Le traitement du choc jusqu'au coeur des tissus

Dr Yves Bouckaert
Soins Intensifs C.H.U. Tivoli

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Intensive Care Med (2014) 40:1795–1815
DOI 10.1007/s00134-014-3525-z

CONFERENCE REPORTS AND EXPERT PANEL

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Consensus on circulatory shock and hemodynamic monitoring. Task force of the European Society of Intensive Care Medicine

Definition, pathophysiology, features and epidemiology of shock

Definition

Shock is best defined as a life-threatening, generalized form of acute circulatory failure associated with inadequate oxygen utilization by the cells. It is a state in which the circulation is unable to deliver sufficient oxygen to meet the demands of the tissues, resulting in cellular dysfunction. The result is cellular dysoxia, i.e. the loss of the physiological independence between oxygen delivery and oxygen consumption, associated with increased lactate levels. Some clinical symptoms suggest an impaired microcirculation, including mottled skin, acrocyanosis, slow capillary refill time and an increased central-to-toe temperature gradient.

- Insuffisance circulatoire aiguë
- Transport en oxygène ne rencontre pas la demande des tissus
- Utilisation inadéquate de l’oxygène par les cellules
- Dysfonction cellulaire
- Augmentation du lactate

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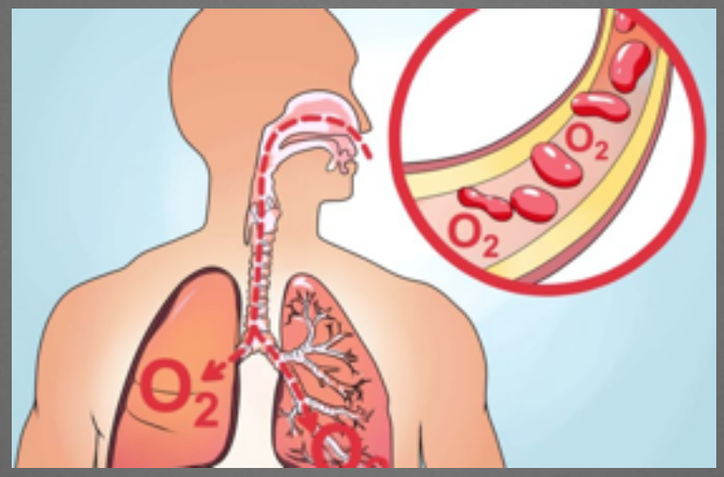
Oxygénation



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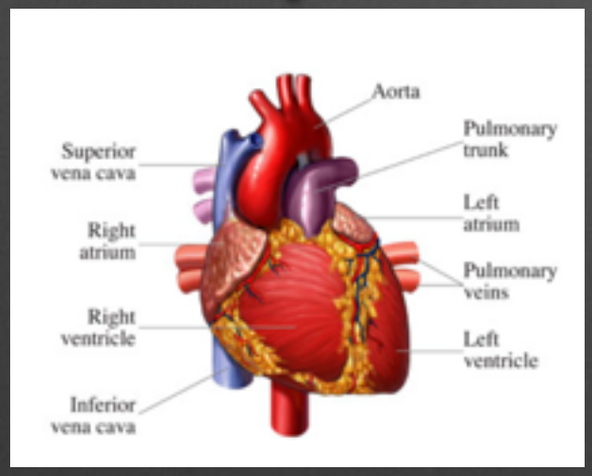

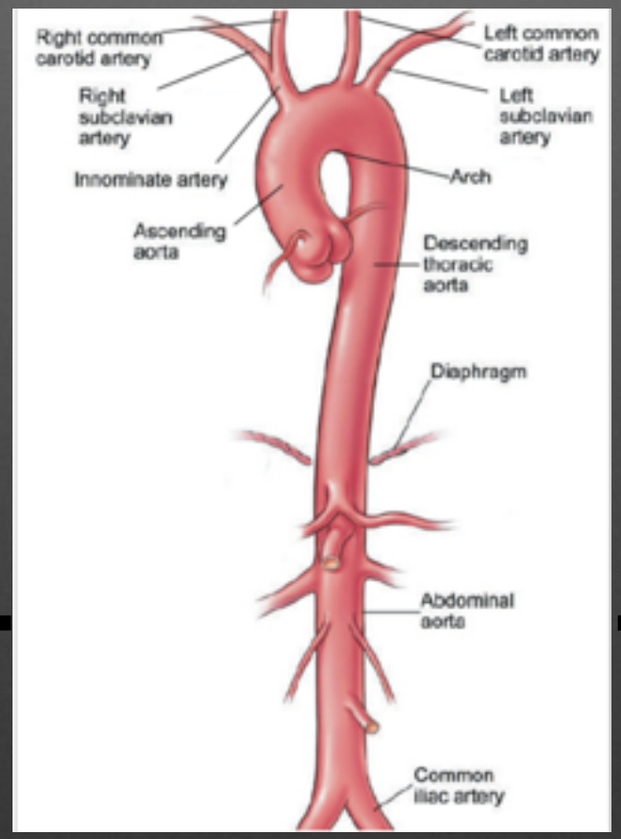

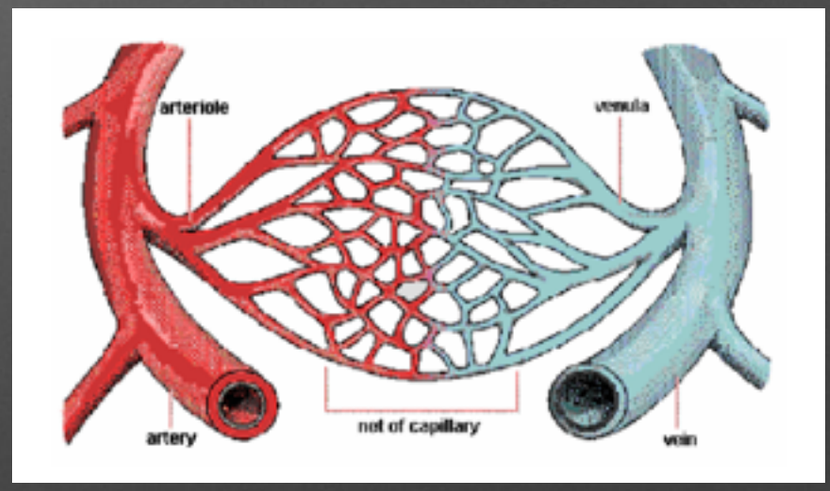

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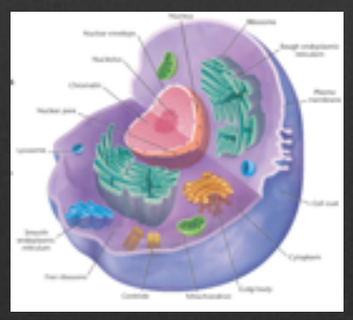

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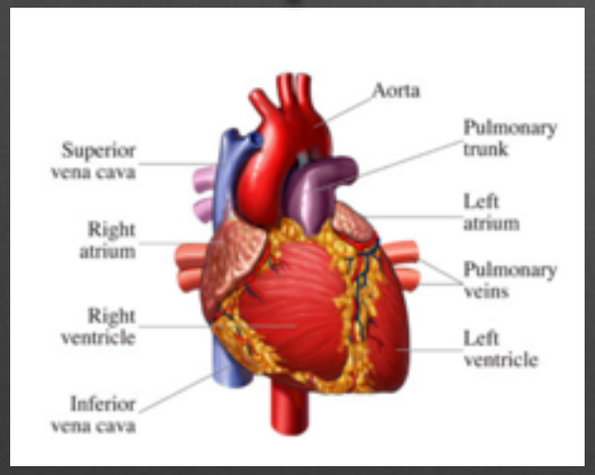
Oxygénation

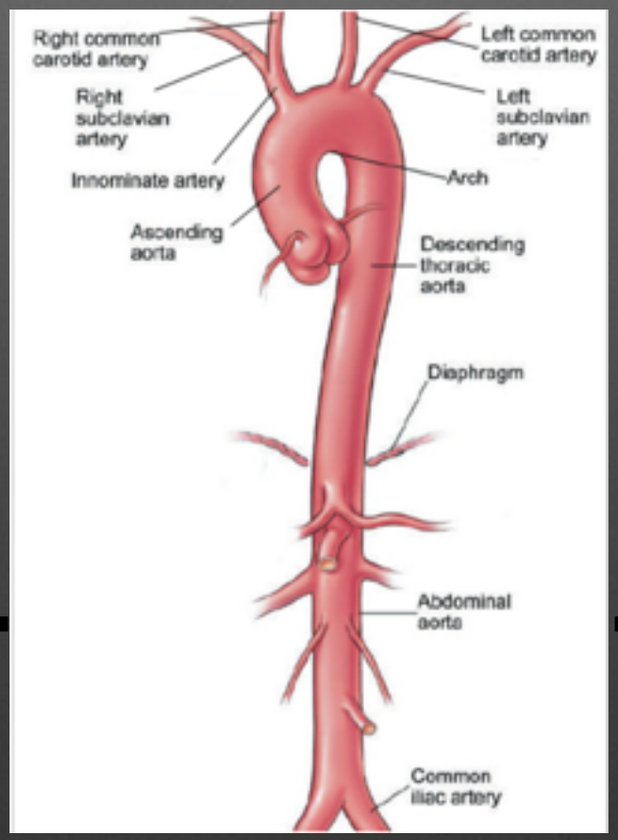
CaO2 = Contenu artériel en O2

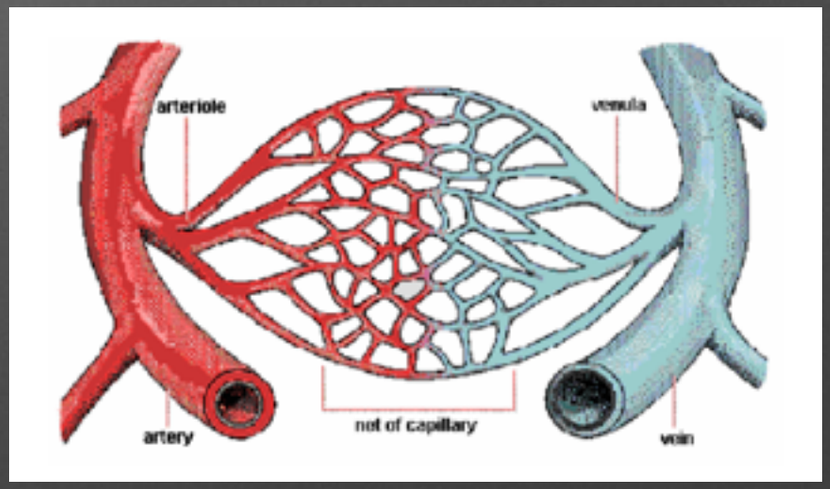
O2

CO2

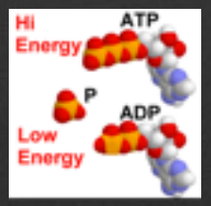
Transport







Consommation



Oxygénation

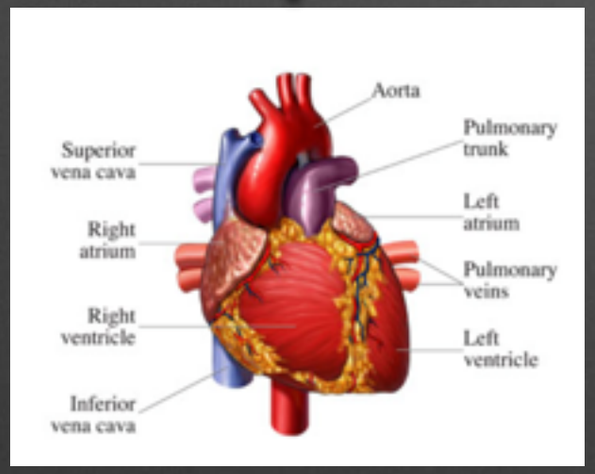
CaO_2 = Contenu artériel en O_2

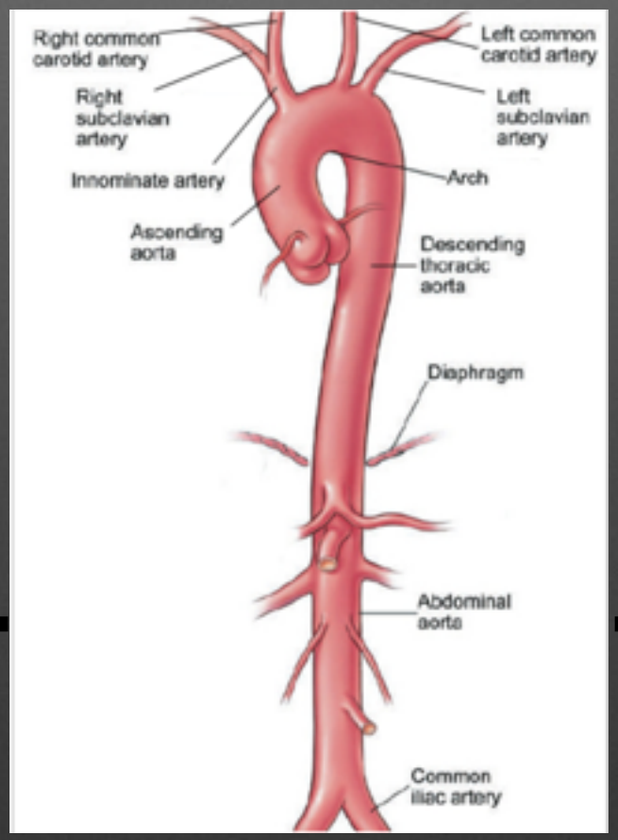
= $SaO_2 \times Hb \times 1{,}39 + 0{,}003 \times PaO_2$

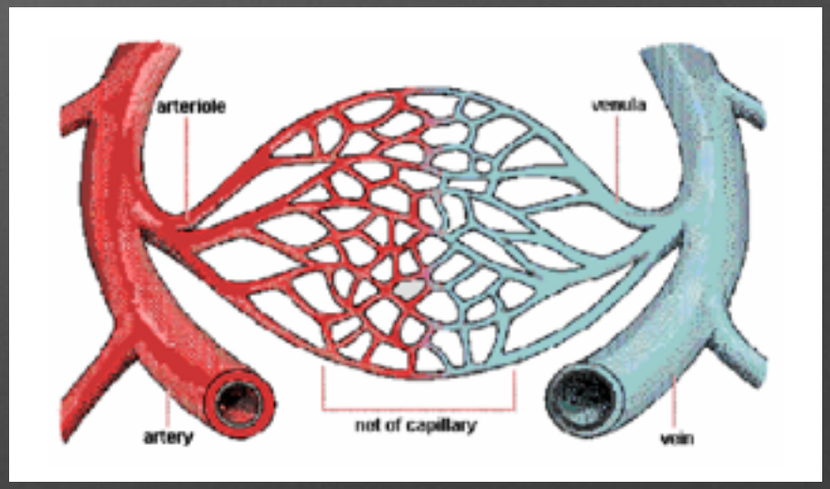
O_2

CO_2

Transport







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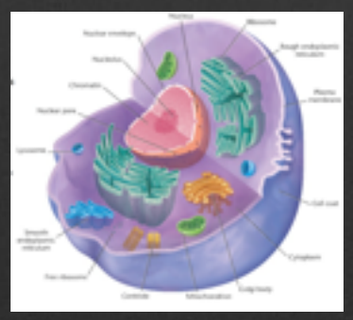
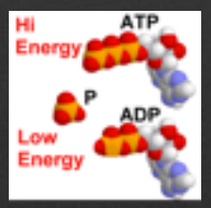




Oxygénation

CaO_2 = Contenu artériel en O_2

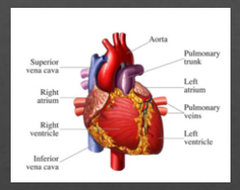
= $SaO_2 \times Hb \times 1{,}39 + 0{,}003 \times PaO_2$

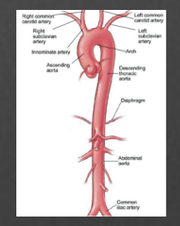
O_2

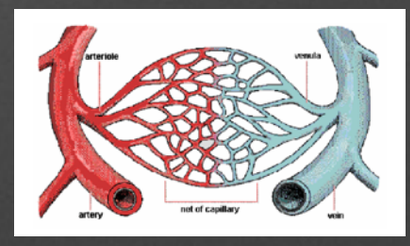
CO_2

Transport

$DO_2 = DC \times CaO_2$







Consommation

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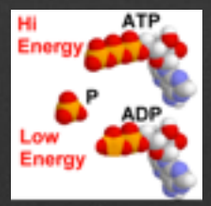
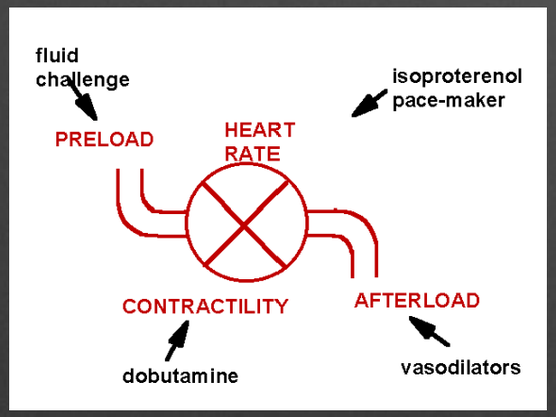
Consommation

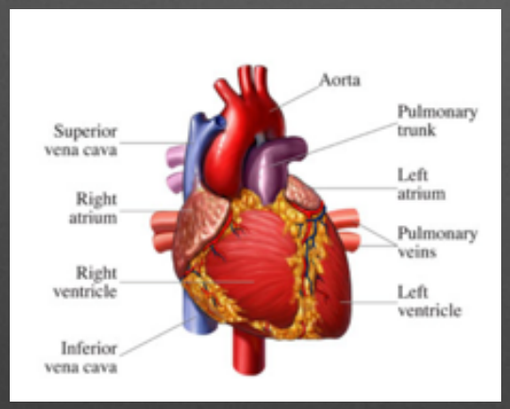


+ CO_2

Le transport en oxygène

$$DO_2 = DC \times CaO_2$$





Hb

SaO_2

PaO_2

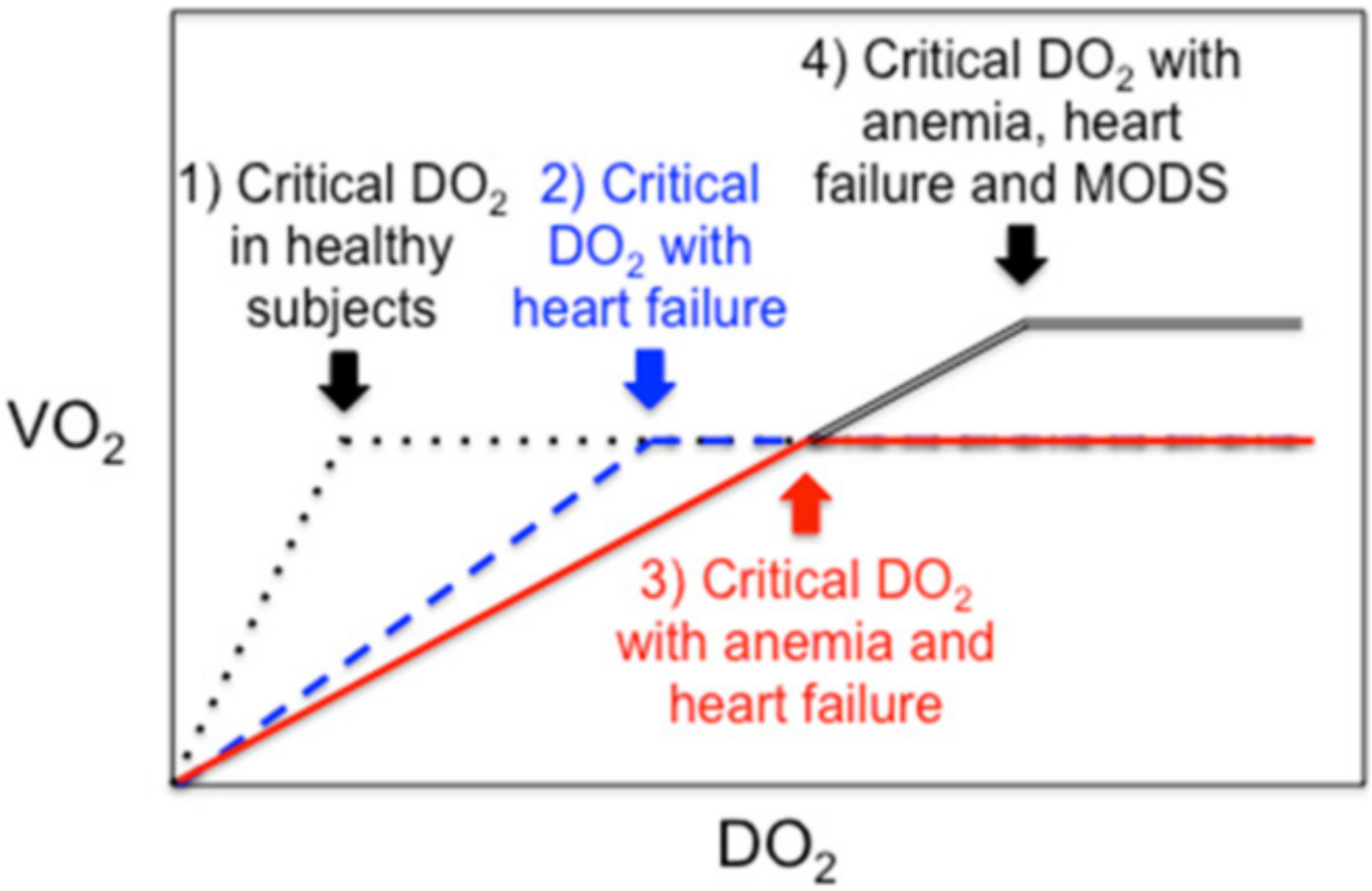
DO_2 = Transport en O_2

DC = Débit cardiaque

CaO_2 = Contenu artériel en O_2

$= SaO_2 \times Hb \times 1{,}39 + 0{,}003 \times PaO_2$

Relation entre la demande et le transport en oxygène



La consommation d'O2

$$VO2 = DC \times (CaO2 - CvO2)$$

$VO2 = DC \times (Hb \times 1{,}39 \times SaO2 - Hb \times 1{,}39 \times SvO2)$

$VO2 = DC \times Hb \times 1{,}39 \times (SaO2 - SvO2)$

$SaO2 - SvO2 = VO2 / DC \times Hb \times 1{,}39$

$$SvO2 = SaO2 - \frac{VO2}{DC \times Hb \times 1{,}39}$$

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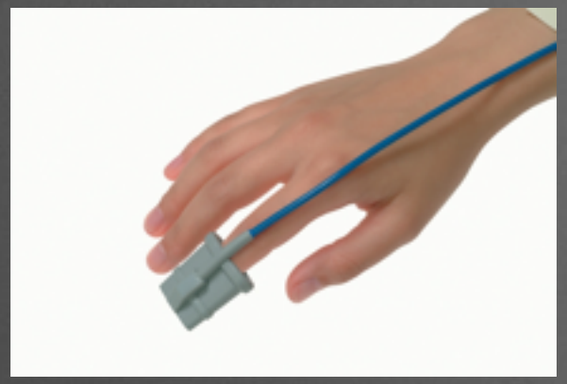
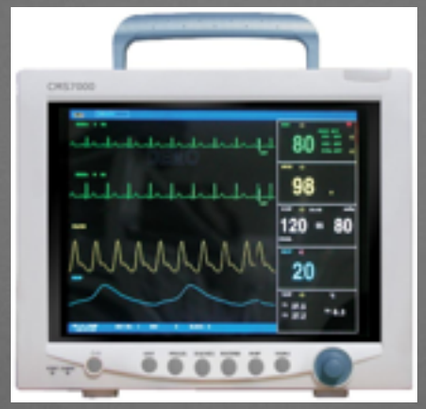
Monitoring

