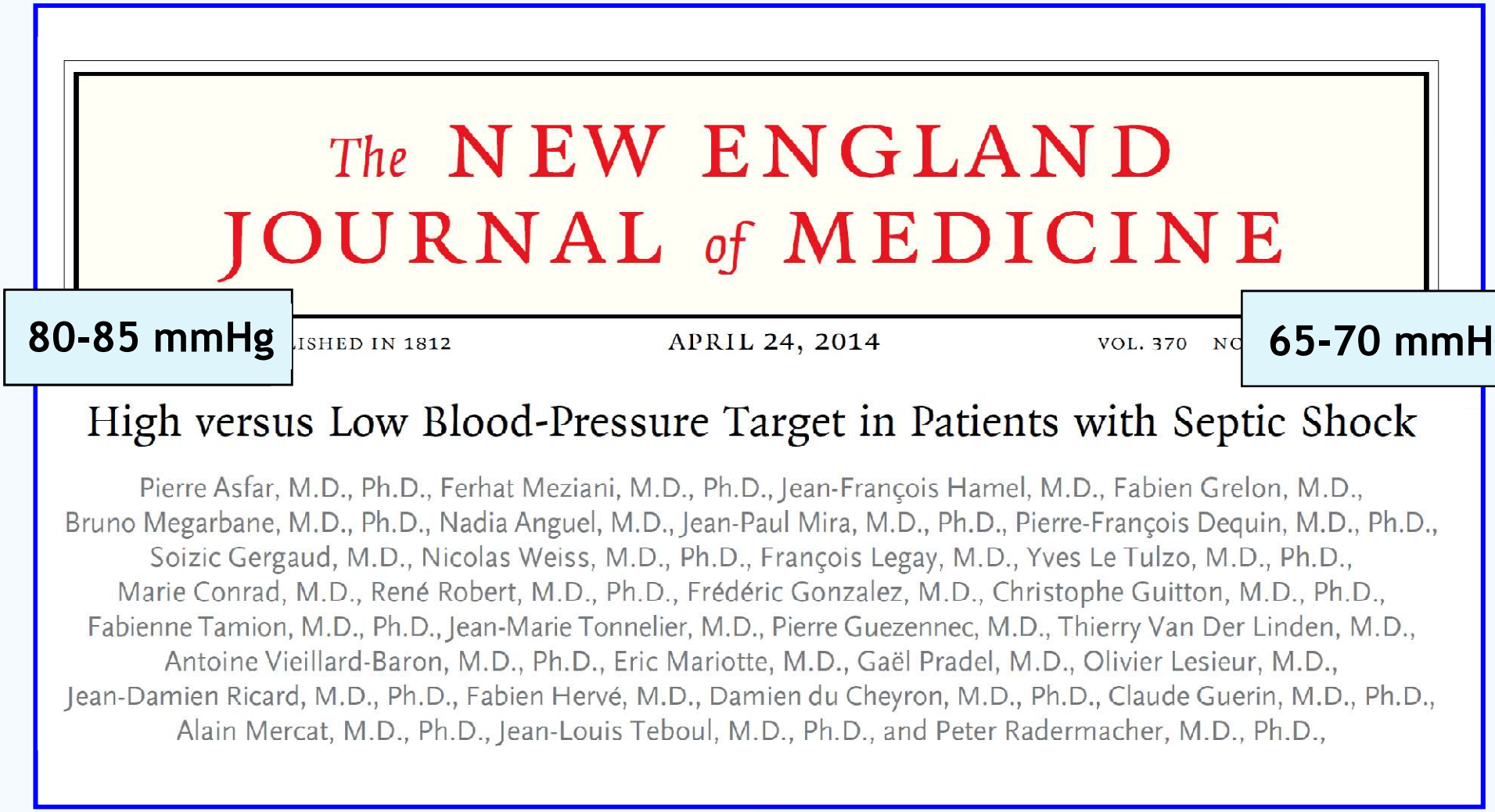
S. STRANDGAARD, J. OLESEN, E. SKINHØJ, N. A. LASSEN

British Medical Journal, 1973, 1, 507–510

débit
sanguin
es organes



PAM : individualiser



The NEW ENGLAND JOURNAL of MEDICINE

ISHED IN 1812 APRIL 24, 2014 VOL. 370 NO

High versus Low Blood-Pressure Target in Patients with Septic Shock

Pierre Asfar, M.D., Ph.D., Ferhat Meziani, M.D., Ph.D., Jean-François Hamel, M.D., Fabien Grelon, M.D., Bruno Megarbane, M.D., Ph.D., Nadia Anguel, M.D., Jean-Paul Mira, M.D., Ph.D., Pierre-François Dequin, M.D., Ph.D., Soizic Gergaud, M.D., Nicolas Weiss, M.D., Ph.D., François Legay, M.D., Yves Le Tulzo, M.D., Ph.D., Marie Conrad, M.D., René Robert, M.D., Ph.D., Frédéric Gonzalez, M.D., Christophe Guitton, M.D., Ph.D., Fabienne Tamion, M.D., Ph.D., Jean-Marie Tonnelier, M.D., Pierre Guezennec, M.D., Thierry Van Der Linden, M.D., Antoine Vieillard-Baron, M.D., Ph.D., Eric Mariotte, M.D., Gaël Pradel, M.D., Olivier Lesieur, M.D., Jean-Damien Ricard, M.D., Ph.D., Fabien Hervé, M.D., Damien du Cheyron, M.D., Ph.D., Claude Guerin, M.D., Ph.D., Alain Mercat, M.D., Ph.D., Jean-Louis Teboul, M.D., Ph.D., and Peter Radermacher, M.D., Ph.D.,