Oxygénation





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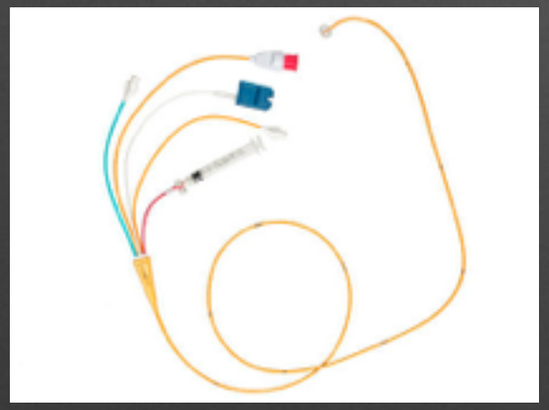

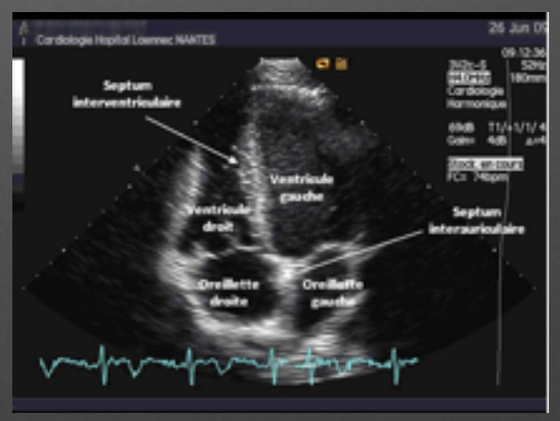

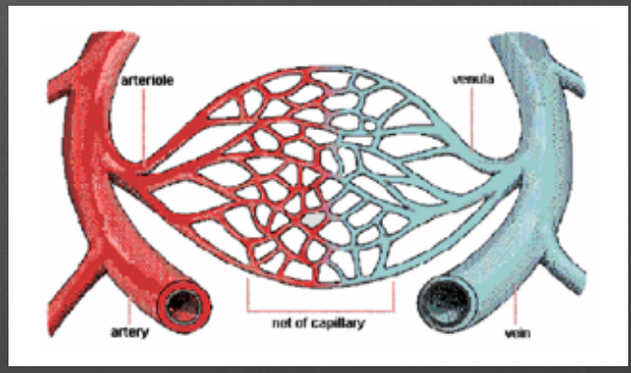

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Consommation

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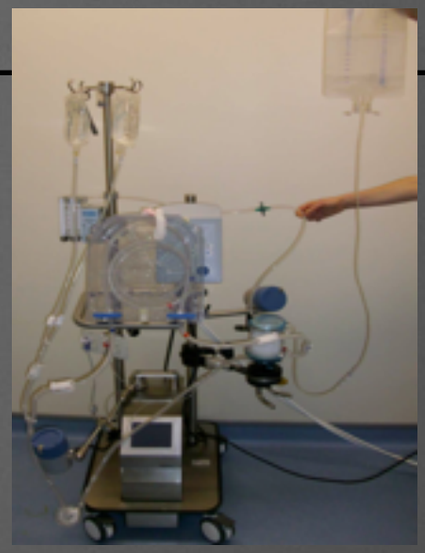
Prise en charge

Oxygénation



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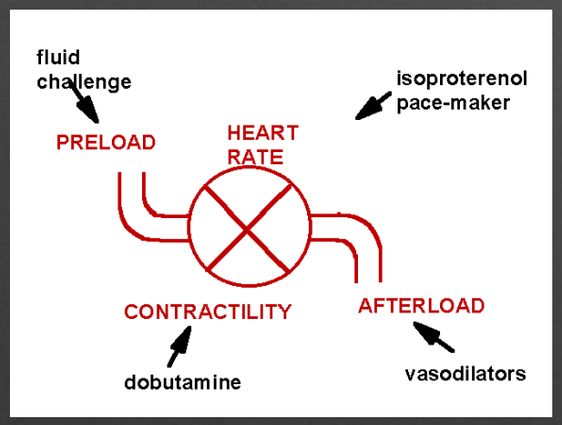

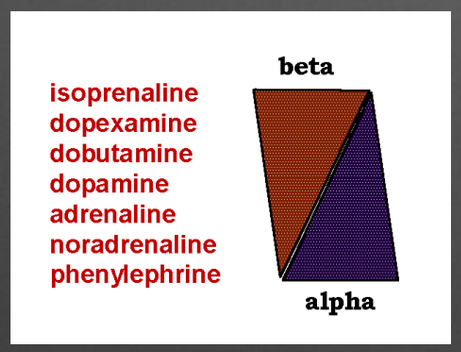

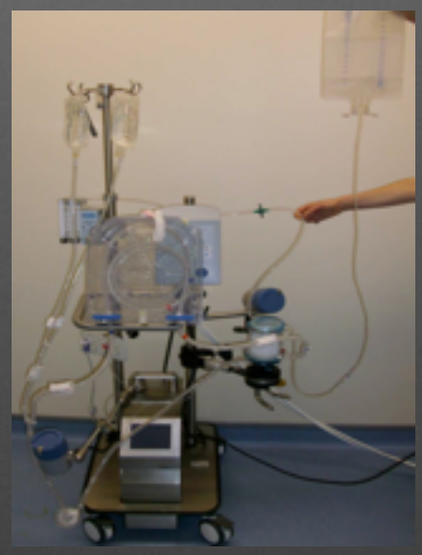

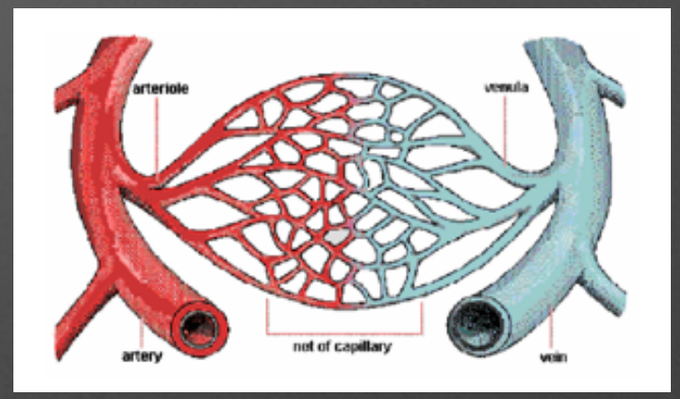

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Consommation

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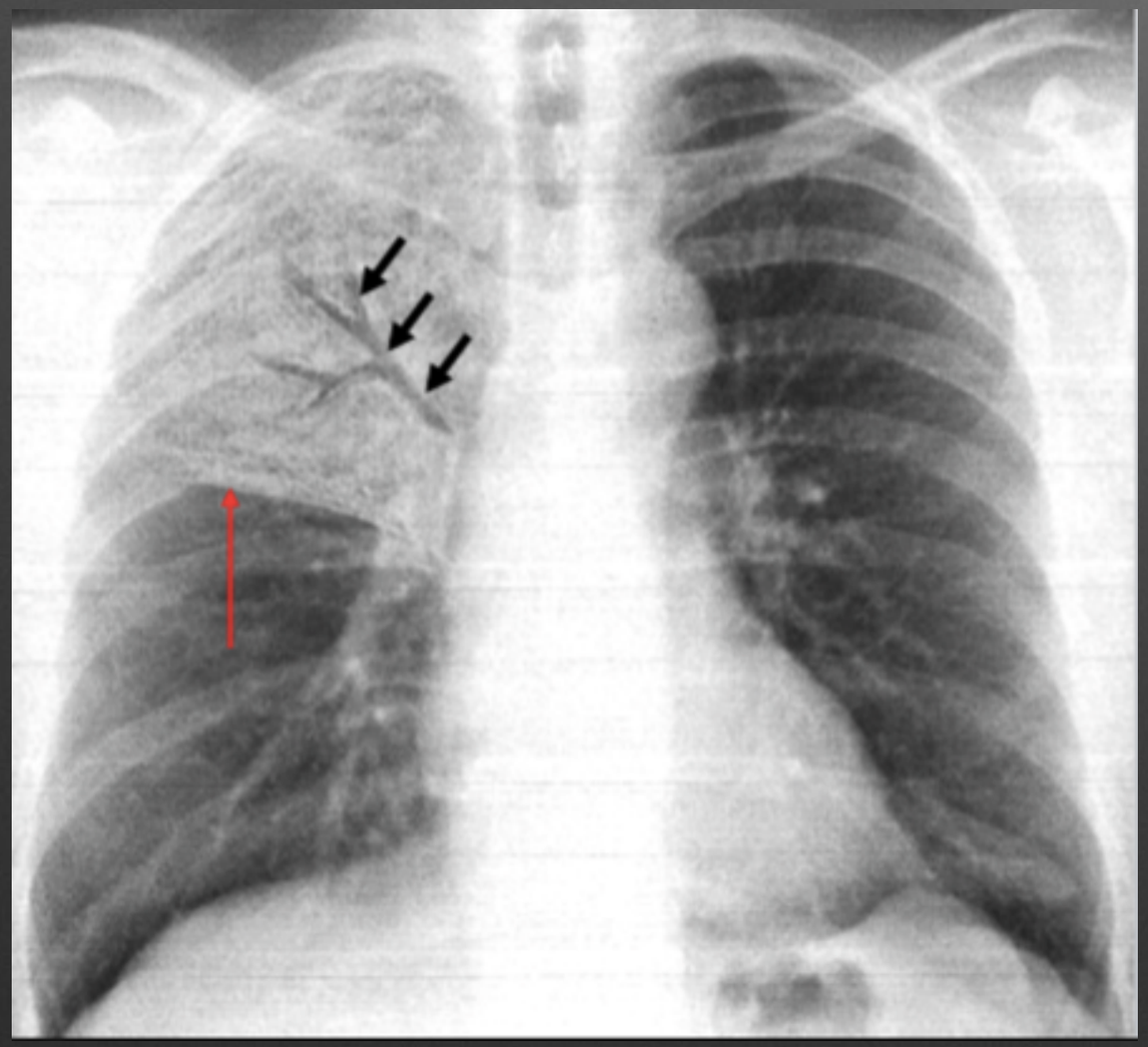
Patient de 42 ans

Pneumonie à pneumocoque

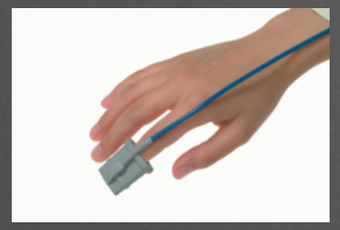


ARDS

Choc septique

Ceftriaxone

Oxygénation

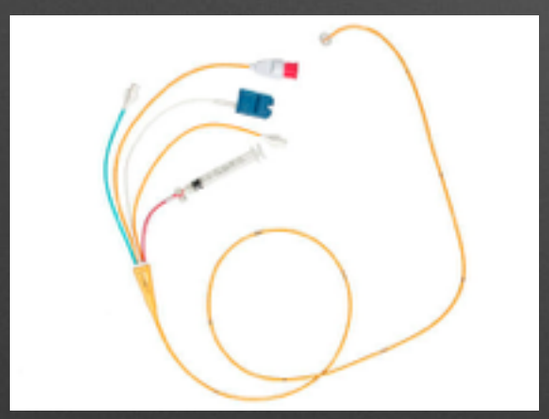


SpO2 94%

peep 10 cmH2O
FIO2 60%

7,31/37/74/95%
Hb 10,3 g/dl

Transport

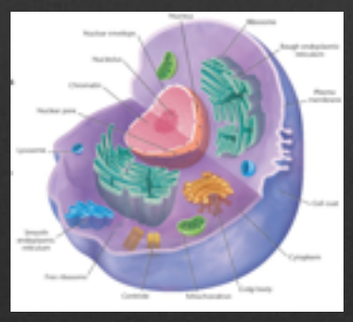


Plasmalyte 4 litres
Noradrénaline 0,8 gamma/kg/min

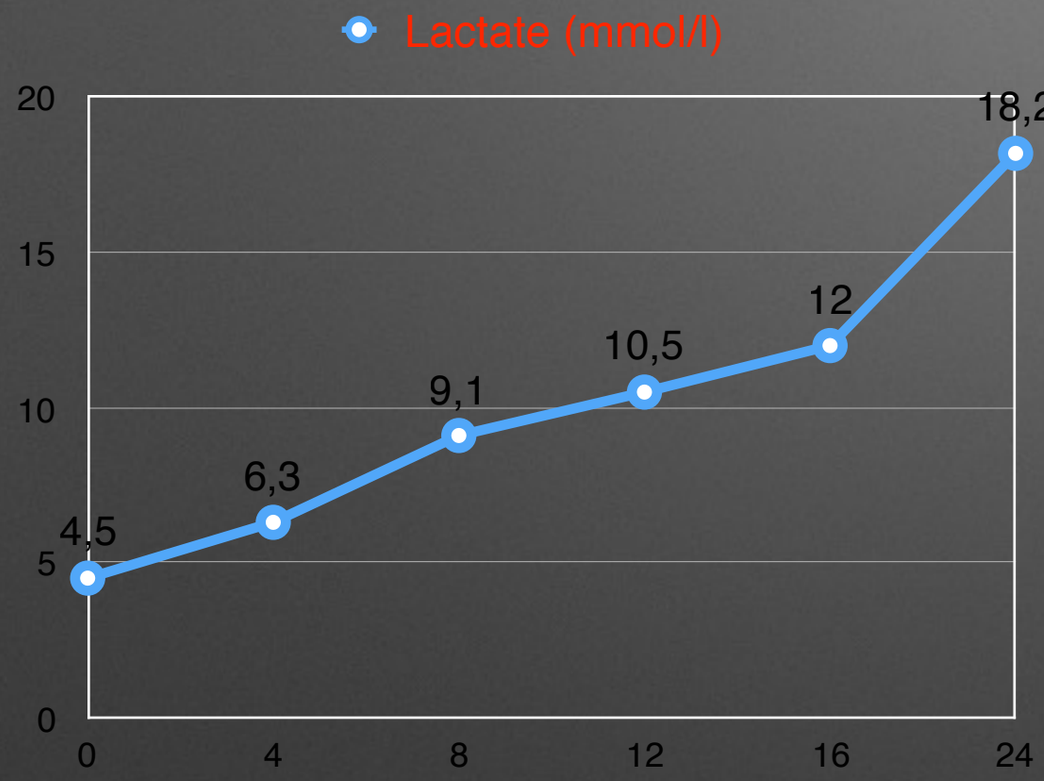
IC 4,1 l/min
SVO2 73%

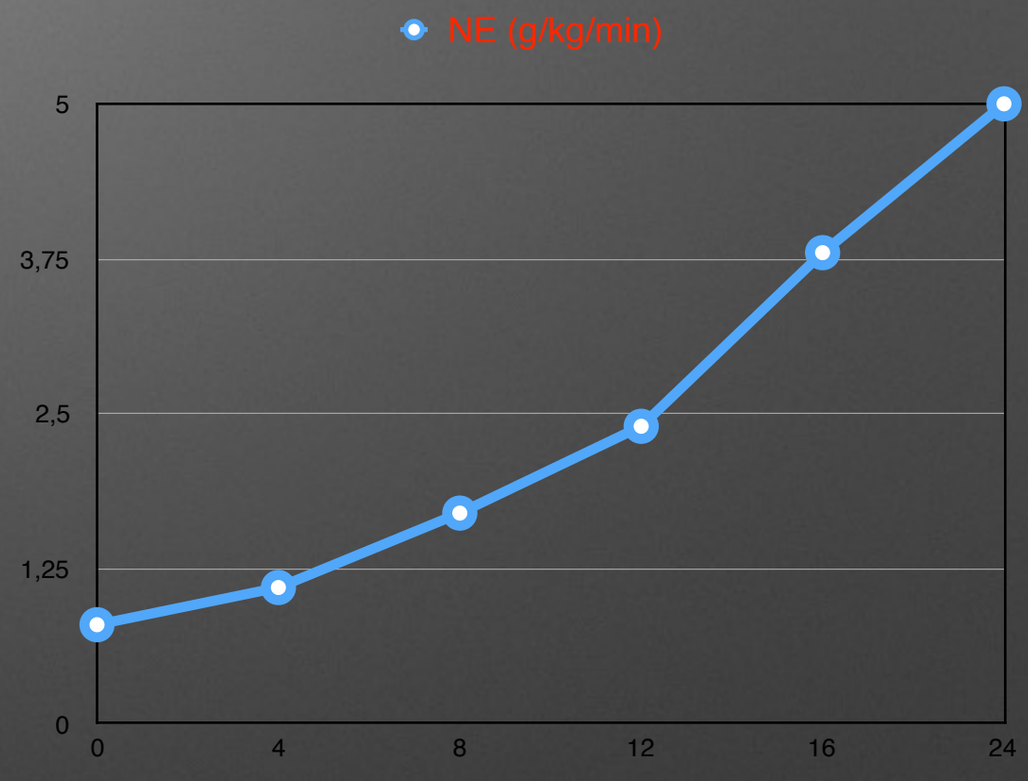
Pam 72 mmHg

Consommation



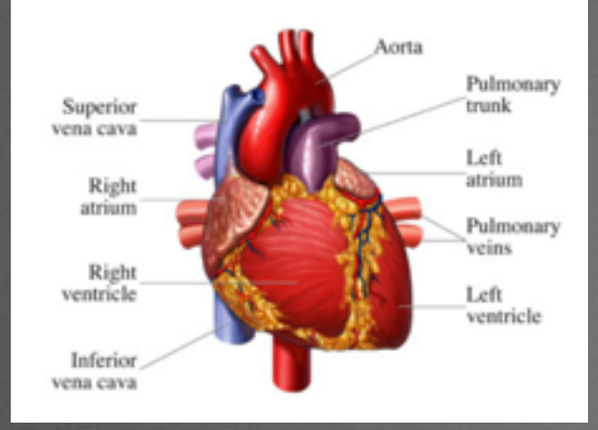
Evolution

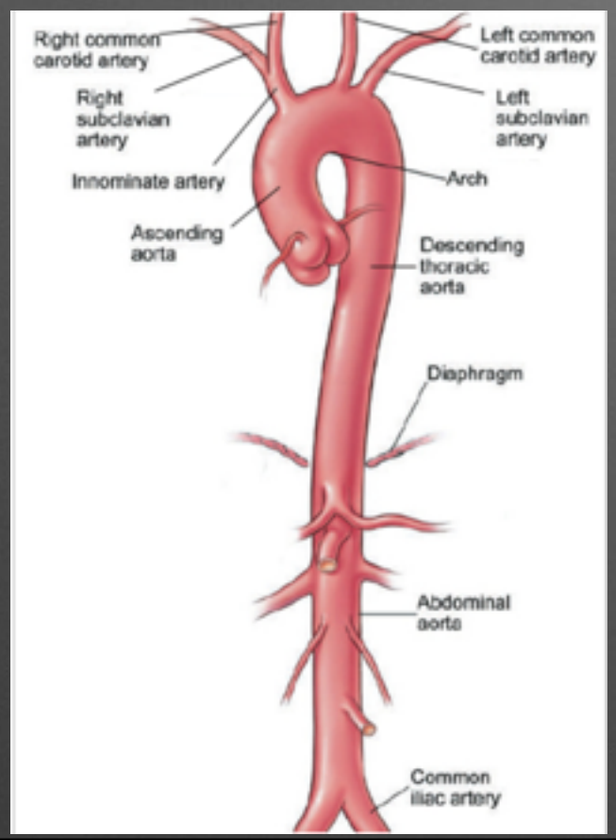


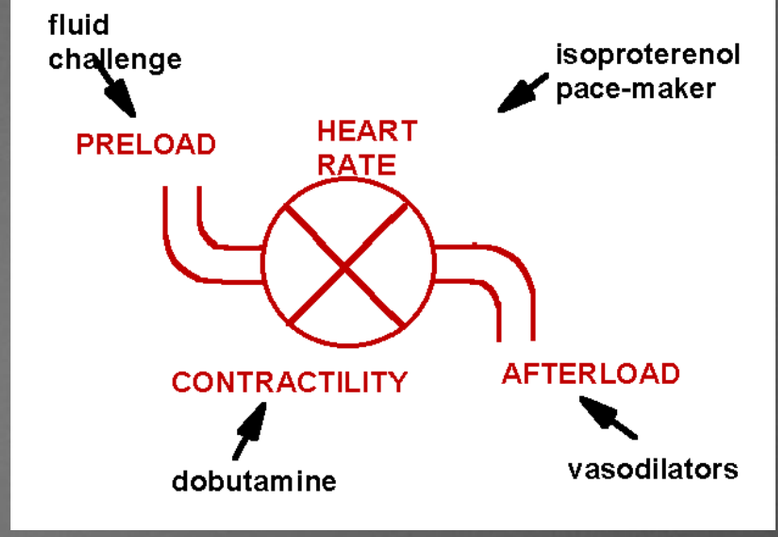


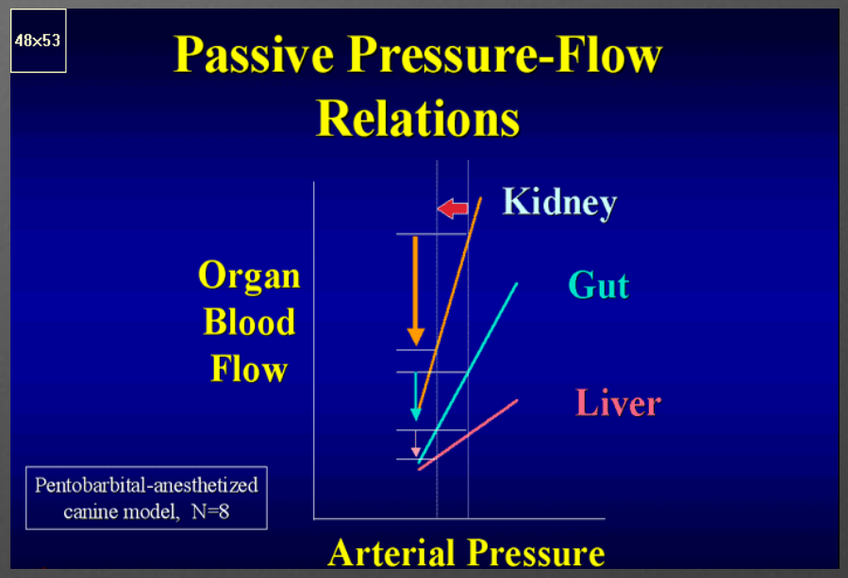
MOF
Décès

Macrocirculation



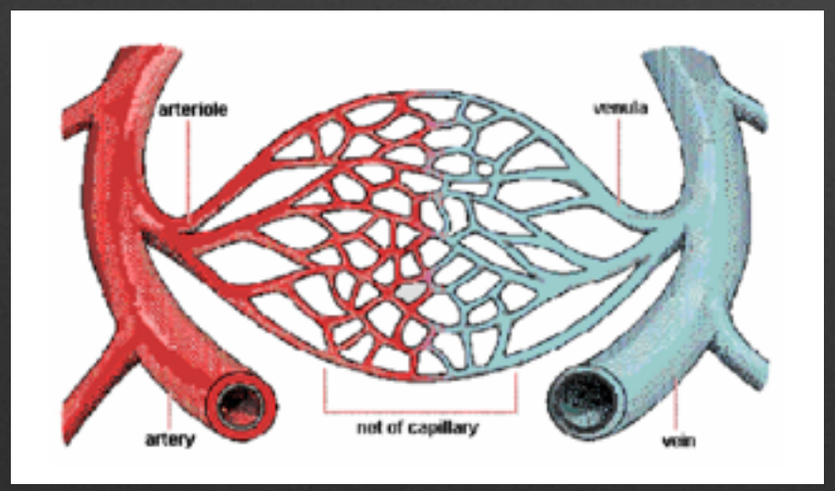






Vasopressors

Micro circulation

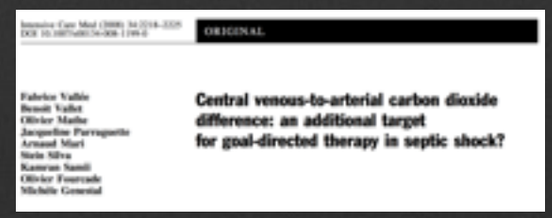


« Perte de cohérence hémodynamique » entre micro- et macro-circulation

Can Ince et al.
J Appl Physiol 120:226-235;2016

SvO2 élevée et lactate élevé

- altération microcirculation
- altération mitochondriale
- altération respiration cellulaire


Intensive Care Med (2008) 34:2218–2225
DOI 10.1007/s00134-008-1199-6

ORIGINAL

Fabrice Vallée
Benoît Vallet
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Arnaud Mari
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Kaouran Samii
Olivier Fourcade
Michèle Genestal

Central venous-to-arterial carbon dioxide difference: an additional target for goal-directed therapy in septic shock?

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Méthodes d'évaluation de la micro-circulation

- Clinique
- Biomarqueurs globaux d'hypoxie tissulaire
- Mesures de l'oxygénation tissulaire
- Mesures de la clearance du CO2
- Mesures de la perfusion tissulaire

Monitoring microcirculation in critical illness.
Kara A, Akin S, Ince C.
Curr Opin Crit Care. 2016 Oct;22(5):444-52.

Méthodes d'évaluation de la micro-circulation

Table 1 Techniques used to evaluate the microcirculation at the bedside

	Variable measured	Main limitations
Techniques measuring microvascular perfusion		
Laser Doppler	Flow (relative), hemoglobin content/ microvascular reactivity test	Global flow to relatively large sampling volume (mixture of arterioles, capillaries, and venules)
Nailfold videomicroscopy	Vascular density, heterogeneity, flow	Restricted to fingers/sensitivity to temperature and vasoconstriction
OPS and SDF	Vascular density, perfusion heterogeneity, flow	Mostly restricted to semiquantitative scoring/limited sites to investigate/ movement and pressure artifacts
Techniques measuring tissue oxygenation		
SvO_2	Adequacy of perfusion to flow	Global measurement
O_2 electrodes	Tissue PO_2	Global measurement in sampled volume (mixture of arterioles, capillaries, and venules)
NIRS	Tissue O_2 saturation	Global measurement in sampled volume (mixture of arterioles, capillaries, and venules)
Reflectance spectroscopy	O_2 saturation/microvascular reactivity test	Global measurement in sampled volume (mixture of arterioles, capillaries, and venules) unless SO_2 histograms are provided
Gastric tonometry	Tissue CO_2 (reflects inadequate perfusion and/or anaerobic metabolism)	Interference (feeding/reflux)/difficult discrimination between low flow and anaerobic metabolism
Sublingual capnometry	Tissue CO_2 (reflects inadequate perfusion and/or anaerobic metabolism)	Availability limited/difficult discrim anaerob
Microdialysis and equilibrium dialysis	Lactate/pyruvate	Time lag/

OPS orthogonal polarization spectral imaging technique; *SDF* sidestream dark field imaging technic saturation; *NIRS* near-infrared spectroscopy; *EMPHO* Erlangen MicroPHOtometer

Intensive Care Med (2010) 36:1813–1825
DOI 10.1007/s00134-010-2005-3

REVIEW

Daniel De Backer
Gustavo Ospina-Tascon
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Jacques Creteur
Jean-Louis Vincent

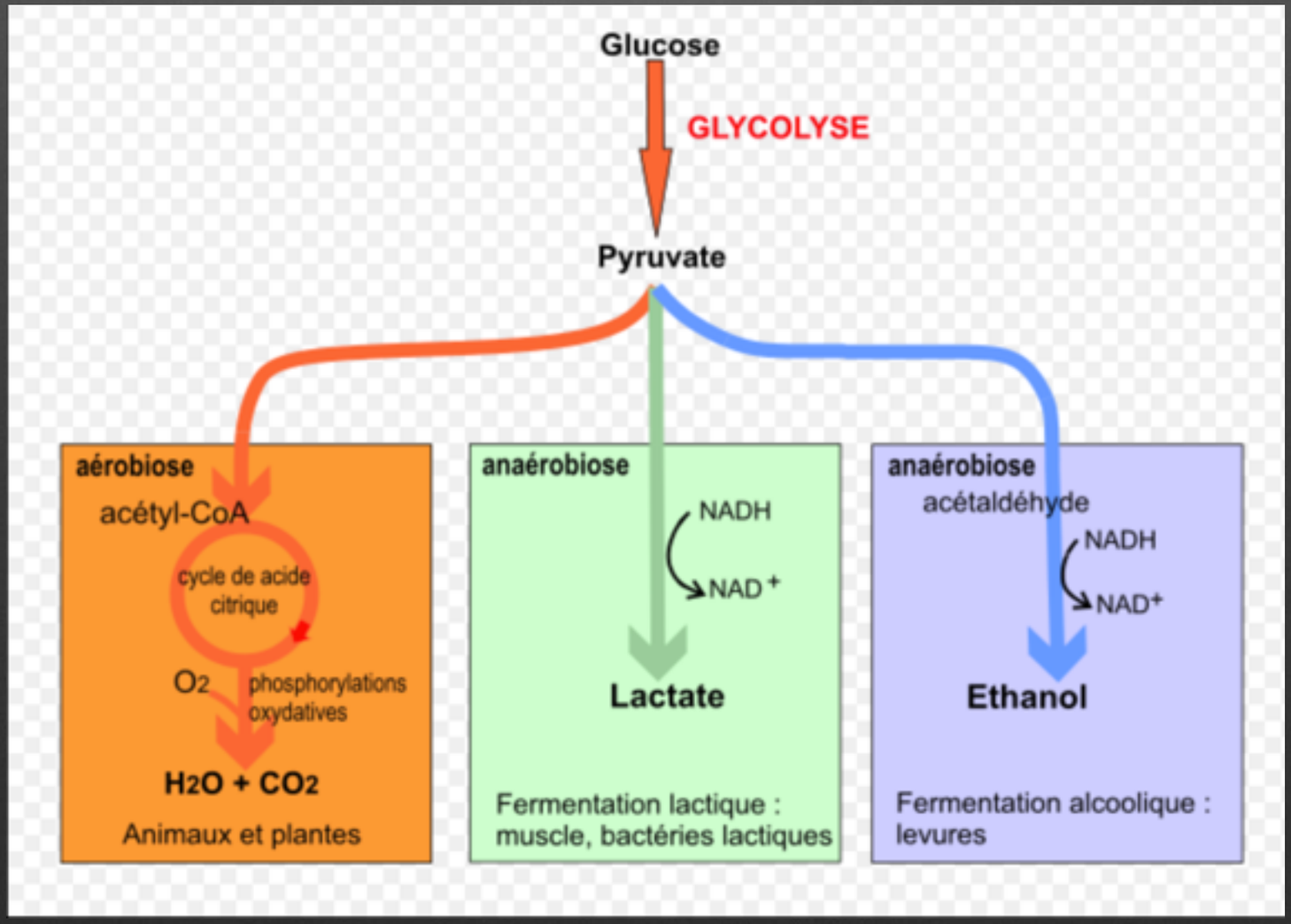
Monitoring the microcirculation in the critically ill patient: current methods and future approaches

Méthodes d'évaluation de la micro-circulation

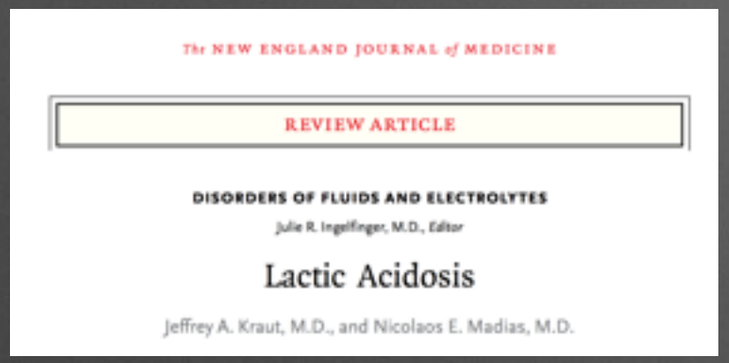
- Clinique
- **Biomarqueurs « globaux »**
  - Mesures de l'oxygénation tissulaire
  - Mesures de la clearance du CO_2
  - Mesures de la perfusion tissulaire

Marqueurs de l’hypoxie tissulaire

Lactate



Lactate



The NEW ENGLAND JOURNAL of MEDICINE

REVIEW ARTICLE

DISORDERS OF FLUIDS AND ELECTROLYTES

Julie R. Ingelfinger, M.D., Editor

Lactic Acidosis

Jeffrey A. Kraut, M.D., and Nicolaos E. Madias, M.D.

MAIS:

Table 1. **Causes of Lactic Acidosis.***

Cause	Presumed Mechanism or Mechanisms	Comments
Cardiogenic or hypovolemic shock, advanced heart failure, or severe trauma	Decreased O_2 delivery to tissues; epinephrine-induced β_2-adrenoceptor stimulation can be a contributory factor	With sepsis, these causes account for the majority of cases of lactic acidosis
Sepsis	Epinephrine-induced β_2-adrenoceptor stimulation with or without decreased O_2 delivery to tissues; reduced clearance of lactate even in hemodynamically stable patients	Evidence of decreased O_2 delivery can be subtle; even in the absence of macrocirculatory impairment, dysfunction of microcirculation can be present
Severe hypoxemia	Decreased O_2 delivery to tissues	Requires Pao_2 <30 mm Hg
Carbon monoxide poisoning	Decreased O_2 delivery to tissues, interference with oxidative phosphorylation	Hyperbaric O_2 therapy is recommended if pH <7.1
Severe anemia	Decreased O_2 delivery to tissues	Requires hemoglobin level <5 g/dl
Vigorous exercise, seizures, or shivering	Increased O_2 requirements	The decrease in pH and hyperlactatemia is transient; lactic acidosis can impair exercise performance
Diabetes mellitus	Mechanism unclear	The risk of death in patients with ketoacidosis can be increased by coexisting lactic acidosis
Cancer	Increased glycolytic activity of tumor (Warburg effect), tumor tissue hypoxia, decreased clearance of lactate with severe liver metastases	Lactic acidosis can be seen in association with lymphomas, leukemias, and solid tumors; HCO_3^- administration may increase lactic acid production; acidic microenvironment is critical for tumorigenesis, angiogenesis, and metastasis
Liver disease	Lactate clearance decreased	Fulminant liver disease can cause substantial hyperlactatemia; hyperlactatemia is usually mild with chronic liver disease alone; lactate clearance can also be decreased when liver function is normal, in association with sepsis
Pheochromocytoma	Decreased O_2 delivery to tissues and epinephrine-induced β_2-adrenoceptor stimulation	In rare cases, lactic acidosis is a presenting feature of pheochromocytoma
Metformin	Interference with oxidative phosphorylation, suppression of hepatic gluconeogenesis	This is usually seen in association with high plasma metformin levels; treatment with dialysis is beneficial
Nucleoside reverse-transcriptase inhibitors	Interference with oxidative phosphorylation	Marked hyperlactatemia is uncommon in the absence of other predisposing factors
Cocaine	Decreased O_2 delivery to tissues and epinephrine-induced β_2-adrenoceptor stimulation	Marked hyperlactatemia is seen in some patients having seizures or being restrained
Toxic alcohols, methanol, ethylene glycol, diethylene glycol	Interference with oxidative phosphorylation	The increase in lactate is small; a small increase in the osmolal gap (usually <20 mOsm/kg H_2O) can be seen in some cases of lactic acidosis without toxic alcohols
Propylene glycol	D-Lactate and L-lactate are normal products of metabolism	Lactic acidosis can occur in the absence of impaired oxidative phosphorylation
Salicylates	Interference with oxidative phosphorylation	Hyperlactatemia is usually minimal
Cyanide	Interference with oxidative phosphorylation	Lactic acidosis is an important manifestation of poisoning
β_2 agonists	Stimulation of aerobic glycolysis	This is most common with treatment of acute asthma; hypokalemia can result from enhanced cellular uptake of potassium
Propofol	Interference with oxidative phosphorylation	Lactic acidosis can be seen with prolonged high-dose infusion
Thiamine deficiency	Impairment of pyruvate dehydrogenase activity	This is most common in children or adults receiving parenteral nutrition or those with fulminant beriberi

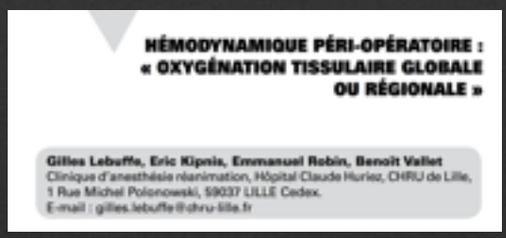
* Pao_2 denotes partial pressure of arterial oxygen.

Marqueurs de l'hypoxie tissulaire

- Le gradient veino-artériel en CO_2
- Le rapport entre le gradient veino-artériel en CO_2 et la différence du contenu artério-veineux en O_2

Le gradient veino-artériel en CO2 P(v-a)CO2

- VCO2= DC x k x P(v-a)CO2
- P(v-a)CO2 = VCO2/DC x k
    - augmentation DC = augmentation clearance CO2
        - hypoxémie cellulaire augmentation VCO2 anaérobie proportionelle à diminution VCO2 aérobie
            - P(v-a)CO2 stable ou diminue
- P(v-a)CO2 augmente si diminution DC et diminution de la perfusion tissulaire


NÉMODYNAMIQUE PÉRI-OPÉRATOIRE :
« OXYGÉNATION TISSULAIRE GLOBALE OU RÉGIONALE »

Gilles Lebuffe, Eric Kipnis, Emmanuel Robin, Benoît Vallet
Clinique d'anesthésie réanimation, Hôpital Claude Huriez, CHRU de Lille, 1 Rue Michel Polonowski, 59037 LILLE Cedex.
E-mail : gilles.lebuffe@chru-lille.fr

P(v-a) CO2

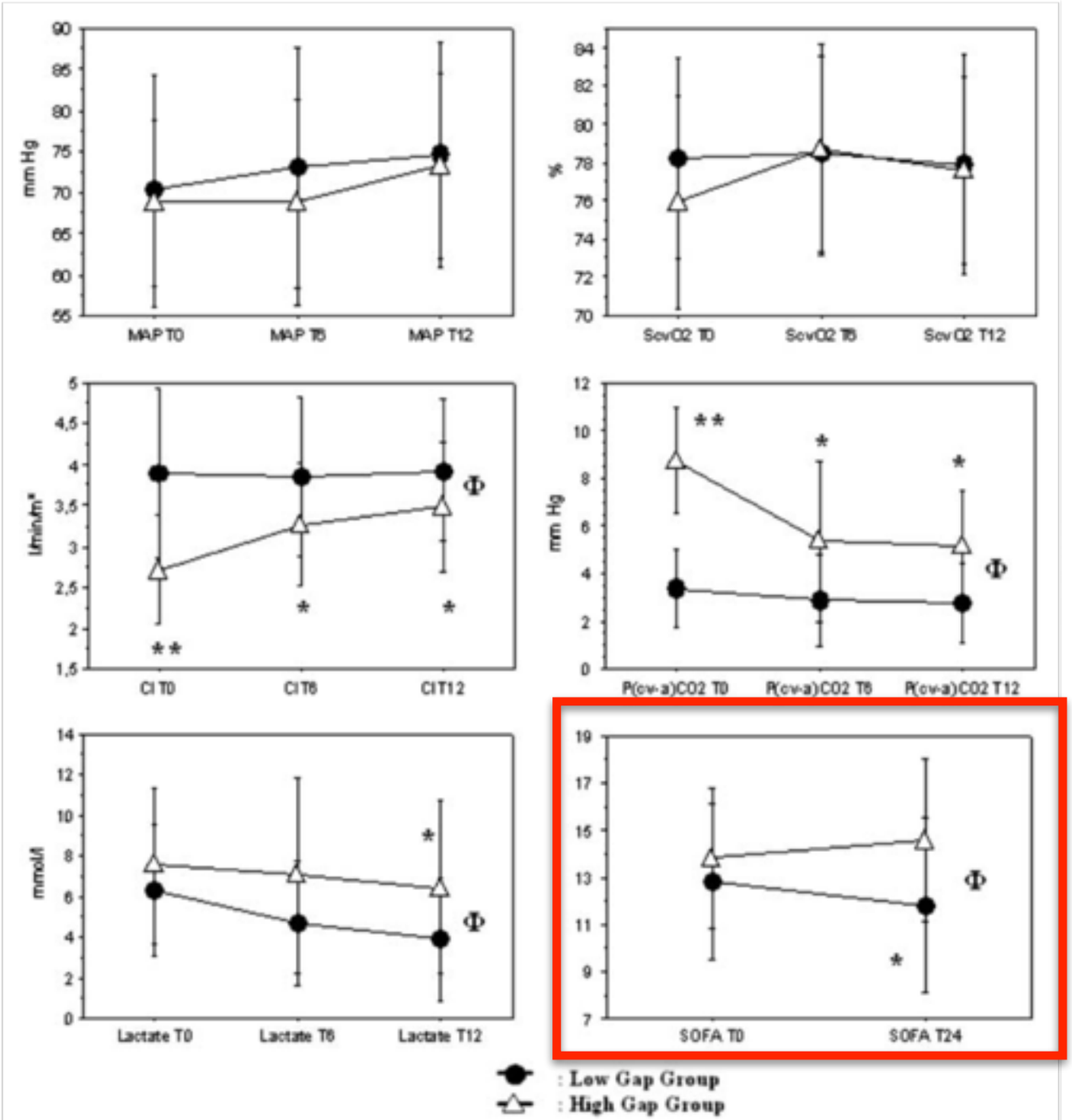
Seuil 6 mmHg

Intensive Care Med (2008) 34:2218–2225
DOI 10.1007/s00134-008-1199-0

ORIGINAL

Fabrice Vallée
Benoît Vallet
Olivier Mathe
Jacqueline Parraguette
Arnaud Mari
Stein Silva
Kamran Samii
Olivier Fourcade
Michèle Genestal

Central venous-to-arterial carbon dioxide difference: an additional target for goal-directed therapy in septic shock?