80-85 mmHg

65-70 mmHg

388 pts

388 pts

The NEW ENGLAND JOURNAL of MEDICINE

ABLISHED IN 1812 APRIL 24, 2014 VOL. 370 NO. 17

sus Low Blood-Pressure Target in Patients with Septic Shock

ar, M.D., Ph.D., Ferhat Meziani, M.D., Ph.D., Jean-François Hamel, M.D., Fabien Grelon, M.D., ne, M.D., Ph.D., Nadia Anguel, M.D., Jean-Paul Mira, M.D., Ph.D., Pierre-François Dequin, M.D., Ph.D., ergaud, M.D., Nicolas Weiss, M.D., Ph.D., François Legay, M.D., Yves Le Tulzo, M.D., Ph.D., ad, M.D., René Robert, M.D., Ph.D., Frédéric Gonzalez, M.D., Christophe Guitton, M.D., Ph.D., ion, M.D., Ph.D., Jean-Marie Tonnelier, M.D., Pierre Guezennec, M.D., Thierry Van Der Linden, M.D., e Vieillard-Baron, M.D., Ph.D., Eric Mariotte, M.D., Gaël Pradel, M.D., Olivier Lesieur, M.D., card, M.D., Ph.D., Fabien Hervé, M.D., Damien du Cheyron, M.D., Ph.D., Claude Guerin, M.D., Ph.D., Mercat, M.D., Ph.D., Jean-Louis Teboul, M.D., Ph.D., and Peter Radermacher, M.D., Ph.D.,

Variable	Low-Target Group (N=388)	High-Target Group (N=388)	P Value
Primary outcome: death at day 28 — no. (%)*	132 (34.0)	142 (36.6)	0.57
Secondary outcomes — no./total no. (%)			
Death at day 90†	164 (42.3)	170 (43.8)	0.74
Survival at day 28 without organ support‡	241 (62.1)	235 (60.6)	0.66
Doubling of plasma creatinine	161 (41.5)	150 (38.7)	0.42
No chronic hypertension	71/215 (33.0)	85/221 (38.5)	0.32
Chronic hypertension	90/173 (52.0)	65/167 (38.9)	0.02
Renal-replacement therapy from day 1 to day 7	139 (35.8)	130 (33.5)	0.50
No chronic hypertension	66/215 (30.7)	77/221 (34.8)	0.36
Chronic hypertension	73/173 (42.2)	53/167 (31.7)	0.046
Atrial fibrillation	11 (2.8)	26 (6.7)	0.02
Ventricular fibrillation or tachycardia	15 (3.9)	22 (5.7)	0.24
Digital ischemia	9 (2.3)	10 (2.6)	0.82
Mesenteric ischemia	9 (2.3)	9 (2.3)	1.00
Bleeding	42 (10.8)	31 (8.0)	0.22

EDITORIAL Open Access

Equilibrating SSC guidelines with individualized care

Jean-Louis Vincent[1*], Mervyn Singer[2], Sharon Einav[3], Rui Moreno[4], Julia Wendon[5], Jean-Louis Teboul[6], Jan Bakker[7,8,9,10], Glenn Hernandez[11], Djillali Annane[12], Angélique M. E. de Man[13], Xavier Monnet[14], V. Marco Ranieri[15], Olfa Hamzaoui[16], Jukka Takala[17], Nicole Juffermans[18,19], Jean-Daniel Chiche[20], Sheila N. Myatra[21] and Daniel De Backer[22]

Critical Care (2021) 25:397

- We recommend **individualizing** arterial **blood pressure levels.**

  Although a mean value of **65 mmHg** may be recommended as an **initial g**

  the optimal level may be **higher** in patients with a history of **hypertensio**

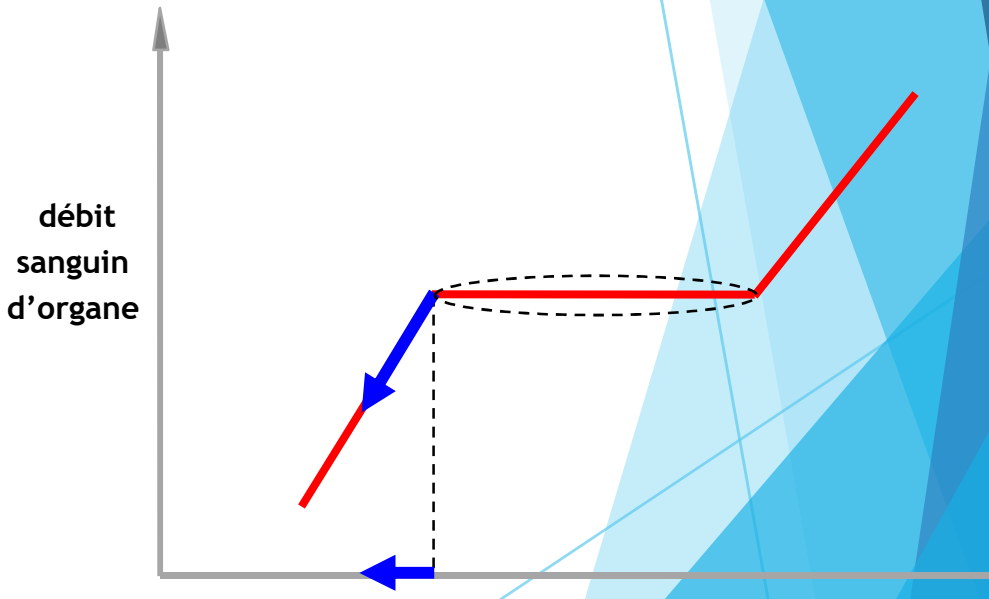
  atherosclerosis or chronic kidney disease