PCO2 Gap/ (a-v)O2 content

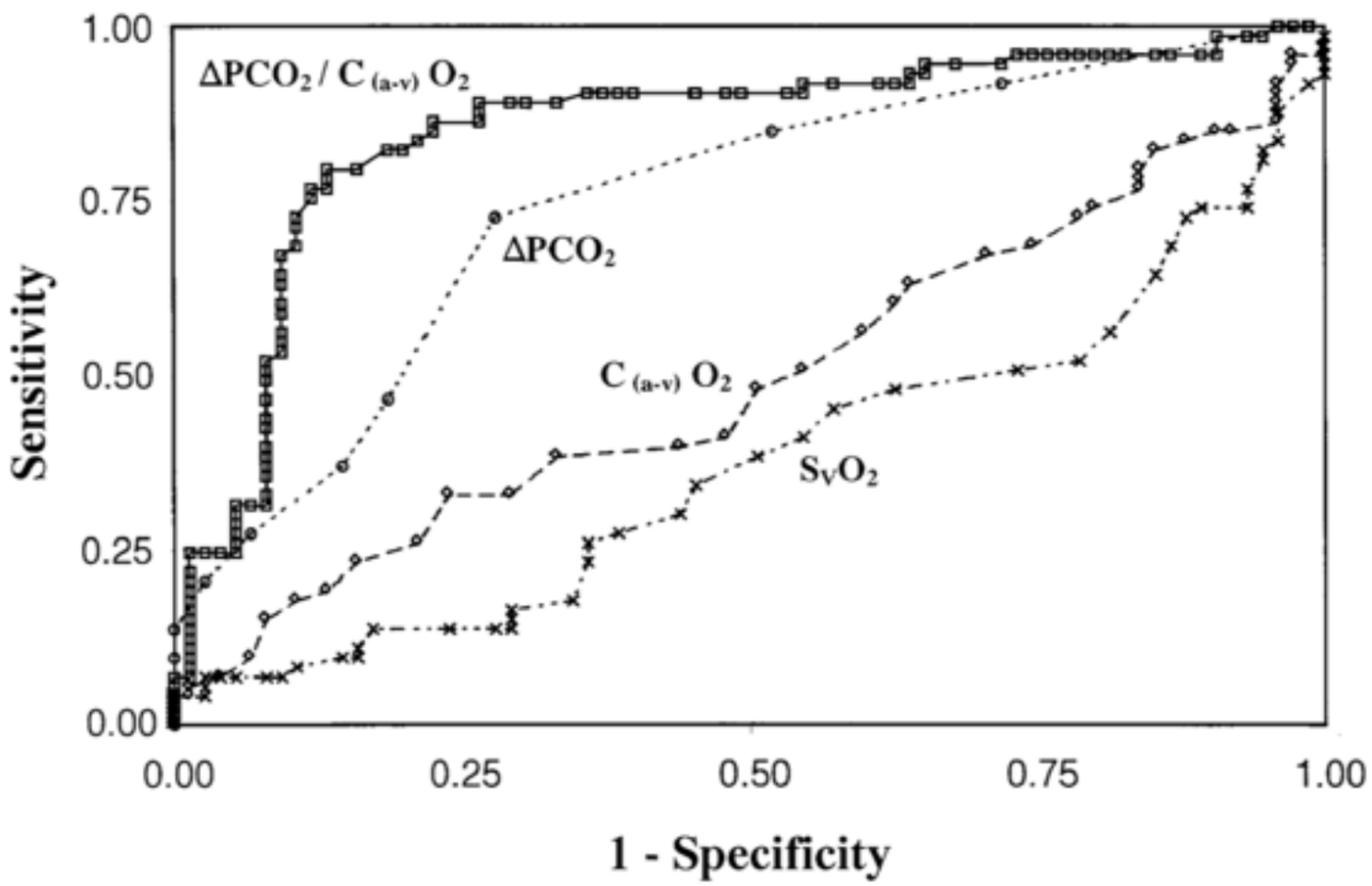


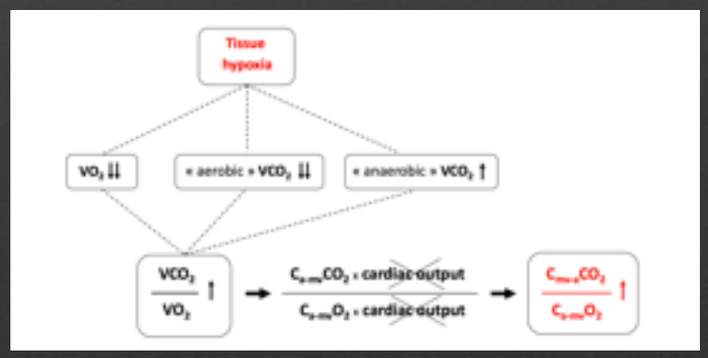
Fig. 1 Receiver operating characteristic curves of the studied O_2- and CO_2-derived parameters for the prediction of hyperlactatemia (arterial lactate level ≥2 mmol/l)

Intensive Care Med (2002) 28:272–277
DOI 10.1007/s00134-002-1215-8

ORIGINAL

Armand Mekontso-Dessap
Vincent Castelain
Nadia Anguel
Mabrouk Bahloul
Franck Schauvliege
Christian Richard
Jean-Louis Teboul

Combination of venoarterial PCO_2 difference with arteriovenous O_2 content difference to detect anaerobic metabolism in patients



Valeur seuil 1,4

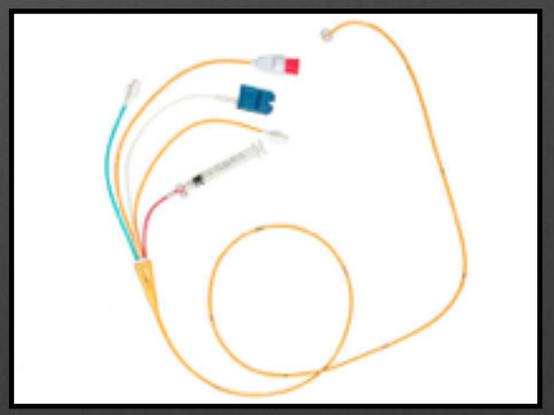
Méthodes d’évaluation de la micro-circulation

- Clinique

SvO2

- **Biomarqueurs « globaux"**

- Mesures de l’oxygénation tissulaire
- Mesures de la clearance du CO2
- Mesures de la perfusion tissulaire

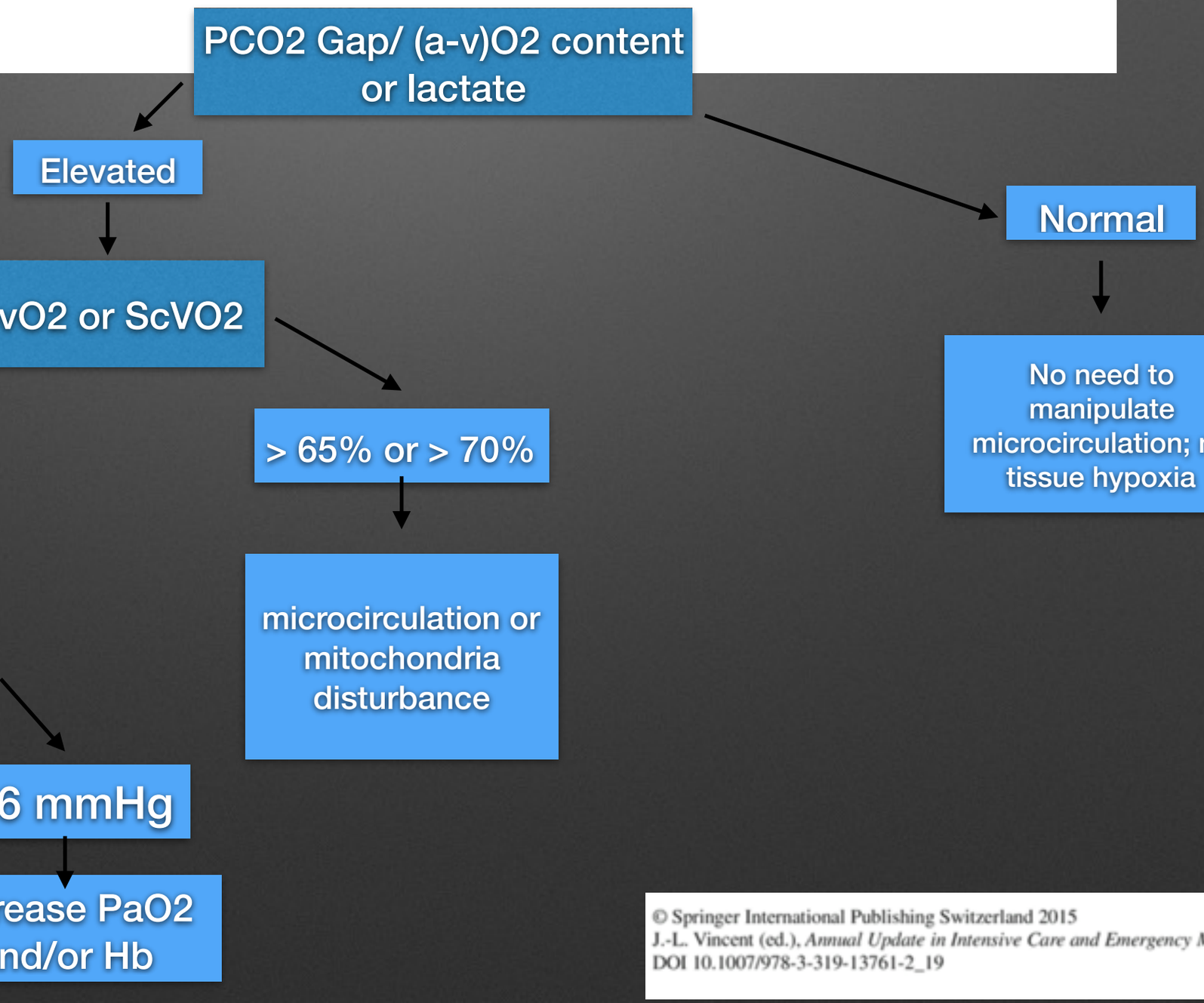


SvO2

$$SvO2 = SaO2 - \frac{VO2}{DC \times Hb \times 1{,}39}$$

Assessing Global Perfusion During Sepsis: SvO_2, Venoarterial PCO_2 Gap or Both?

J.-L. Teboul and X. Monnet



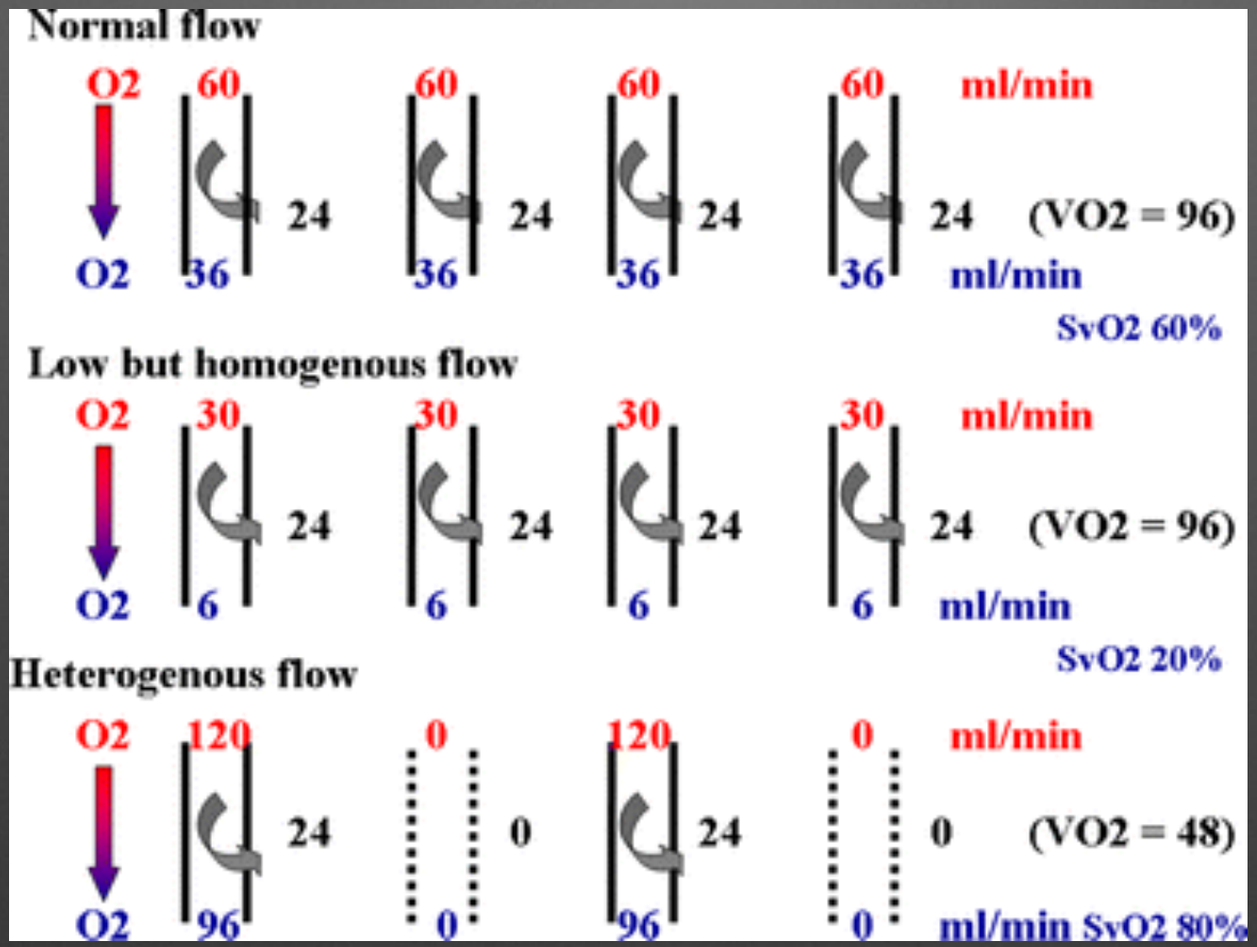
J.-L. Vincent (ed.), *Annual Update in Intensive Care and Emergency Medicine 2015*,
DOI 10.1007/978-3-319-13761-2_19

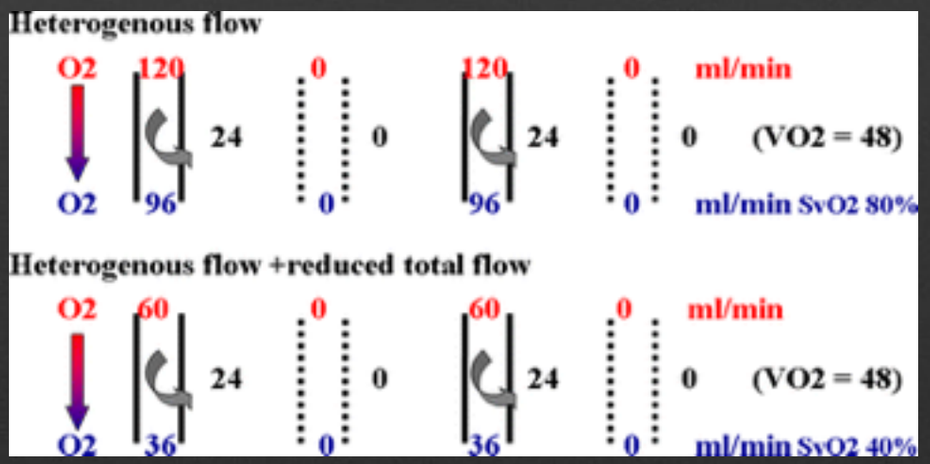
Mitochondrie

- incapable d’utiliser l’O2 pour produire l’ATP
- diminution de l’extraction de l’O2
- excès NO ; effet inhibiteur sur phosphorylation oxydative

Can Ince et al.
J Appl Physiol 120:226-235;2016

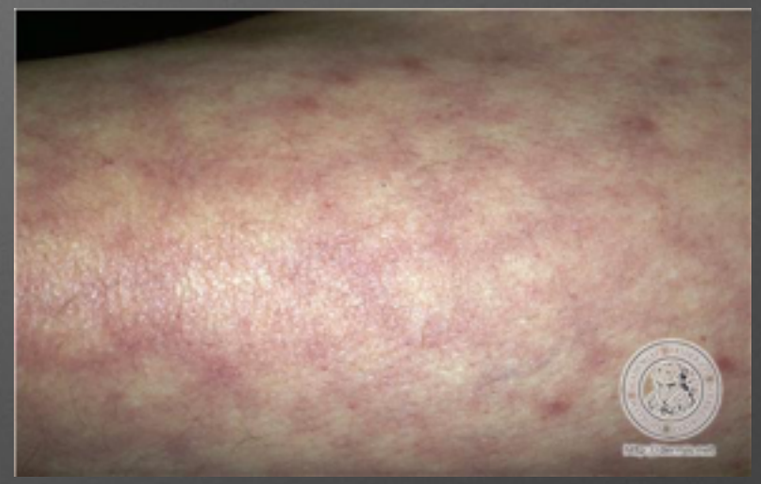
SvO2 élevée
Concept du choc distributif

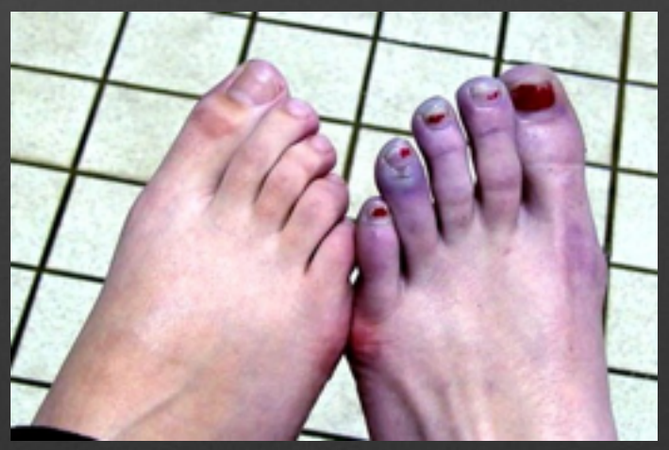




Méthodes d'évaluation de la micro-circulation

- **Clinique**
- Biomarqueurs
- Mesures de l'oxygénation tissulaire
- Mesures de la clearance du CO2
- Mesures de la perfusion tissulaire





Méthodes d'évaluation de la micro-circulation

- Clinique
- Biomarqueurs globaux d'hypoxie
- Mesures de l'oxygénation tissulaire
- Mesures de la clearance du CO2
- Mesures de la perfusion tissulaire

Evaluation de l'oxygénation tissulaire

- Electrodes PO2

  - PO2 max dans volume comprenant 100 micro-vaisseaux

- Reflectance and Near-infrared Spectroscopy (StO2)

(dépendant du transport, de la consommation et de l'Hb)

Evaluation de l'oxygénation tissulaire

Near-infrared Spectroscopy (StO2)

Epreuve d'occlusion vasculaire

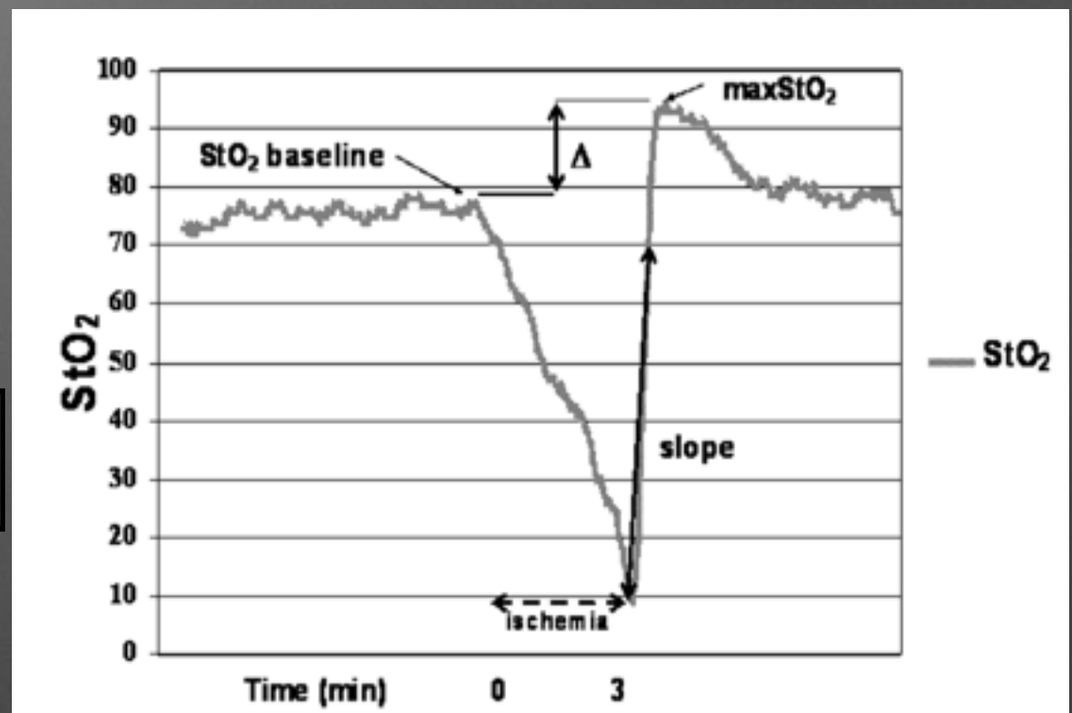
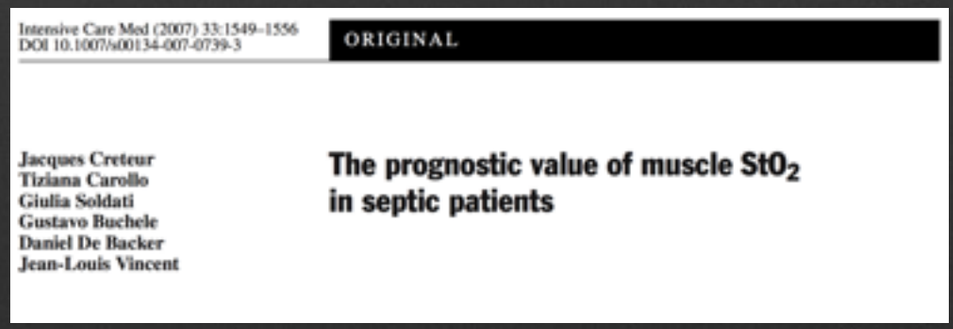