PAM: Cible thérapeutique

Quelle valeur seuil ?

Est-elle la même chez tous les patients?

Est-elle la même dans toutes les situations?



SPECIAL ISSUE INSIGHT

Central venous pressure (CVP)

Olfa Hamzaoui[1*] and Jean-Louis Teboul[2,3]

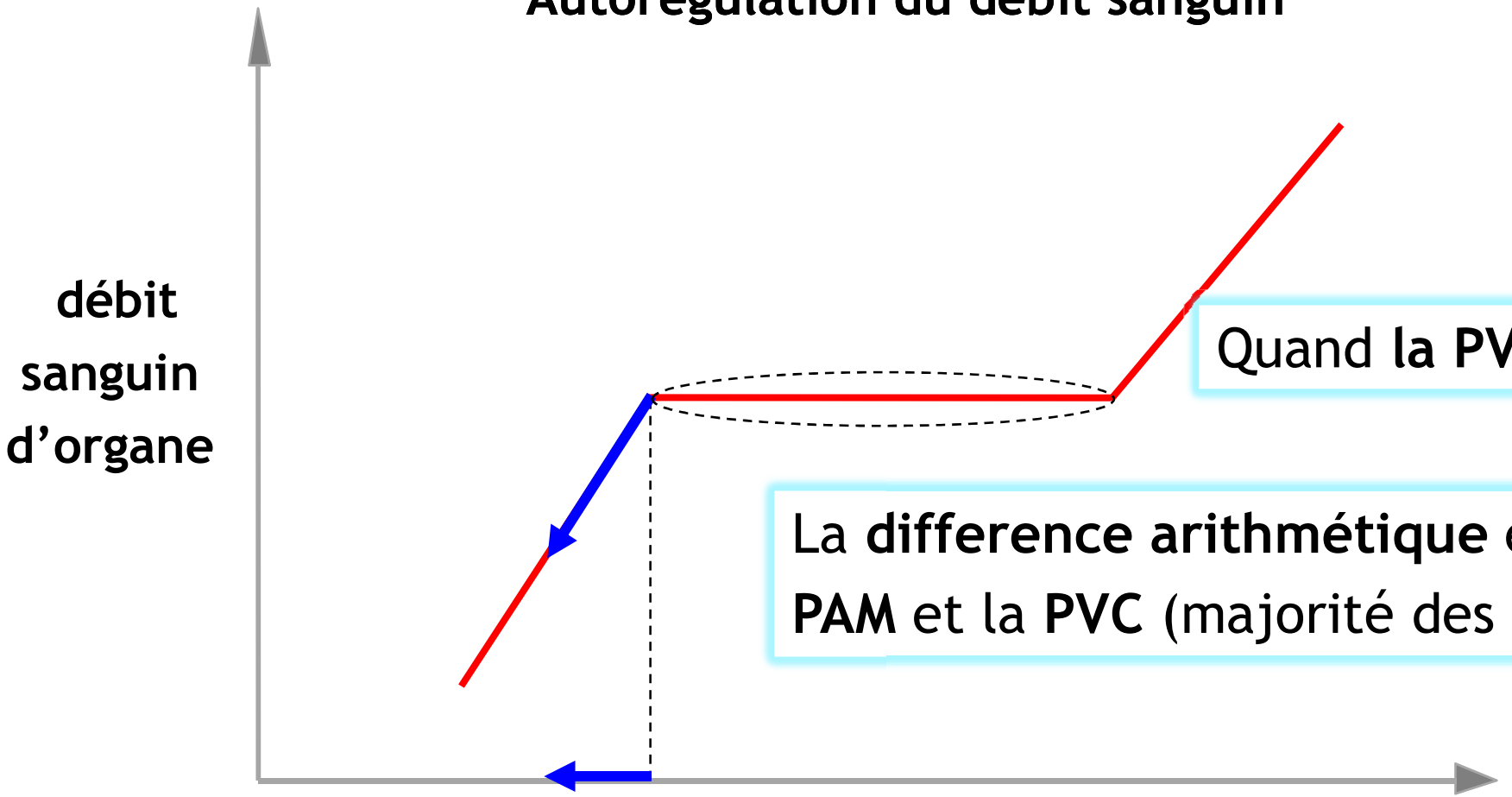
Intensive Care Med (2022) 48:1498–1500

CVP as the downstream pressure for organ perfusion

The CVP also reflects the downstream pressure for perfusion of most vital organs (e.g., brain and kidney). The mean perfusion pressure (MPP) of such organs is the difference between mean arterial pressure (MAP) and CVP.