Fig. 1 Representative StO_2 curve. Δ, difference between maximum StO_2 value during the reperfusion period and baseline StO_2. *Slope*, slope of the increase in StO_2 during the first 14 s of the reperfusion period

Reflet de la dysfonction endothéliale


Intensive Care Med (2007) 33:1549–1556
DOI 10.1007/s00134-007-0739-3

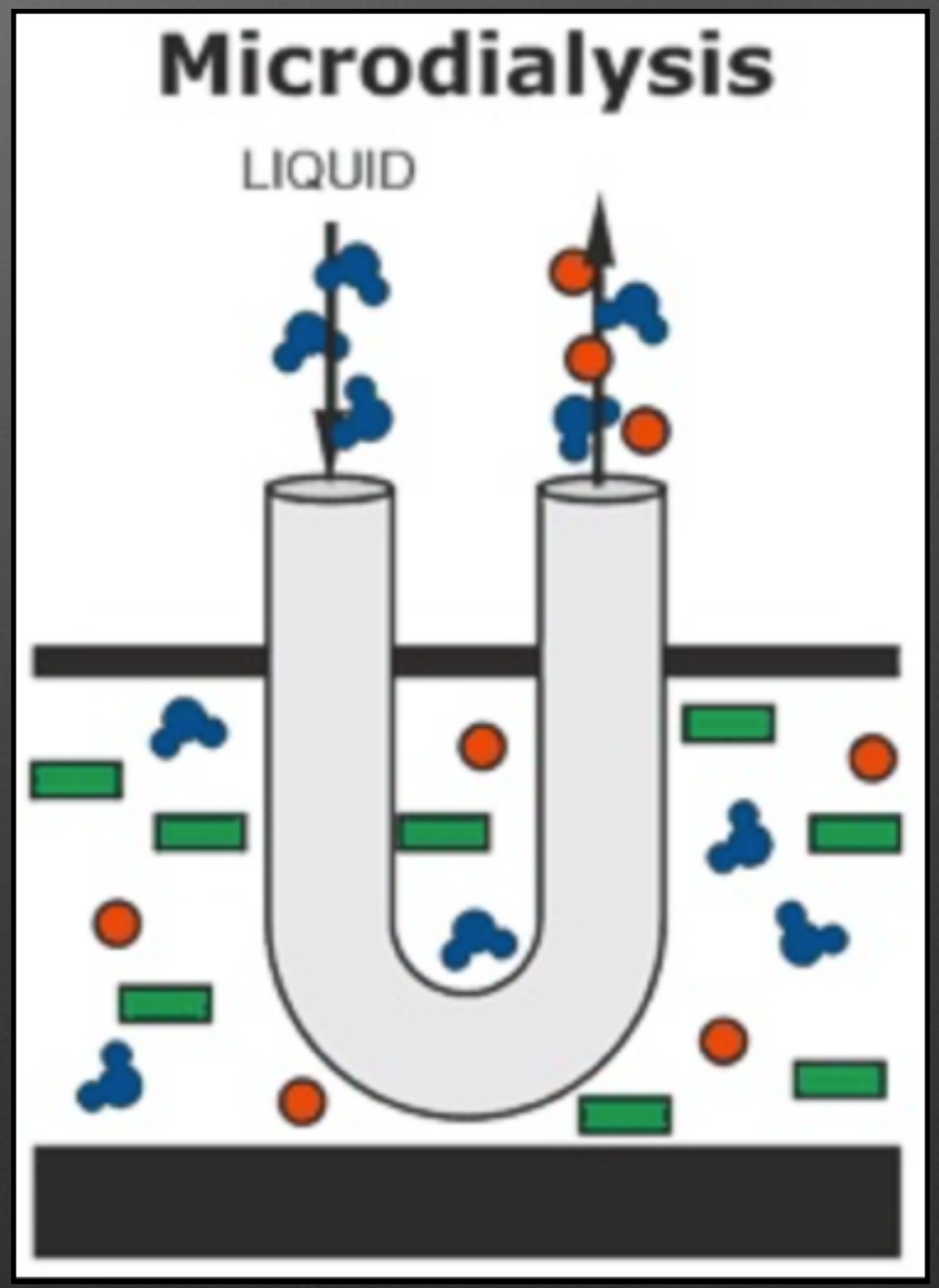
ORIGINAL

Jacques Creteur
Tiziana Carollo
Giulia Soldati
Gustavo Buchele
Daniel De Backer
Jean-Louis Vincent

The prognostic value of muscle StO_2 in septic patients

Microdialyse

- Mesure de « l'hypoxie tissulaire »
- Lactate / Pyruvate
  - augmente dans choc septique

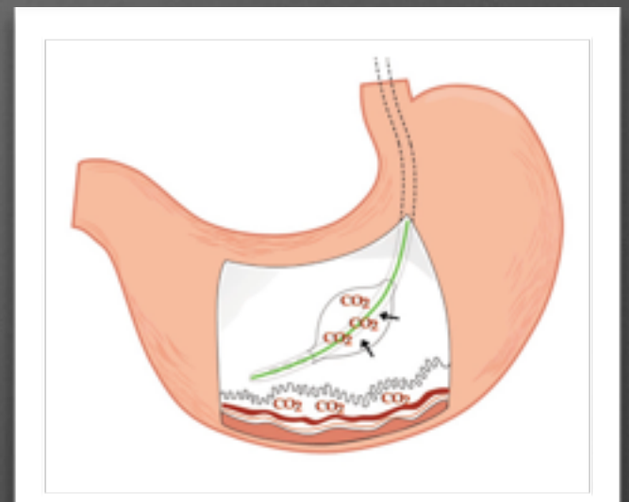


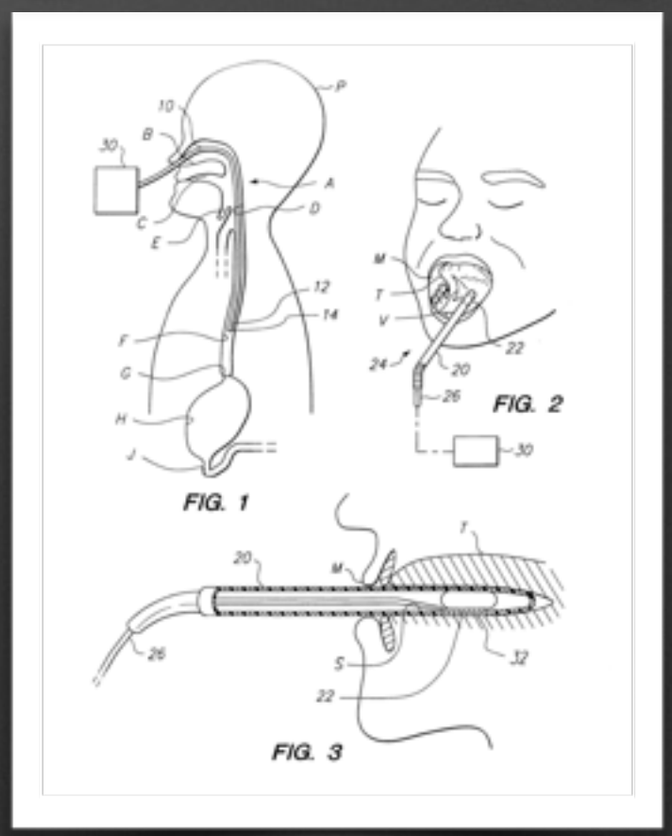
Méthodes d'évaluation de la micro-circulation

- Clinique
- Biomarqueurs globaux d'hypoxie
- Mesures de l'oxygénation tissulaire
- Mesures de la clearance du CO_2
- Mesures de la perfusion tissulaire

PCO2 tissulaire
Le gradient régiono-artériel en CO2

- CO2 dépend du flux et de la production dans le tissu
- Dépend de PaCO2: mesure du P(r-a)CO2
- Renseigne sur l'adéquation du flux
- Seuil 8 à 10 mmHg
- Tonométrie gastrique
- PCO2 sublinguale - flux - inversement proportionnel à la proportion de capillaires perfusés



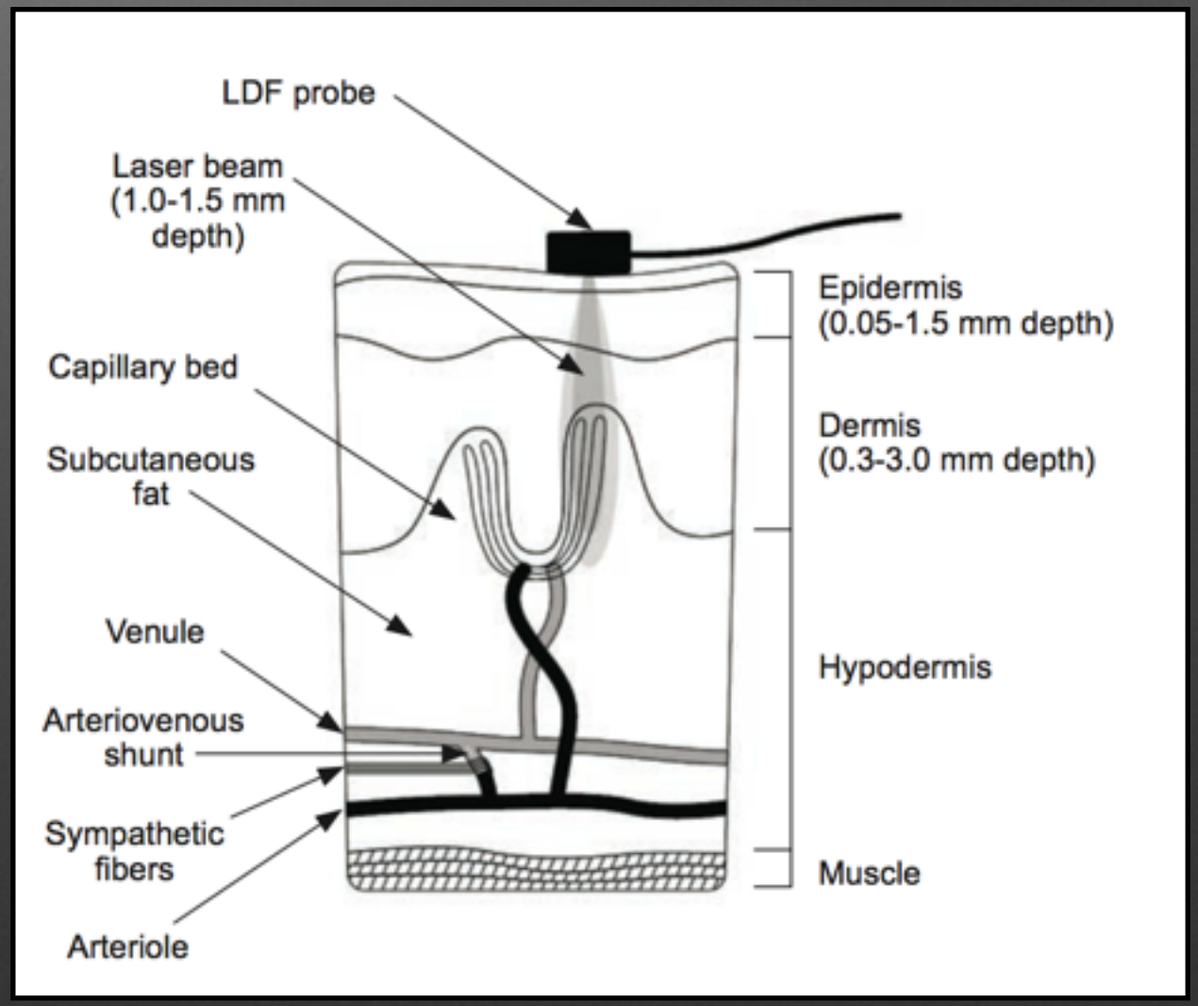


Méthodes d'évaluation de la micro-circulation

- Clinique
- Biomarqueurs globaux d'hypoxie
- Mesures de l'oxygénation tissulaire
- Mesures de la clearance du CO2
- Mesures de la perfusion tissulaire

Laser Doppler

- mesure du débit microcirculat.
- unités arbitraires
- dans un volume variable
- moyenne de 50 vaisseaux
- évolution chez un même patient
- aveugle à l'hétérogénéité
- peau ou tube digestif haut



Vidéomicroscopie

- OPS (Orthogonal Polarization Spectral)
- SDF (Sidestream DarkField)
- IDF (Incidental DarkField)

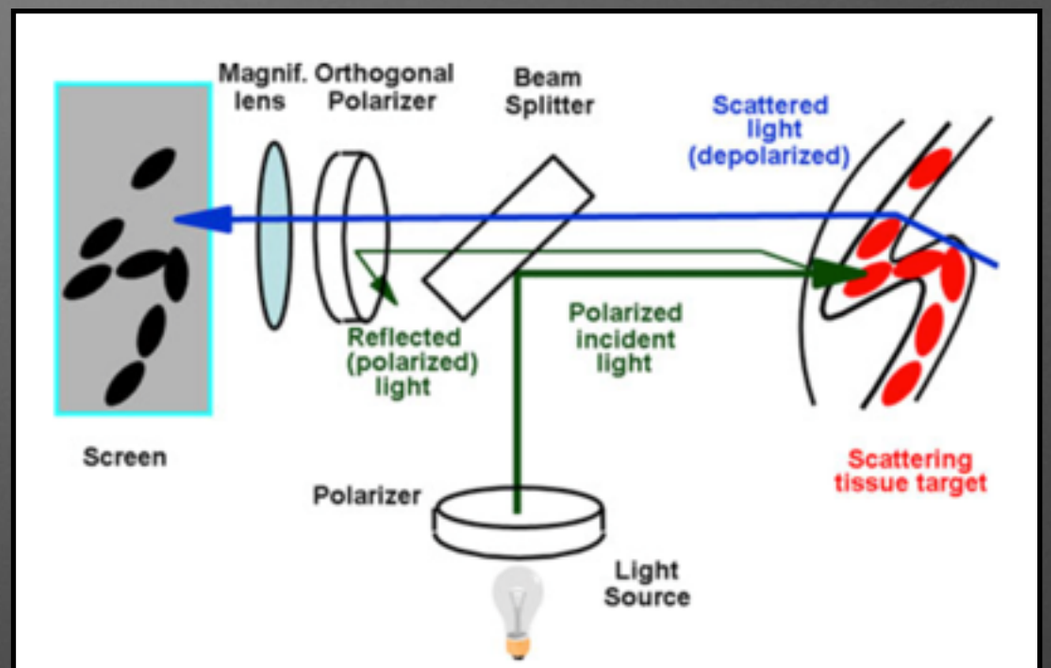


Fig. 3 Orthogonal polarization spectral (OPS) imaging technique.

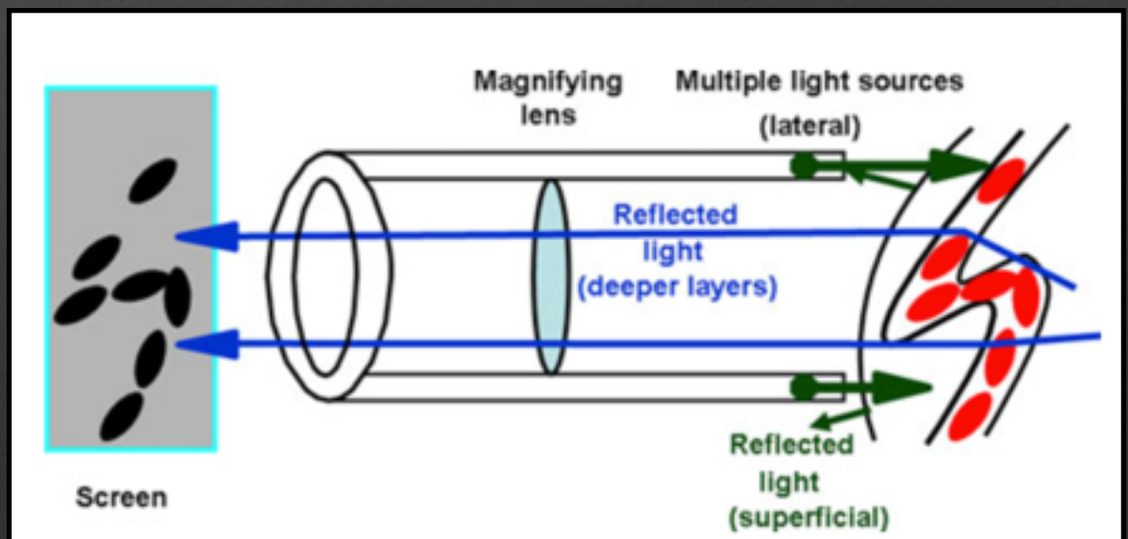
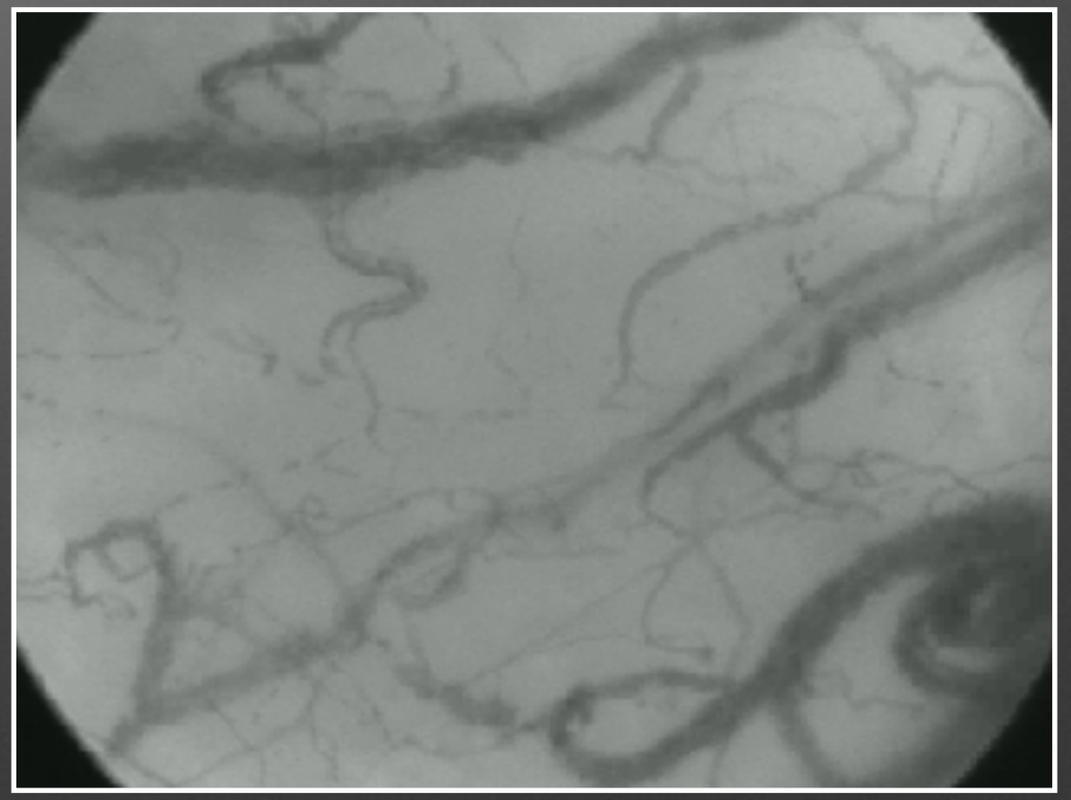


Fig. 4 Sidestream dark field (SDF) imaging technique. Green light

Vidéomicroscopie

- Densité vasculaire
- Flux-perfusion microvasculaire
- Hétérogénéité de la perfusion



Vidéomicroscopie

Tanaka *et al. Critical Care* (2015) 19:388
DOI 10.1186/s13054-015-1106-3

CRITICAL CARE

RESEARCH Open Access

Qualitative real-time analysis by nurses of sublingual microcirculation in intensive care unit: the MICRONURSE study

Sébastien Tanaka[1], Anatole Harrois[1,2], Camille Nicolaï[1], Mélanie Flores[1], Sophie Hamada[1], Eric Vicaut[2] and Jacques Duranteau[1,2,3*]

Conclusion: A real-time qualitative bedside evaluation of MFI by nurses showed good agreement with the conventional delayed analysis by physicians. The bedside evaluations of MFI and TVD were highly sensitive and specific for detecting impaired microvascular flow and low capillary density. These results suggest that this real-time technique could become part of ICU nurse routine surveillance and be implemented in algorithms for hemodynamic resuscitation in future clinical trials and regular practice. These results are an essential step to demonstrate whether these real-time measurements have a clinical impact in the management of ICU patients.