PPM = PAM - PVC ⇒ **PAM** reflète **PPM** quand la PVC est basse

Autoregulation du débit sanguin



Low mean perfusion pressure is a risk factor for progression of acute kidney injury in critically ill patients – A retrospective analysis

Marlies Ostermann[1*], Anna Hall[2] and Siobhan Crichton[3]

BMC Nephrology (2017) 18:151

Table 2 Multivariable analysis: Risk factors for progression from AKI I to AKI III

Parameter	OR (95% CI)[a]	p-value
Cumulative fluid balance on day of AKI I [ml]	1.00 (0.99–1.00),	0.98
MAP <65 mmHg for >1 h in first 12 h after diagnosis of AKI I	0.97 (0.48–1.96)	0.93

La **pression de perfusion moyenne** (PPM = PAM - PVC), mais pas **la PAM** était un facteur indépendant associé à la **progression** de **l'IRA.**

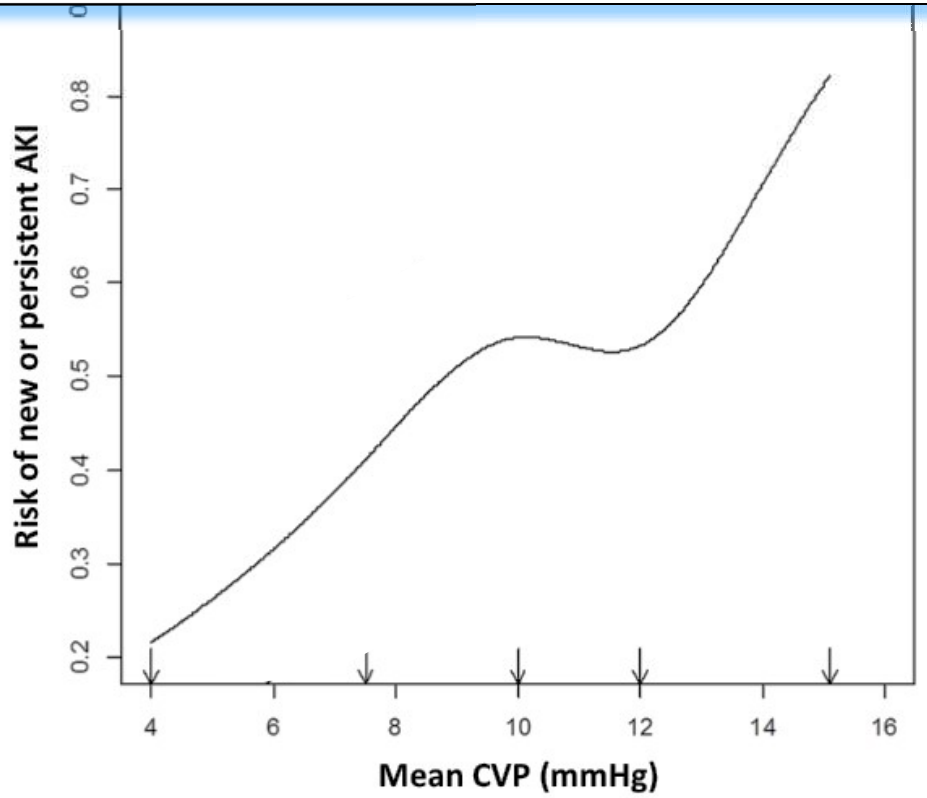
Une valeur de **PPM** de **60 mmHg** était retrouvée comme **valeur-seuil.**

Association between systemic hemodynamics and septic acute kidney injury in critically ill patients: a retrospective observational study

Matthieu Legrand[1,2*], Claire Dupuis[1], Christelle Simon[1], Etienne Gayat[1,3], Joaquim Mateo[1], Anne-Claire Lukaszewicz[1,2,4] and Didier Payen[1,2,4]

Critical Care 2013, **17**:R278

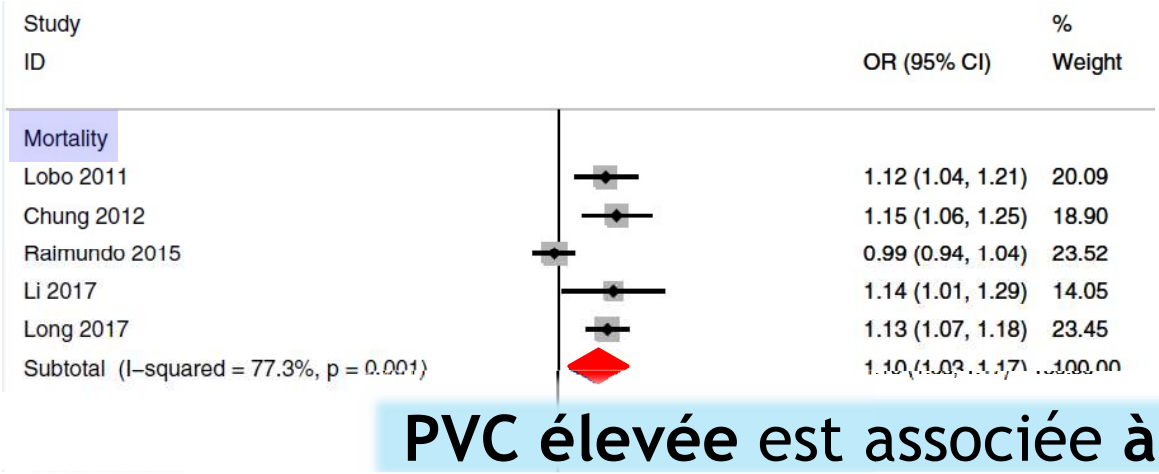
Plus la **PVC** est **élevée**, plus **élevé** est le risque d'**IRA**



Elevated central venous pressure is associated with increased mortality and acute kidney injury in critically ill patients: a meta-analysis

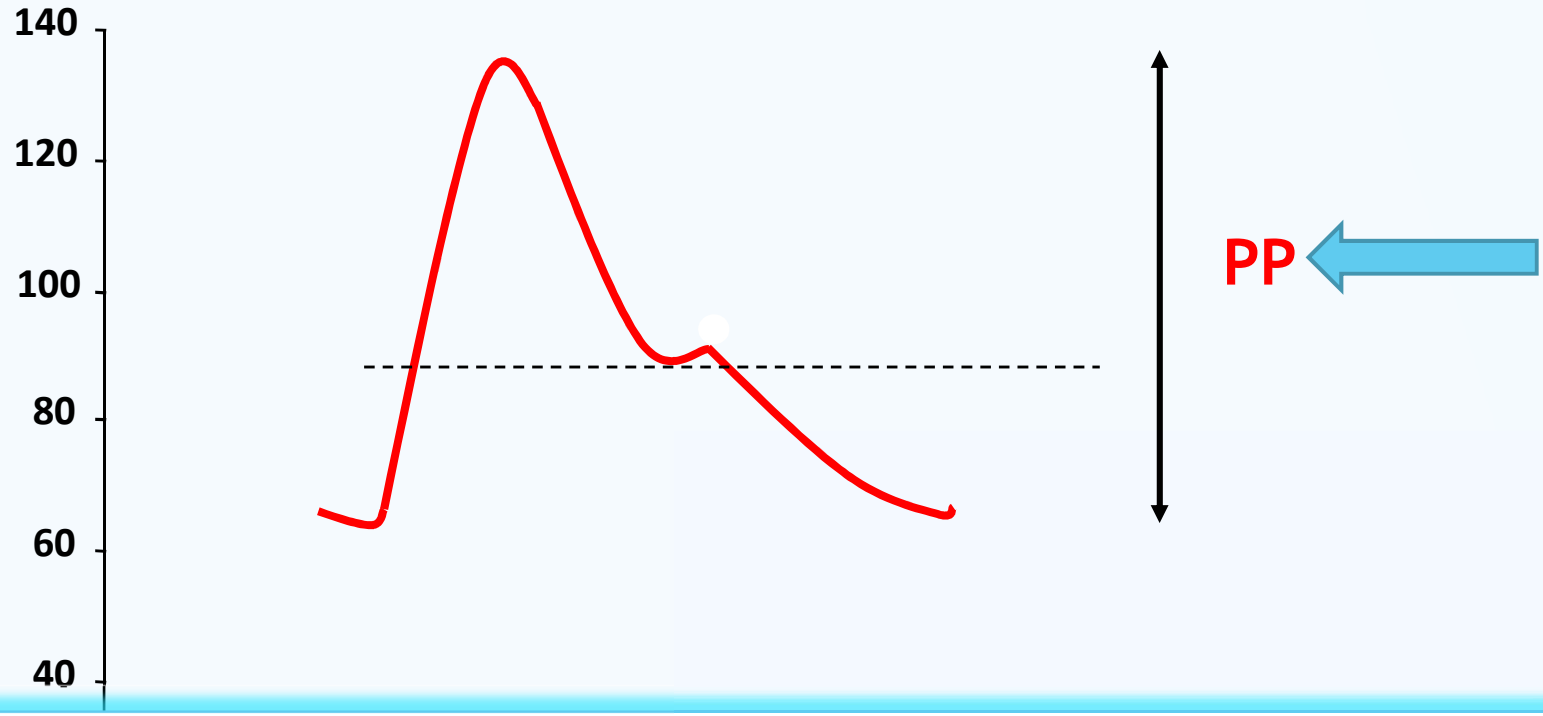
Chuan-Yu Chen[1], Yan Zhou[1], Peng Wang[1], En-Yao Qi[1] and Wan-Jie Gu[2*]

Critical Care (2020) 24:80



PVC élevée est associée **à un risqué élevé de mortalit**

Pression artérielle*(mmHg)*



Pression Pulsée aortique = k. VES . rigidité aortique

Chemla et al AJP 1998

Pression Pulsée aortique = k. VES . rigidité aortique

Pour une **rigidité aortique** donnée → **Variation** de **PP <u>aortique</u>** devrait refléter **la variation** du **VES**