Table des matières

Altérations de la micro-circulation dans le sepsis

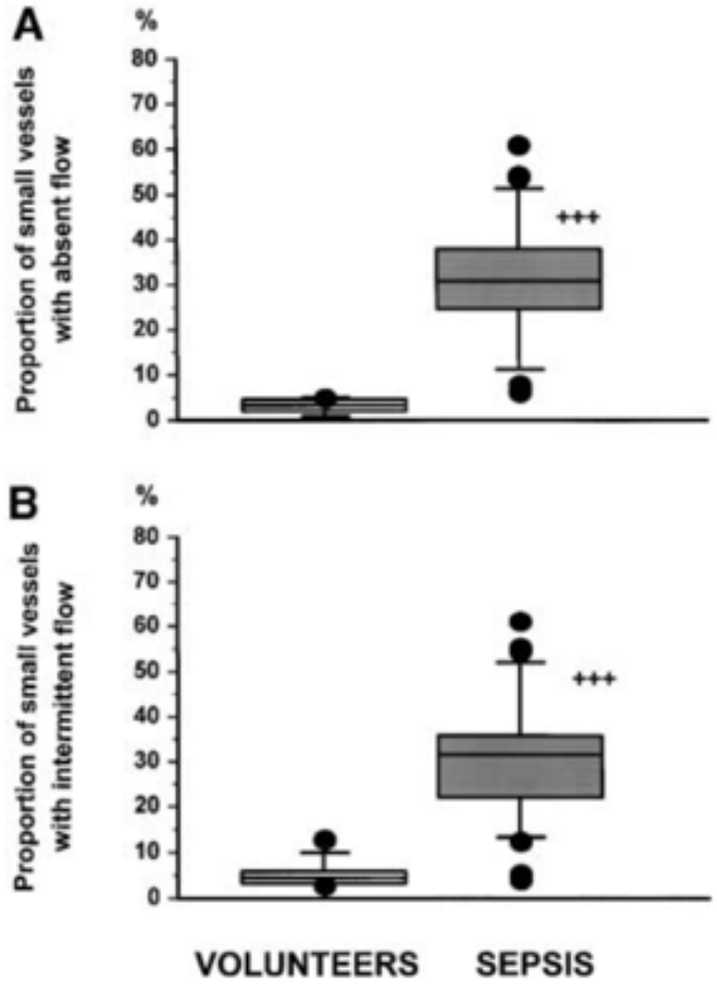


Figure 3. Proportion of small vessels with absent (*A*) or intermittent (*B*) perfusion. Volunteers are represented by *open rectangles*, patients with sepsis by *gray rectangles*. $^{+++}p < 0.001$ versus volunteers. The physiologic data of the volunteers and of the patients are presented in Table 2.

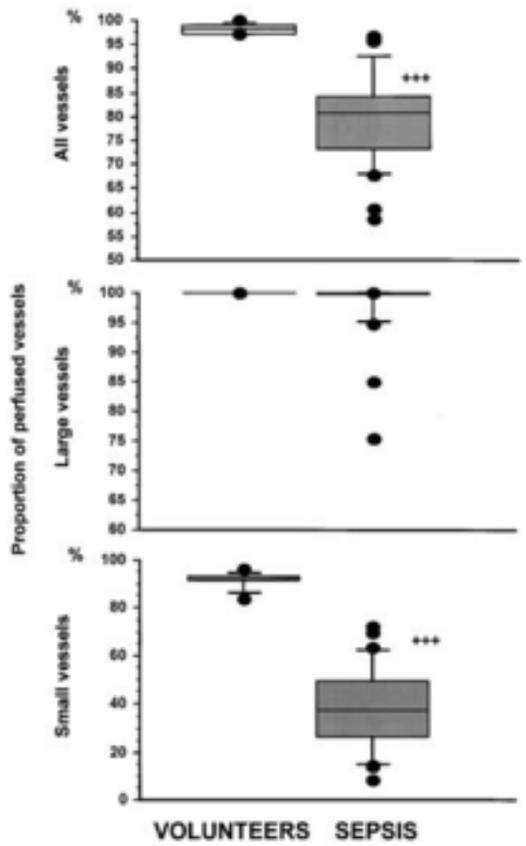


Figure 2. Proportion of perfused vessels. *Top*: All vessels. *Middle*: Large vessels (diameter larger than 20 μm). *Bottom*: Small vessels (diameter smaller or equal to 20 μm). Volunteers are represented by *open rectangles*, patients with sepsis by *gray rectangles*. $^{+++}p < 0.001$ versus volunteers. The physiologic data of the volunteers and of the patients are presented in Table 2.

Microvascular Blood Flow Is Altered in Patients with Sepsis

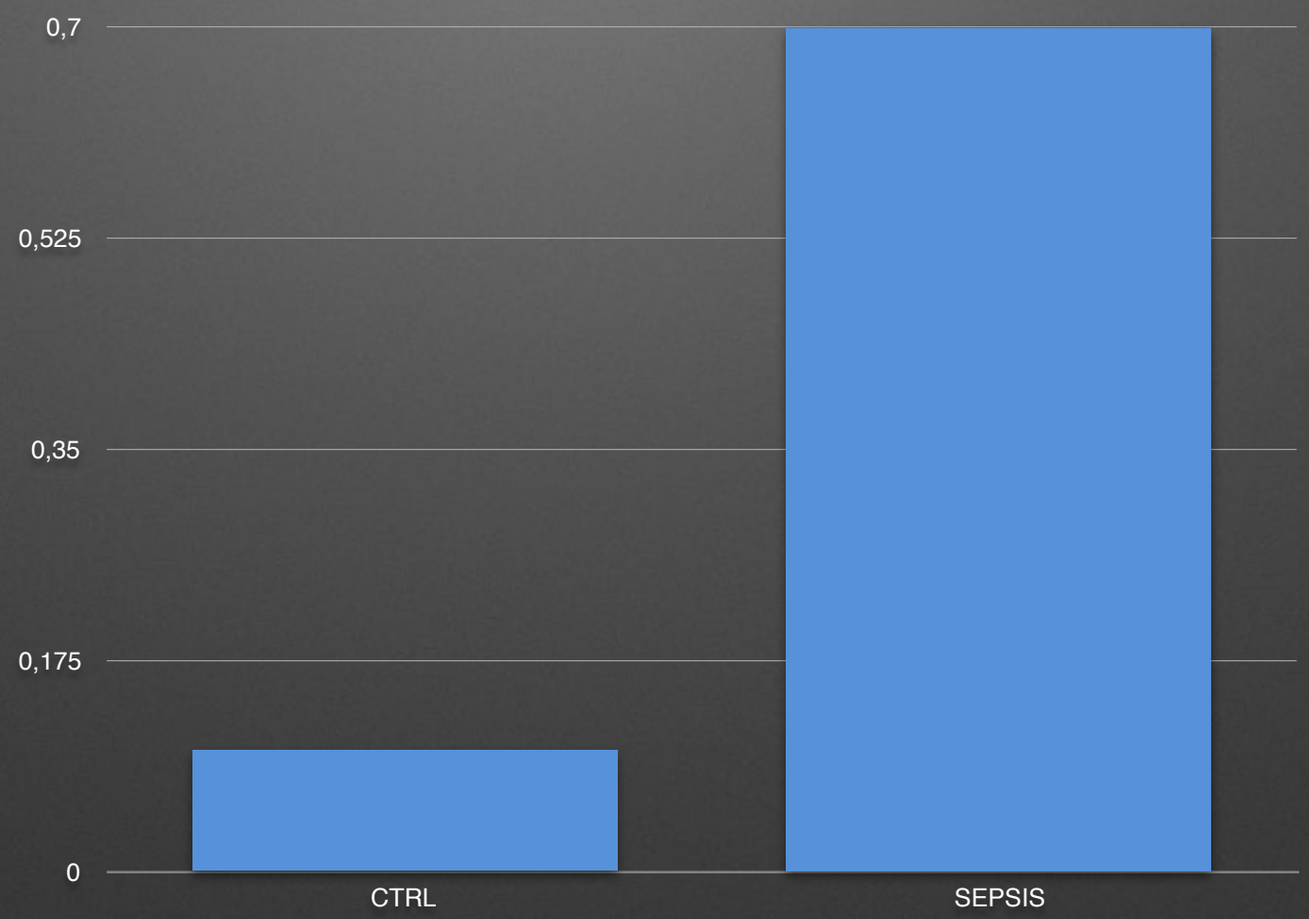
Daniel De Backer, Jacques Creteur, Jean-Charles Preiser, Marc-Jacques Dubois, and Jean-Louis Vincent

Department of Intensive Care, Erasme University Hospital, Free University of Brussels, Brussels, Belgium

Am J Respir Crit Care Med Vol 166. pp 98–104, 2002

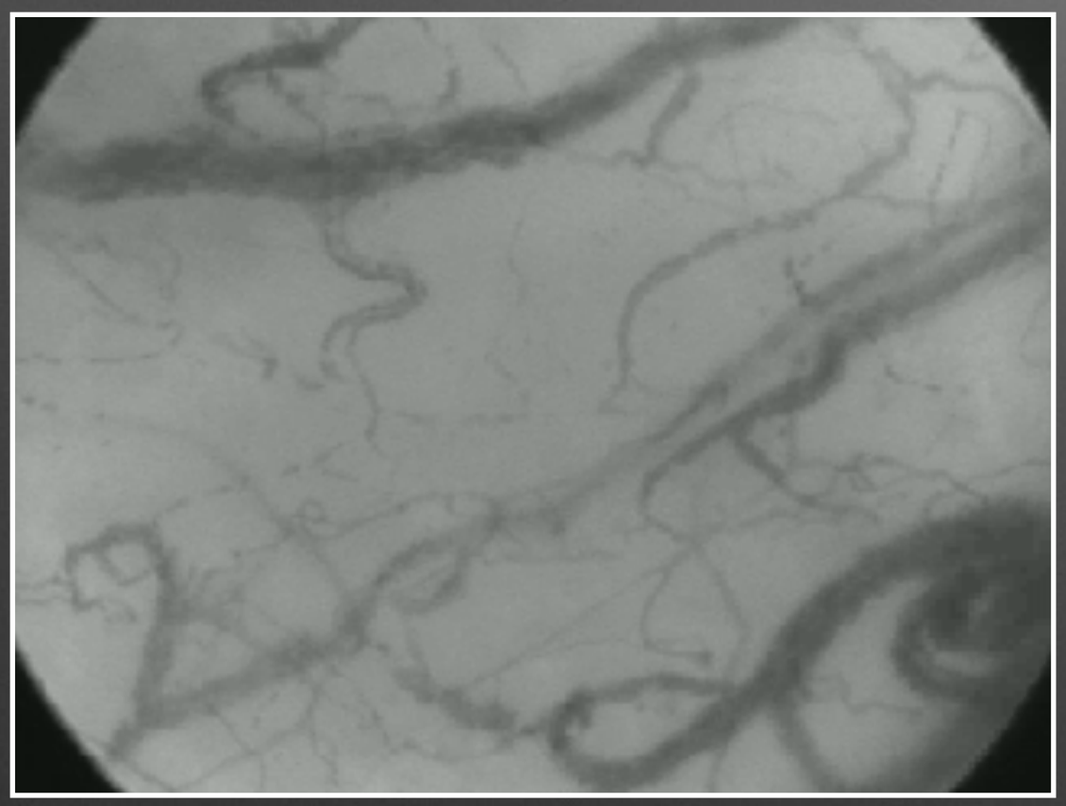
Heterogeneity index

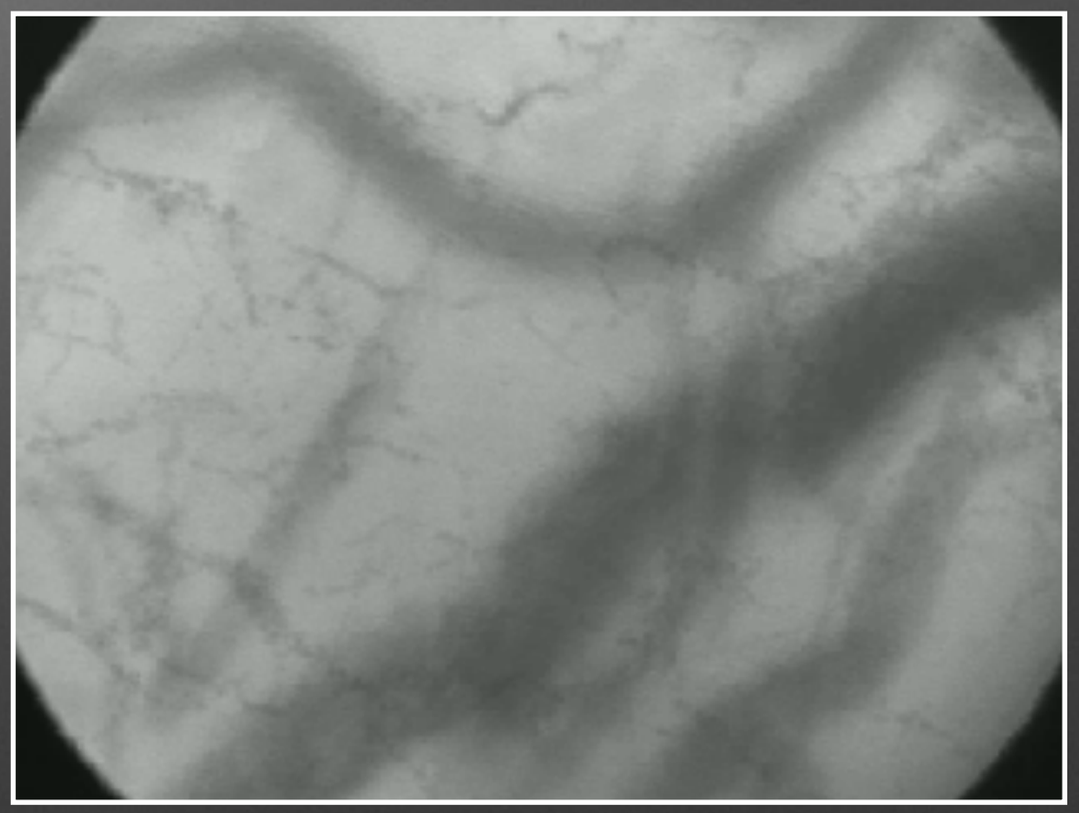
N = 26
p < 0,01



Trzeciak et al.
Ann Emerg Med. 2007 Jan;49(1):88-98, 98.e1-2.

OPS et Sepis



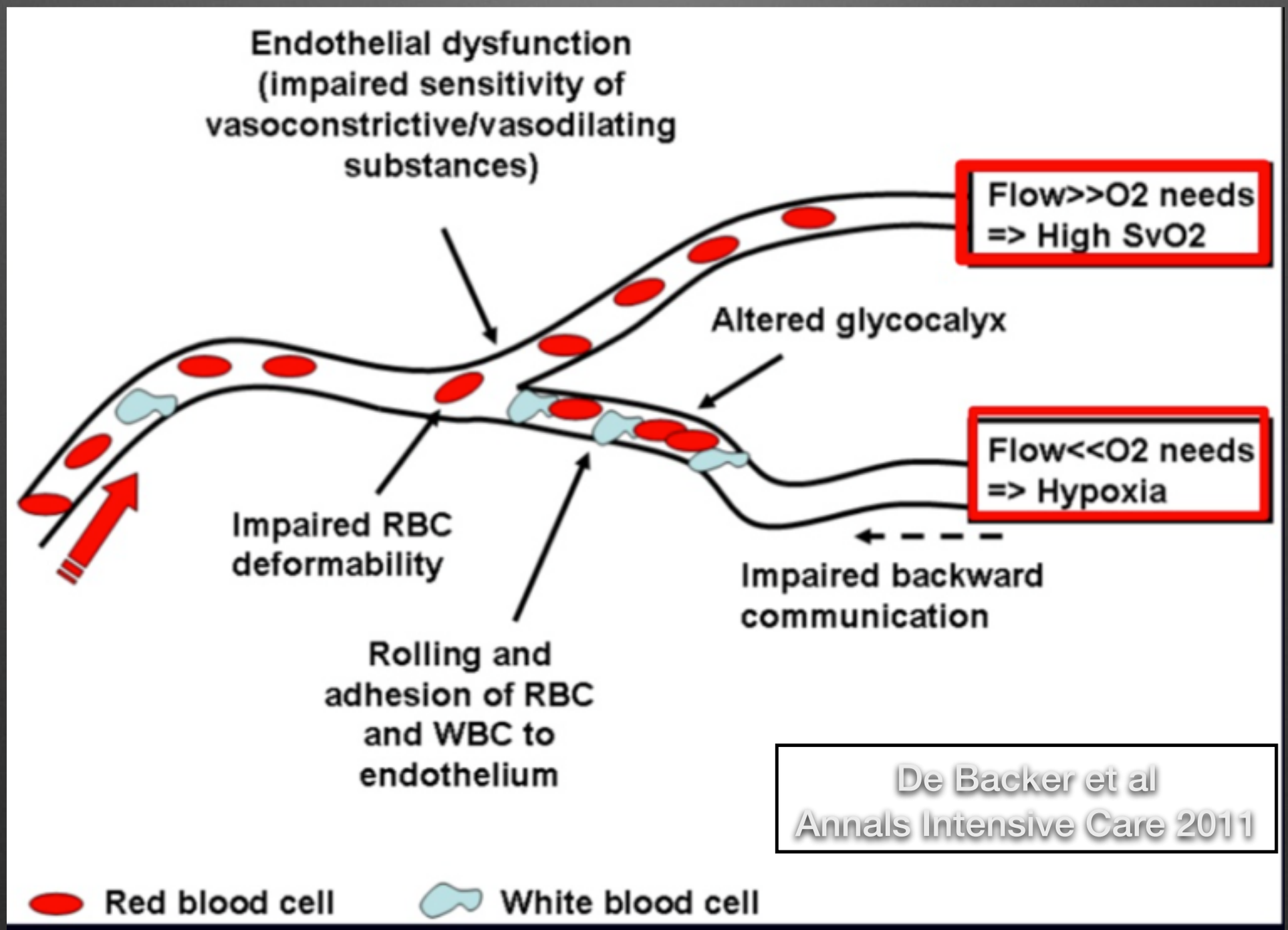


Altérations de la micro-ciculation dans le choc

- Hémorragique et cardiogénique:
  - Diminution de la densité de capillaires fonctionnels
  - Augmentation de la distance de diffusion de l'O2
- Septique:
  - Diminution de la densité vasculaire
  - Débit dans les capillaires absent ou intermittent
  - Hétérogénéité

Secor et al ICM 2010
Verdant et al CCM 2009
Madorin et al CCM 1999

Altérations de la micro-circulation dans le choc



« Perte de cohérence hémodynamique » entre micro- et macro-circulation

- 4 types:

1. Distribution hétérogène de la microcirculation

2. Hémodilution - augmentation distance de diffusion

3. Manipulation inadéquate de la macrocirculation

   - trop de vasopressseurs, PVC haute,…

4. Oedème qui limite la diffusion

Can Ince et al.
J Appl Physiol 120:226-235;2016

Table des matières

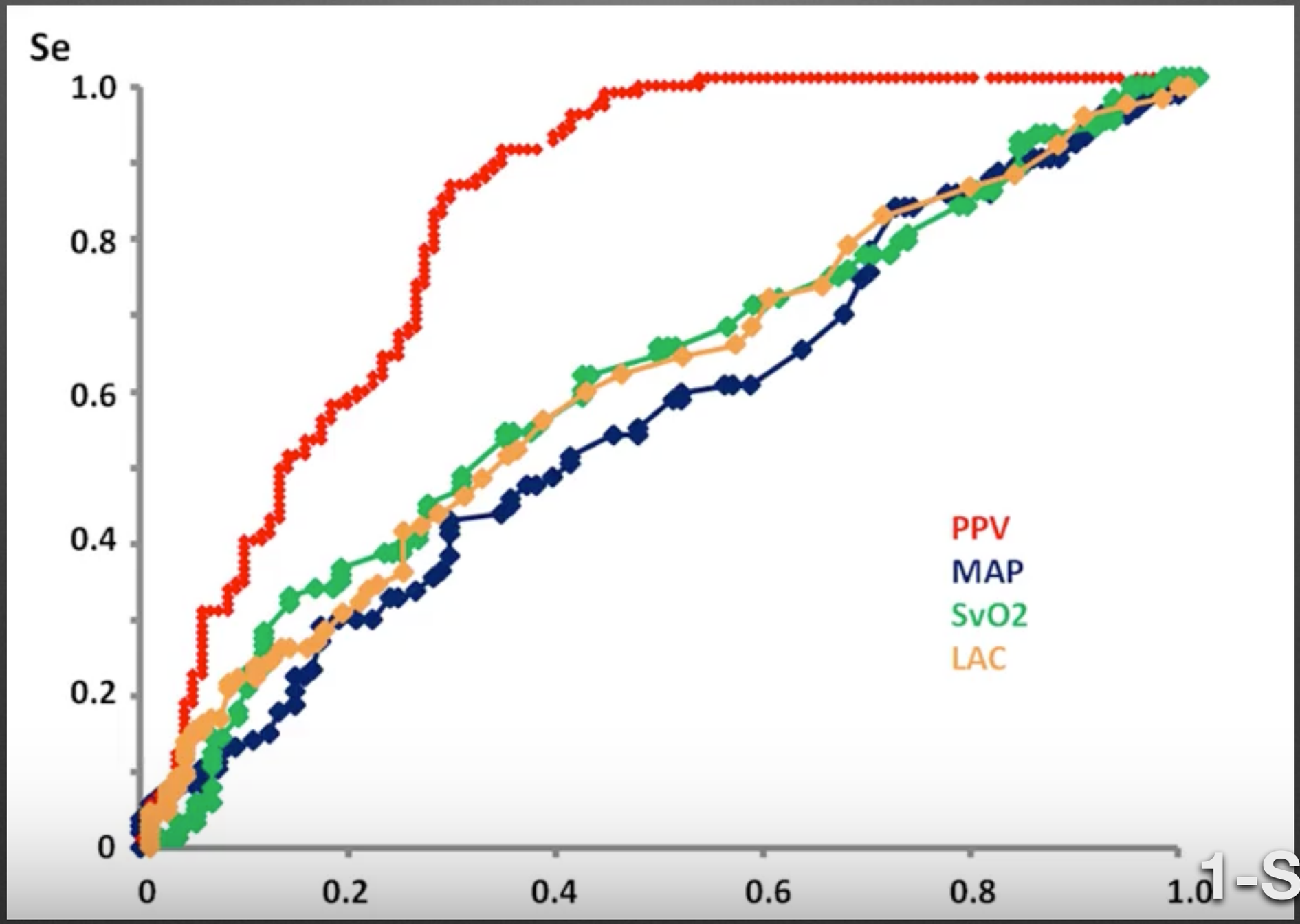
Utilité monitoring

N = 33 septic shock
SDF Evaluation after EGDT
SOFA after 24 hours

Early increases in microcirculatory perfusion during protocol-directed resuscitation are associated with reduced multi-organ failure at 24 h in patients with **sepsis**.
Trzeciak S, McCoy JV, Phillip Dellinger R, Arnold RC, Rizzuto M, Abate NL, Shapiro NI, Parrillo JE, Hollenberg SM; Microcirculatory Alterations in Resuscitation and Shock (MARS) investigators..
Intensive Care Med. 2008 Dec;34(12):2210-7. doi: 10.1007/s00134-008-1193-6.

Valeur pronostique de la dysfonction micro-circulatoire

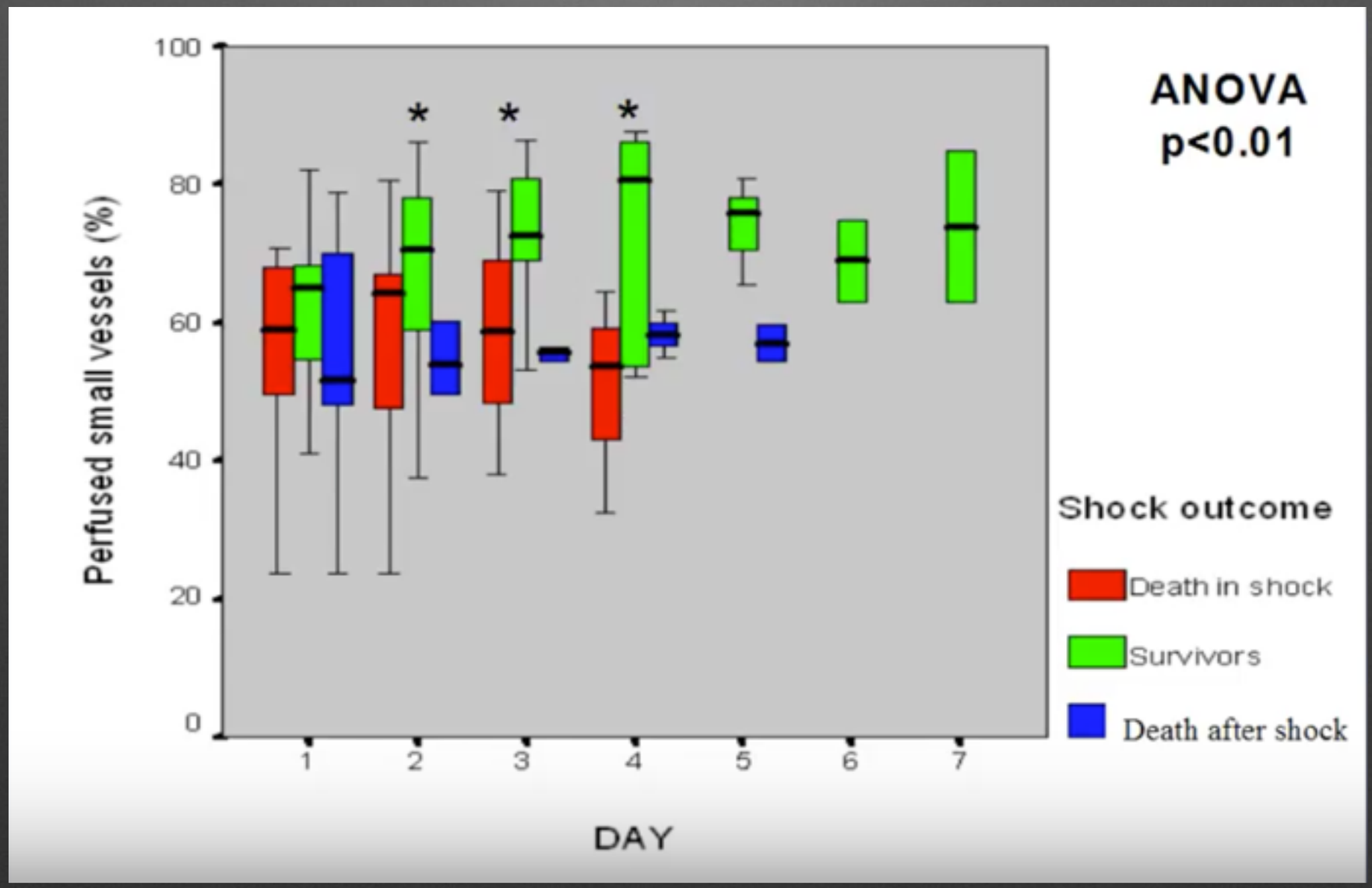
Severe sepsis



De Backer D, Donadello K, Sakr Y, Ospina-Tascon G, Salgado D, Scolletta S, Vincent JL.
Crit Care Med. 2013 Mar;41(3):791-9

Valeur pronostique de la dysfonction micro-circulatoire

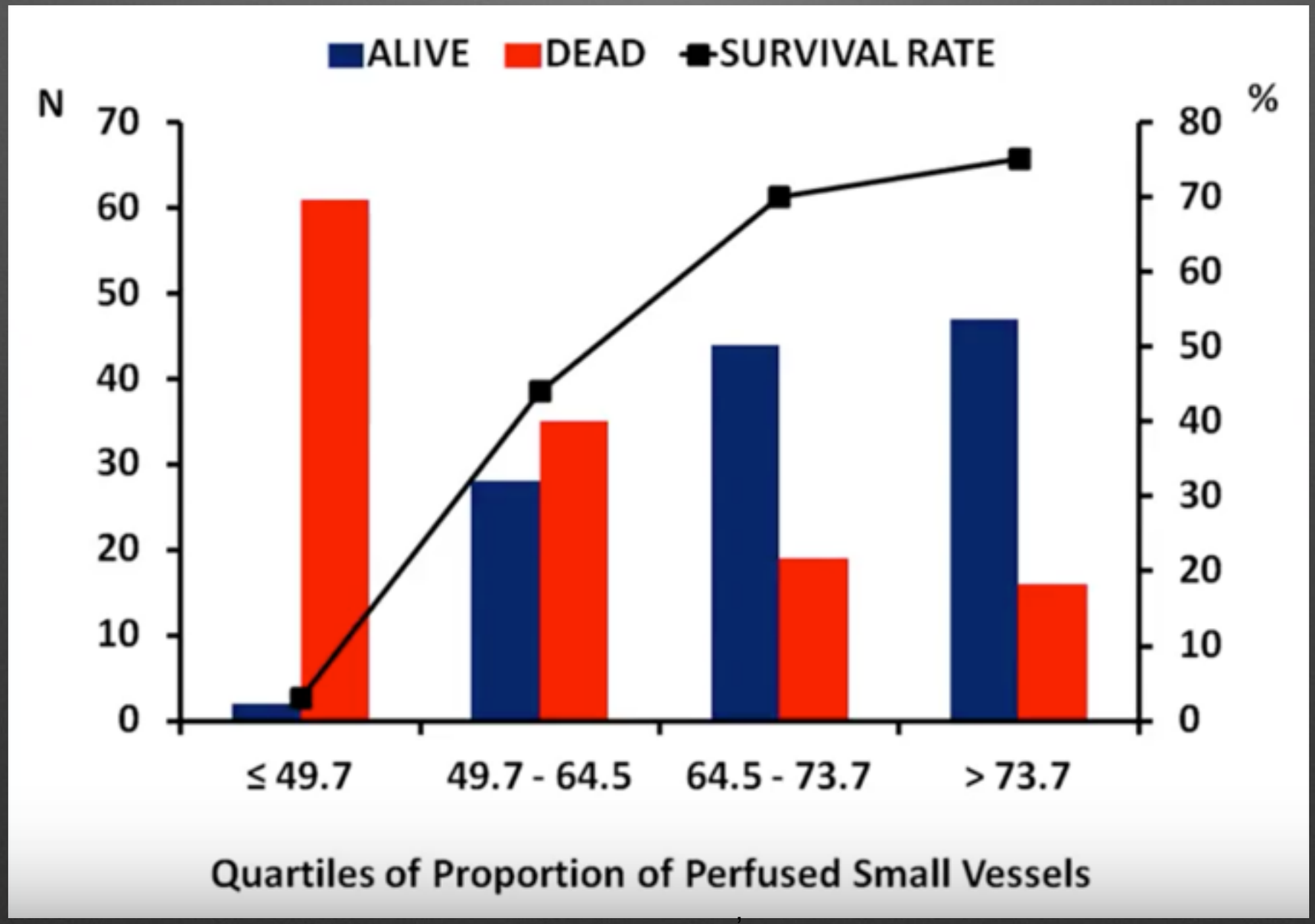
Severe sepsis



Sakr Y, Dubois MJ, De Backer D, Creteur J, Vincent JL.
Crit Care Med. 2004 Sep;32(9):1825-31.

Valeur pronostique de la dysfonction micro-circulatoire

Severe sepsis



De Backer D, Donadello K, Sakr Y, Ospina-Tascon G, Salgado D, Scolletta S, Vincent JL.
Crit Care Med. 2013 Mar;41(3):791-9

Sepsis

Near-infrared Spectroscopy (StO2)

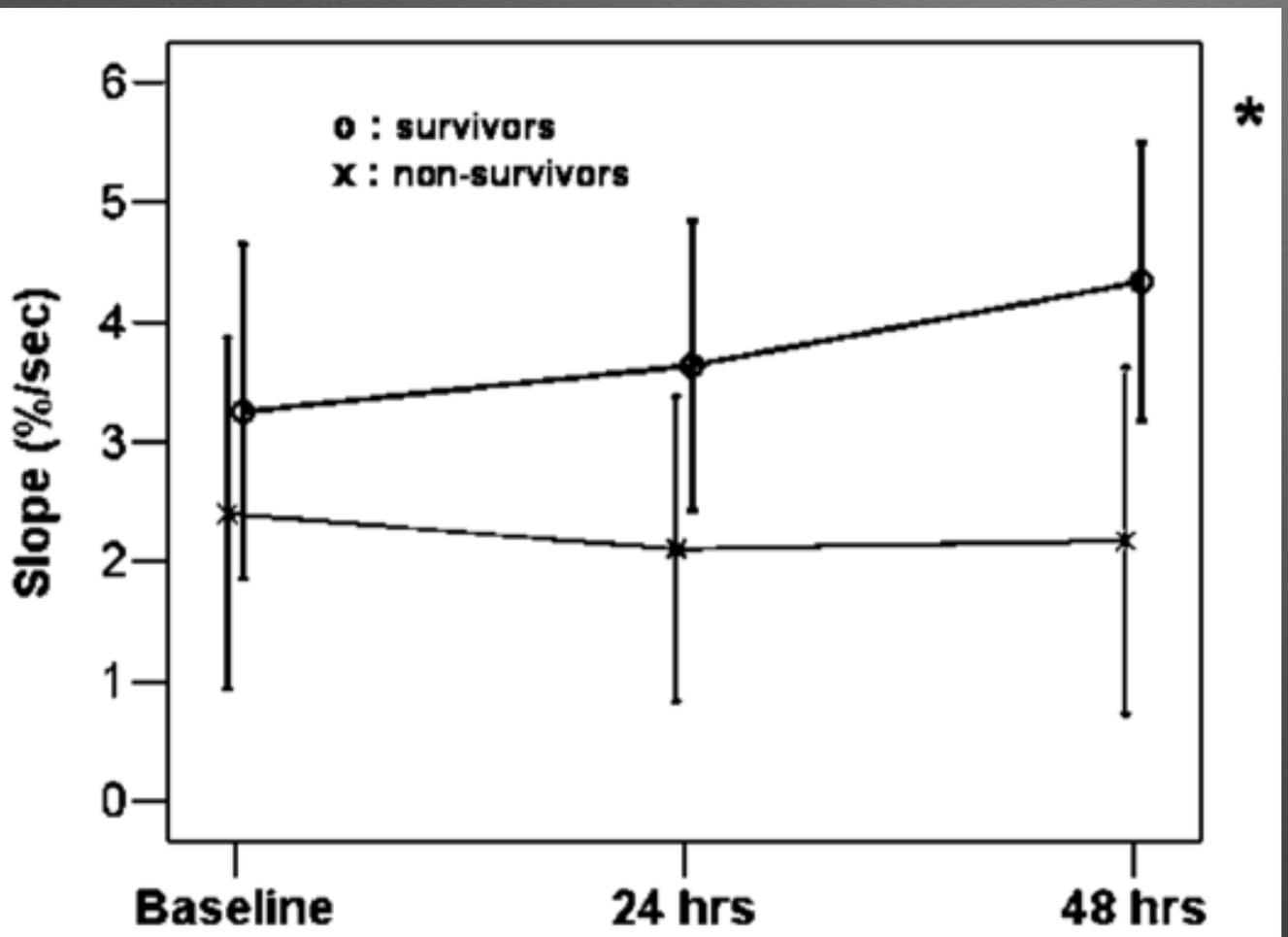


Fig. 4 Time course of slope (mean ± SD) in survivors ($n = 28$; *circles*) and non-survivors ($n = 24$; *crosses*) at baseline, and after 24 and 48 h in 52 septic patients. *Asterisk*, Significant difference at 0.05 level between groups across time

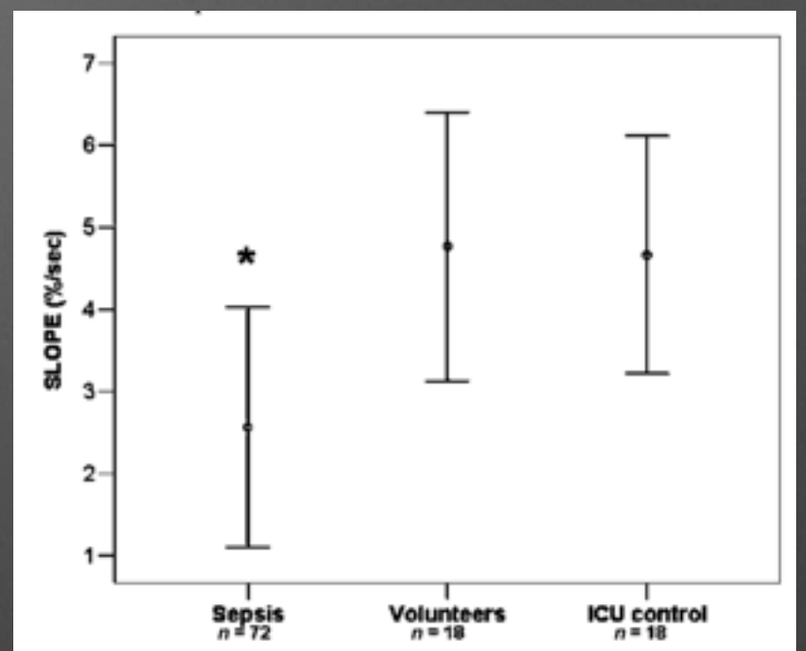


Fig. 2 Slope in septic patients ($n = 72$), healthy volunteers ($n = 18$), and ICU control patients ($n = 18$). *Asterisk*, Significant difference at 0.05 level vs. healthy volunteers and ICU control

Intensive Care Med (2007) 33:1549–1556
DOI 10.1007/s00134-007-0739-3

ORIGINAL

Jacques Creteur
Tiziana Carollo
Giulia Soldati
Gustavo Buchele
Daniel De Backer
Jean-Louis Vincent

The prognostic value of muscle StO_2 in septic patients

Valeur pronostique dans le choc cardiogénique

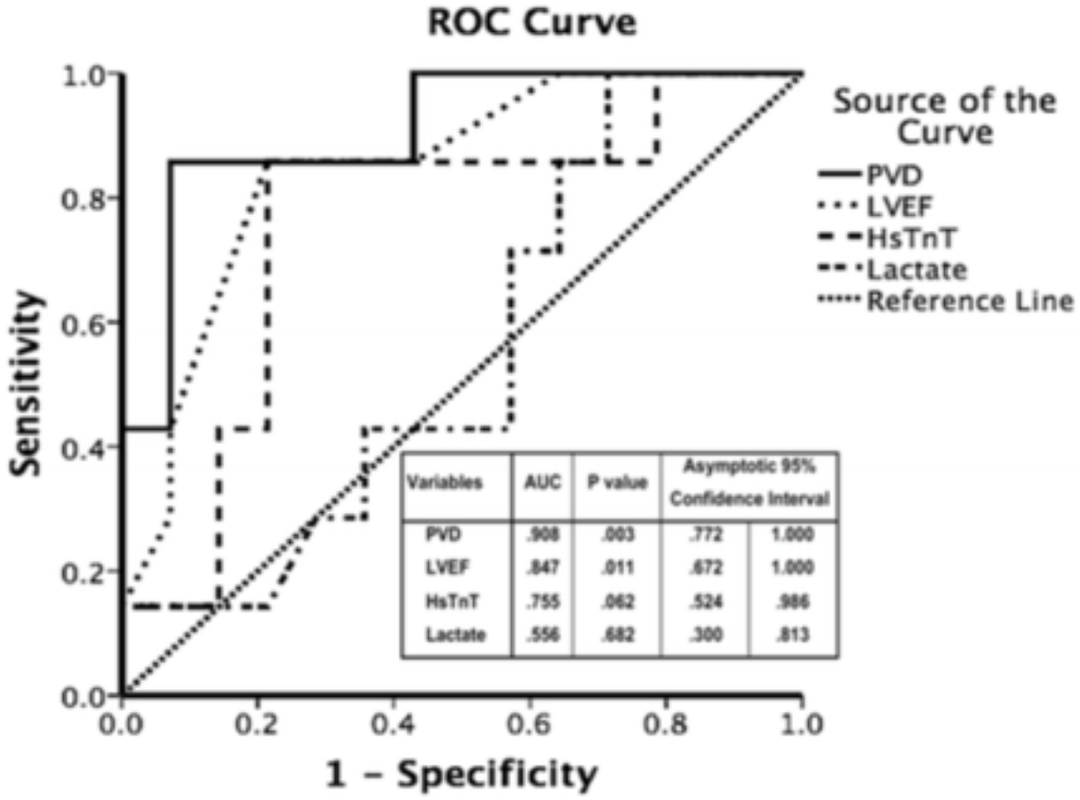


Fig. 4
Receiver operating characteristics (*ROC*) curves showing the relationship between sensitivity and 1 – specificity in determining the perfused vessel density (*PVD*) all vessels, high sensitive troponin T (*HsTnT*), lactate, and left ventricular ejection fraction (*LVEF*) to predict ICU survival

Microcirculatory assessment of patients under VA-ECMO

Atila Kara† ✉, Sakir Akin†, Dinis dos Reis Miranda, Ard Struijs, Kadir Caliskan, Robert J. van Thiel, Eric A. Dubois, Wouter de Wilde, Felix Zijlstra, Diederik Gommers and Can Ince
† Contributed equally

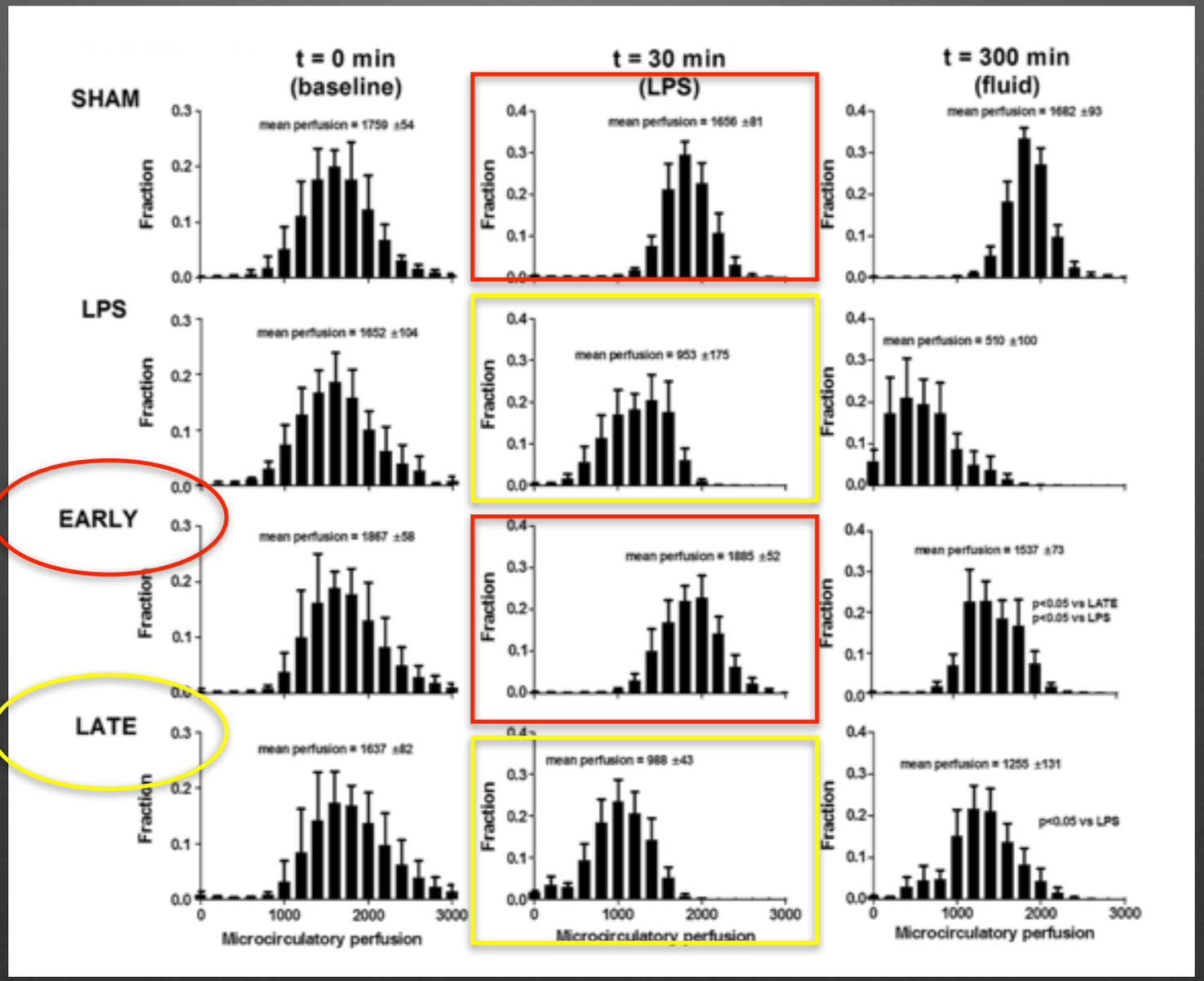
Critical Care 2016 **20**:344 | DOI: 10.1186/s13054-016-1519-7