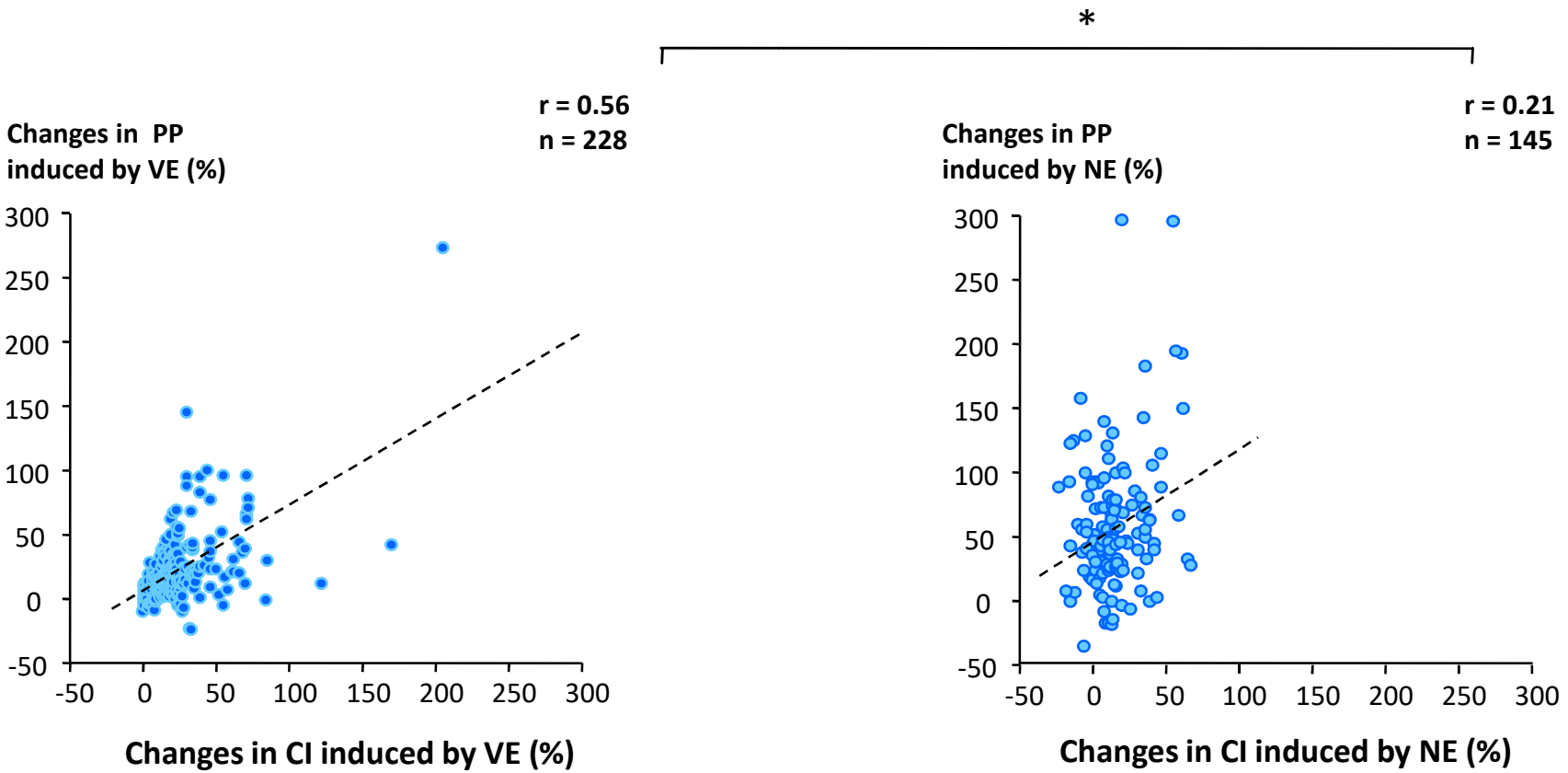
Utile pour suivre la **la variation du VES** sous un traitement

→ **Est-ce que la variation PP <u>périphérique</u> reflète la variation du VES?**

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; 39:1394–1399



Intensive Care Med (2011) 37:942–949

ORIGINAL

Nicolas Dufour
Denis Chemla
Jean-Louis Teboul
Xavier Monnet
Christian Richard
David Osman

Changes in pulse pressure following fluid loading: a comparison between aortic root (non-invasive tonometry) and femoral artery (invasive recordings)

Table 5 Relationship between changes in PP and SV after volume expansion in young and elderly patients

PP versus SV relationship	Age <60 years		Age ≥60 years	
	r	*p*	*r*	*p*
Femoral	0.46	0.03	0.75	<0.01

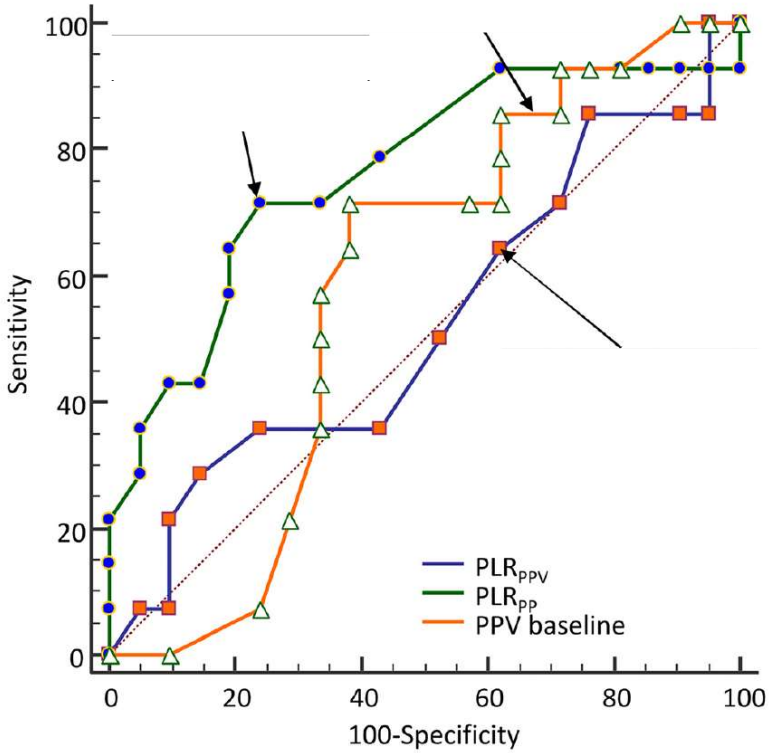
amic changes of pulse pressure but not of pulse pressure variation
ng passive leg raising predict preload responsiveness in critically
tients with spontaneous breathing activity

i, MD, PhD [a,b], Francesca Moretto, MD [a], Dominique Prat, MD [c], Frederic Jacobs, MD [c],
Louis Teboul, MD, PhD [a,b], Olfa Hamzaoui, MD [c,*]

Journal of Critical Care 72 (2022) 154141

33 Patients ventilated with pressure support mode or total spontaneously breathing

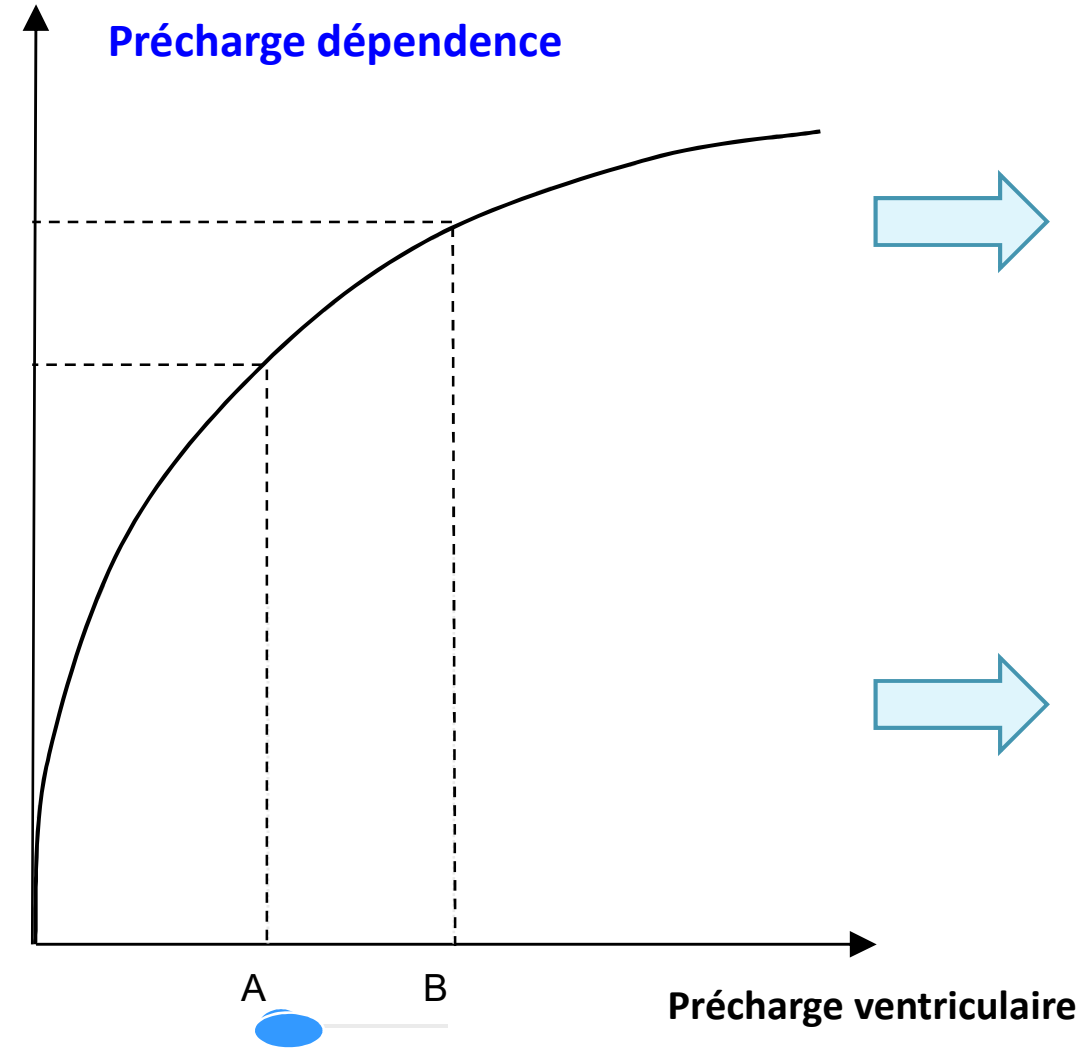
To evaluate Delta (PP) and/or pu
pressure variation (PPV)
during (PLR) can be used to evalu
preload responsiveness



in patients **with spontaneous breathing activity**, **the increase in PP of equal to or higher than 2 mmHg during PLR** may be **helpful to discriminate** preload **responders** from **non-responders** with fair accuracy

- Analyse des valeurs de la pression artérielle statique
- **Analyse de la variation dynamique de la pression artérielle**

Intéraction Coeur-Poumon



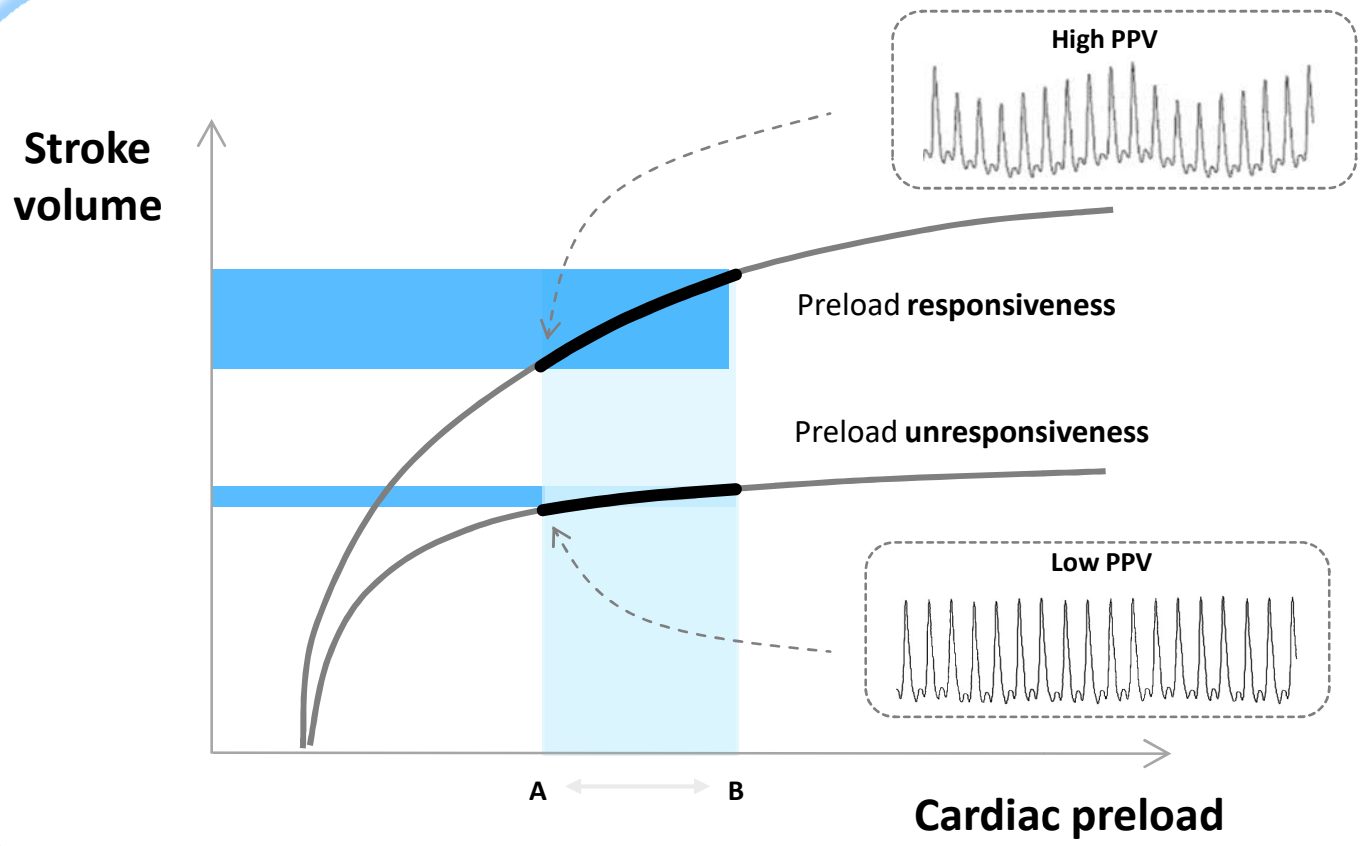
VM peut induire **une variation cyclique de la précharge** et **du VES e**
cas précharge dépendance des deux ventricules

Avec une valeur constante de la compliance aortique PP peut réflete VES

Arterial Pulse Pressure Variation with Mechanical Ventilation

Jean-Louis Teboul[1], Xavier Monnet[1], Denis Chemla[2], and Frédéric Michard[3]

Am J Respir Crit Care Med Vol 199, Iss 1, pp 22–31, Jan 1, 2019



Physiologie Appliquée

Que doit-on retenir ?

La pression artérielle est un vrai outil de monitorage

Toutes les **composantes statiques** de la pression artérielle (**PAS**, **PAD**, **PAM**, **P**
sont **importantes à considérer** lors de la prise en charge des patients de Réa

- **PAS** : reflète **la postcharge VG**
- **PAD :** peut être utilisé **comme « trigger » pour débuter les vasopresseurs**
- **PAM** : **une cible thérapeutique**
- **PP** : peut être utilisé comme un **substitut du VES**

La **variabilité de la PP (deltaPP)** **sous VM** peut-être utilisée comme un indicat
de **précharge-dépendance**

Merci pour votre attention

Merci pour votre attention

Des questions ?