Table des matières

Comment améliorer la micro-circulation

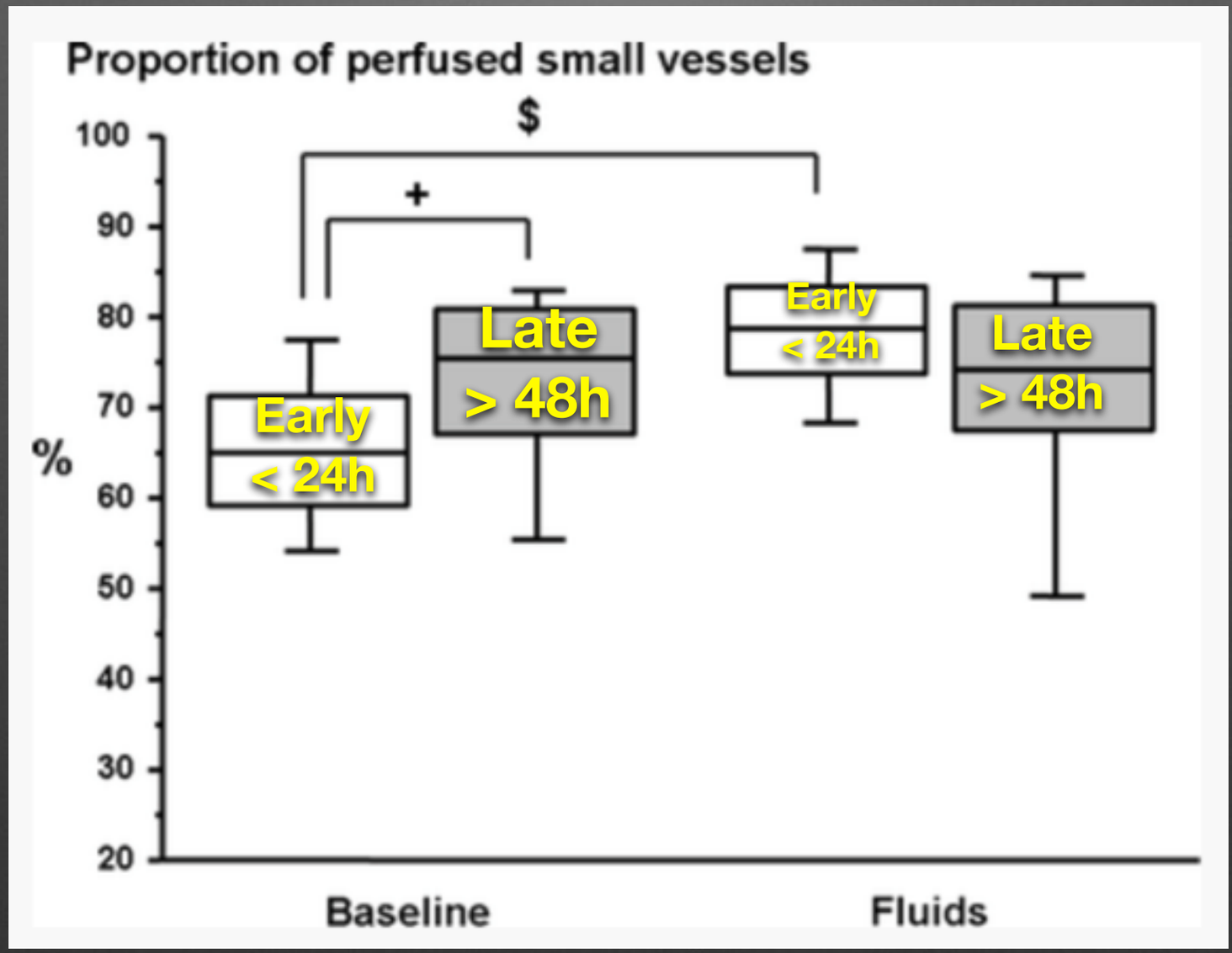
- Les fluides
- Les globules rouges
- Les intotropes
- Les vasopresseurs
- Les vasodilatateurs
- La fonction endothéliale

Timing Fuides



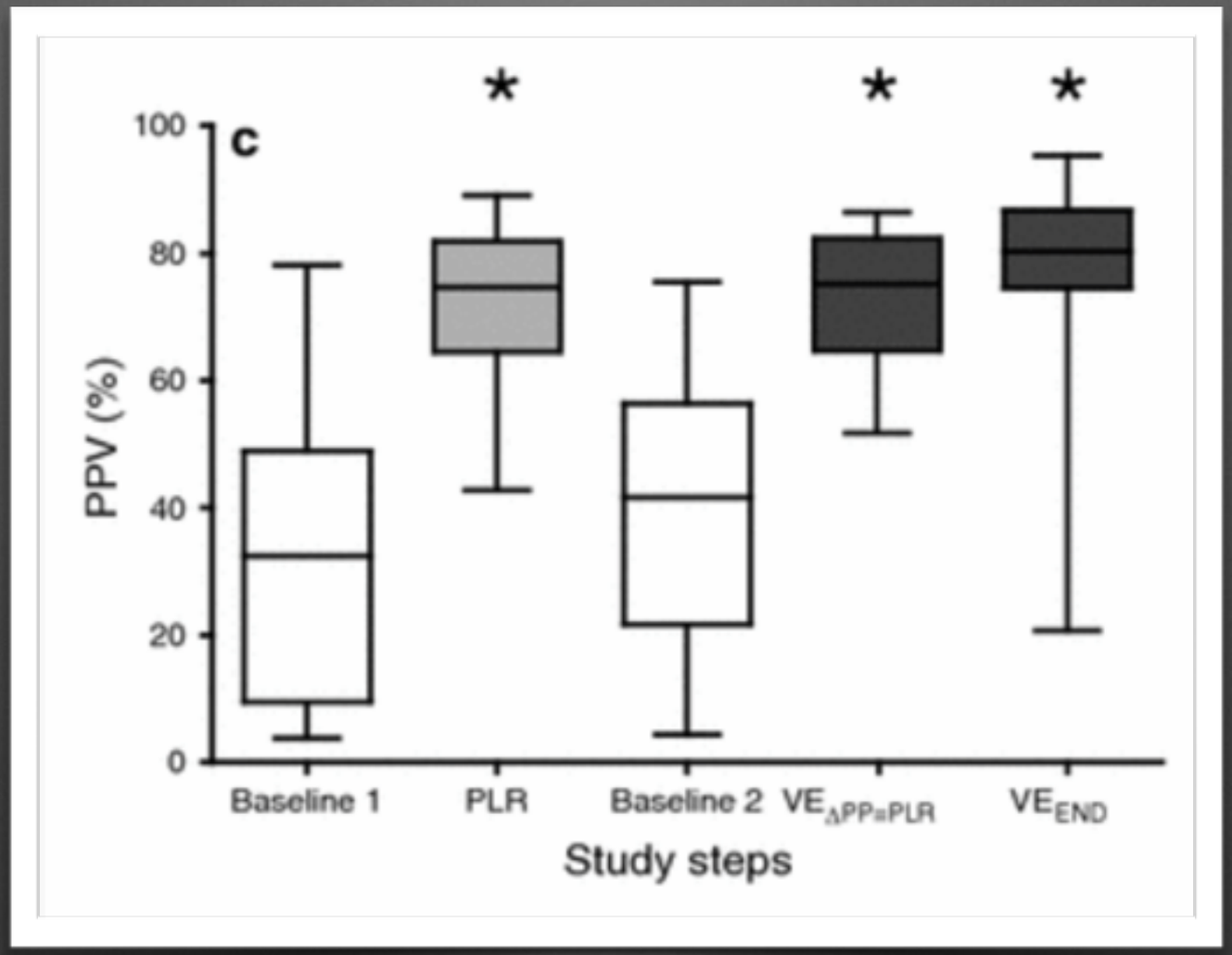
The role of renal hypoperfusion in development of renal microcirculatory dysfunction in endotoxemic rats.
Legrand M, Bezemer R, Kandil A, Demirci C, Payen D, Ince C.
Intensive Care Med. 2011 Sep;37(9):1534-42.

Les fluides



Effects of fluids on microvascular perfusion in patients with severe sepsis.
Ospina-Tascon G1, Neves AP, Occhipinti G, Donadello K, Büchele G, Simion D, Chierego ML, Silva TO, Fonseca A, Vincent JL, De Backer D.
Intensive Care Med. 2010 Jun;36(6):949-55

Les fluides



CO: 5,1 6,0 5,1 5,9 6,5

Both passive leg raising and intravascular volume expansion improve sublingual microcirculatory perfusion in severe sepsis and septic shock patients.
Pottecher J, Deruddre S, Teboul JL, Georger JF, Laplace C, Benhamou D, Vicaut E, Duranteau J.
Intensive Care Med. 2010 Nov;36(11):1867-74.

Les fluides

Intensive Care Med (2013) 39:612–619
DOI 10.1007/s00134-012-2793-8

ORIGINAL

Andrius Pranskunas
Matty Koopmans
Peter M. Koetsier
Vidas Pilvinis
E. Christiaan Boerma

Microcirculatory blood flow as a tool to select ICU patients eligible for fluid therapy

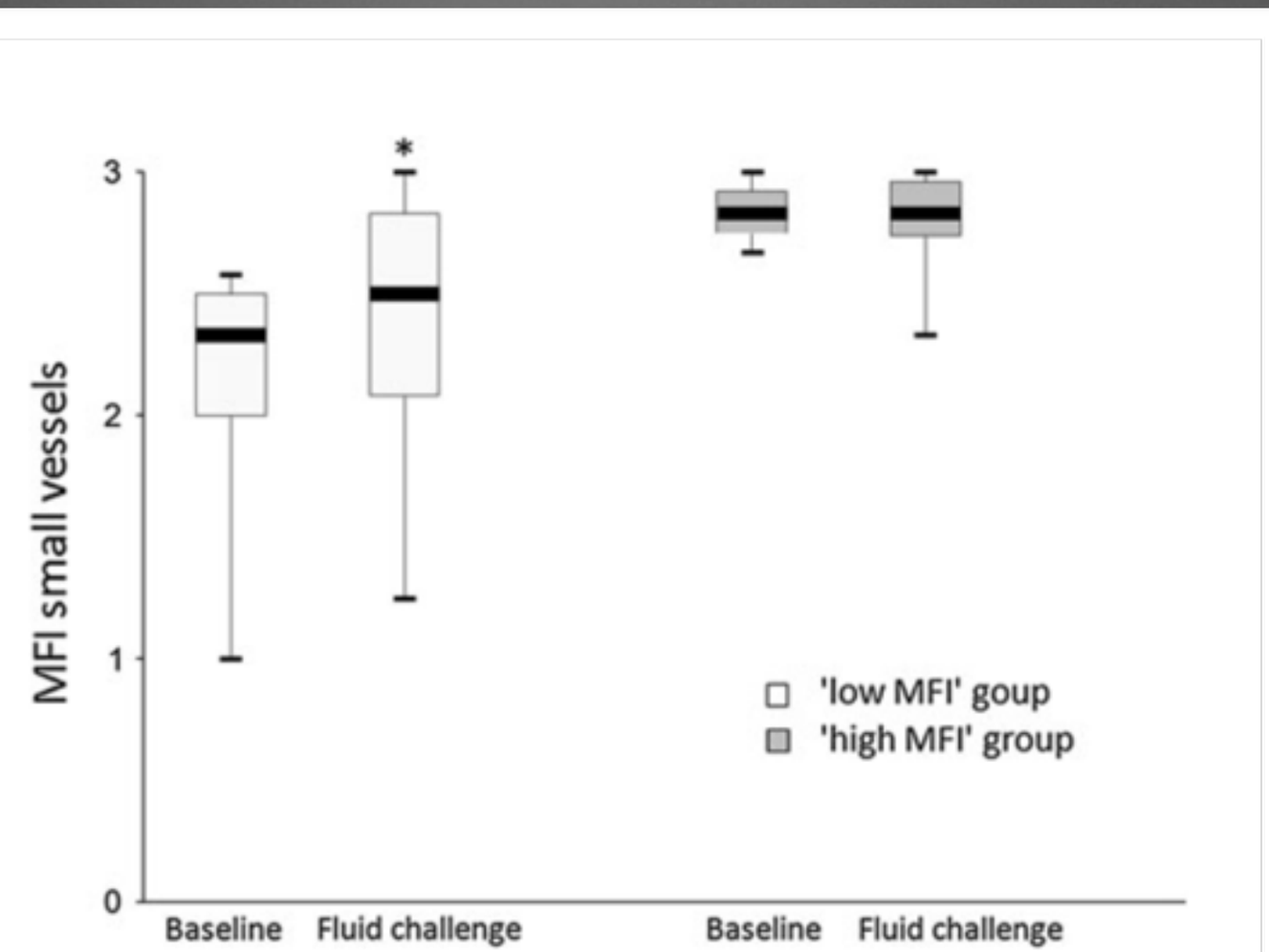


Fig. 1 *Boxplots* of the microvascular flow index (MFI) in response to fluid administration in patients with MFI <2.6 (low MFI) and ≥2.6 (high MFI) at baseline. *$p < 0.005$

Les fluides

Intensive Care Med (2013) 39:612–619
DOI 10.1007/s00134-012-2793-8

ORIGINAL

Andrius Pranskunas
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Microcirculatory blood flow as a tool to select ICU patients eligible for fluid therapy

Altération microC

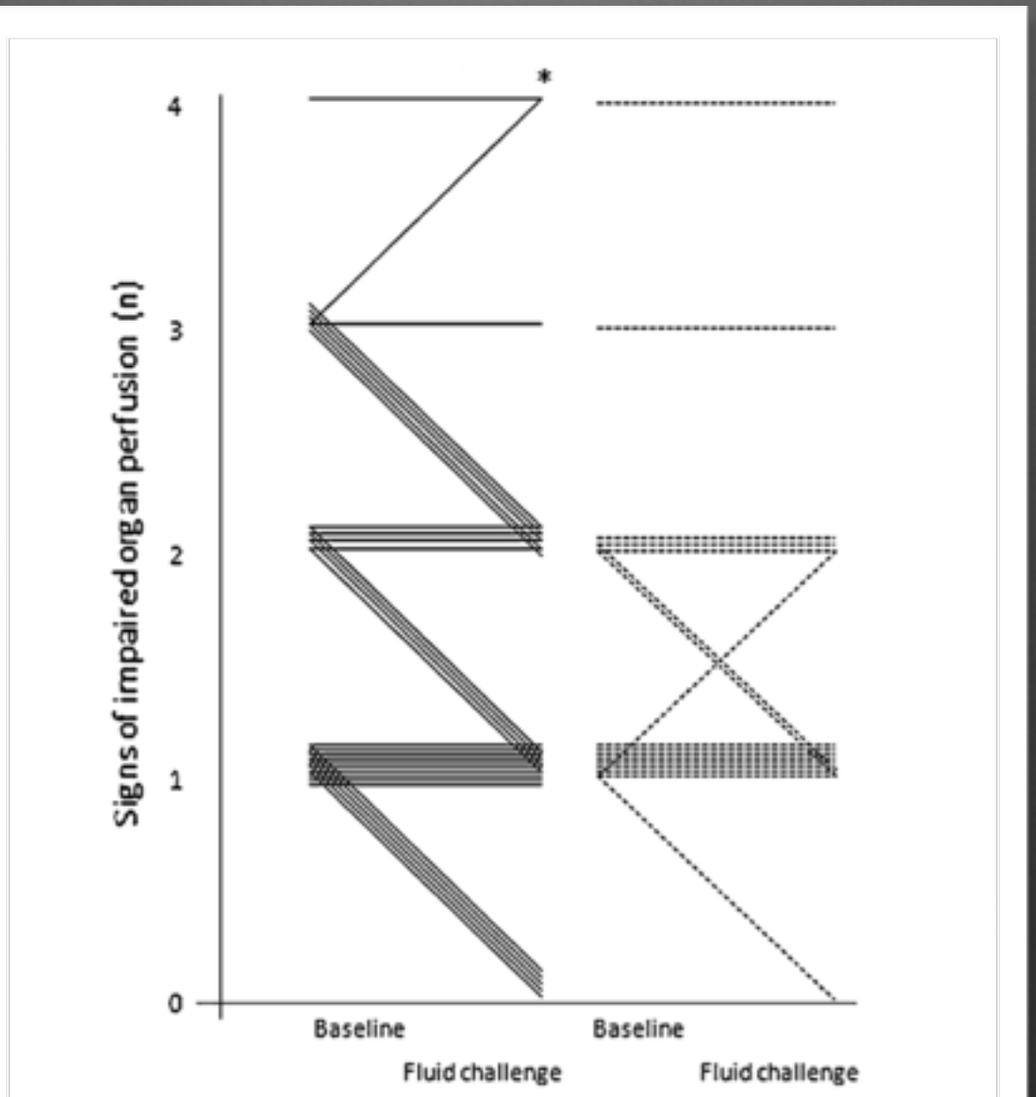
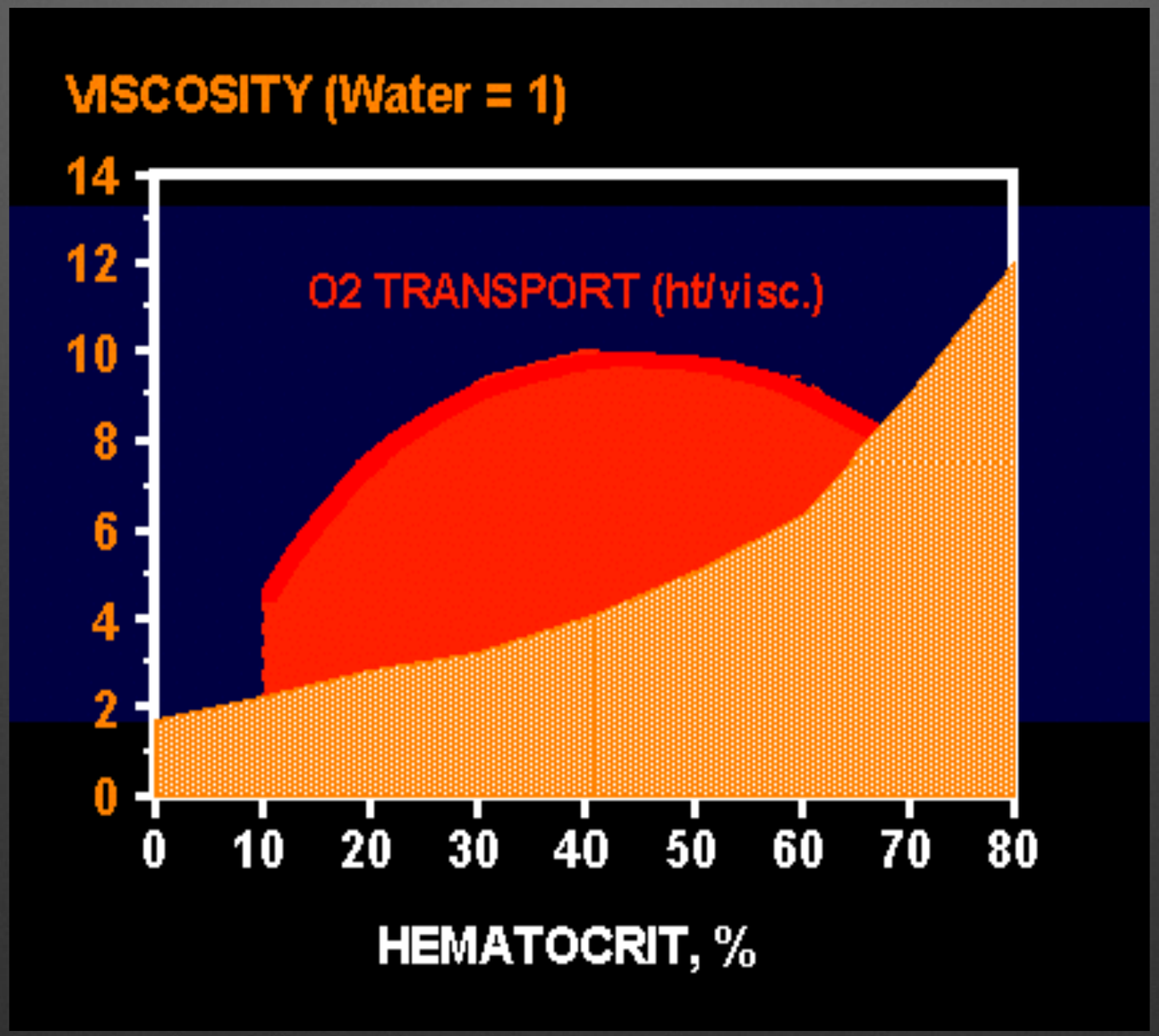


Fig. 2 Change in number of "clinical signs of impaired organ perfusion" for individual patients in response to fluid administration. *Closed lines* low MFI group (MFI <2.6 at baseline), *dotted lines* high MFI group (MFI ≥2.6 at baseline). *$p < 0.001$

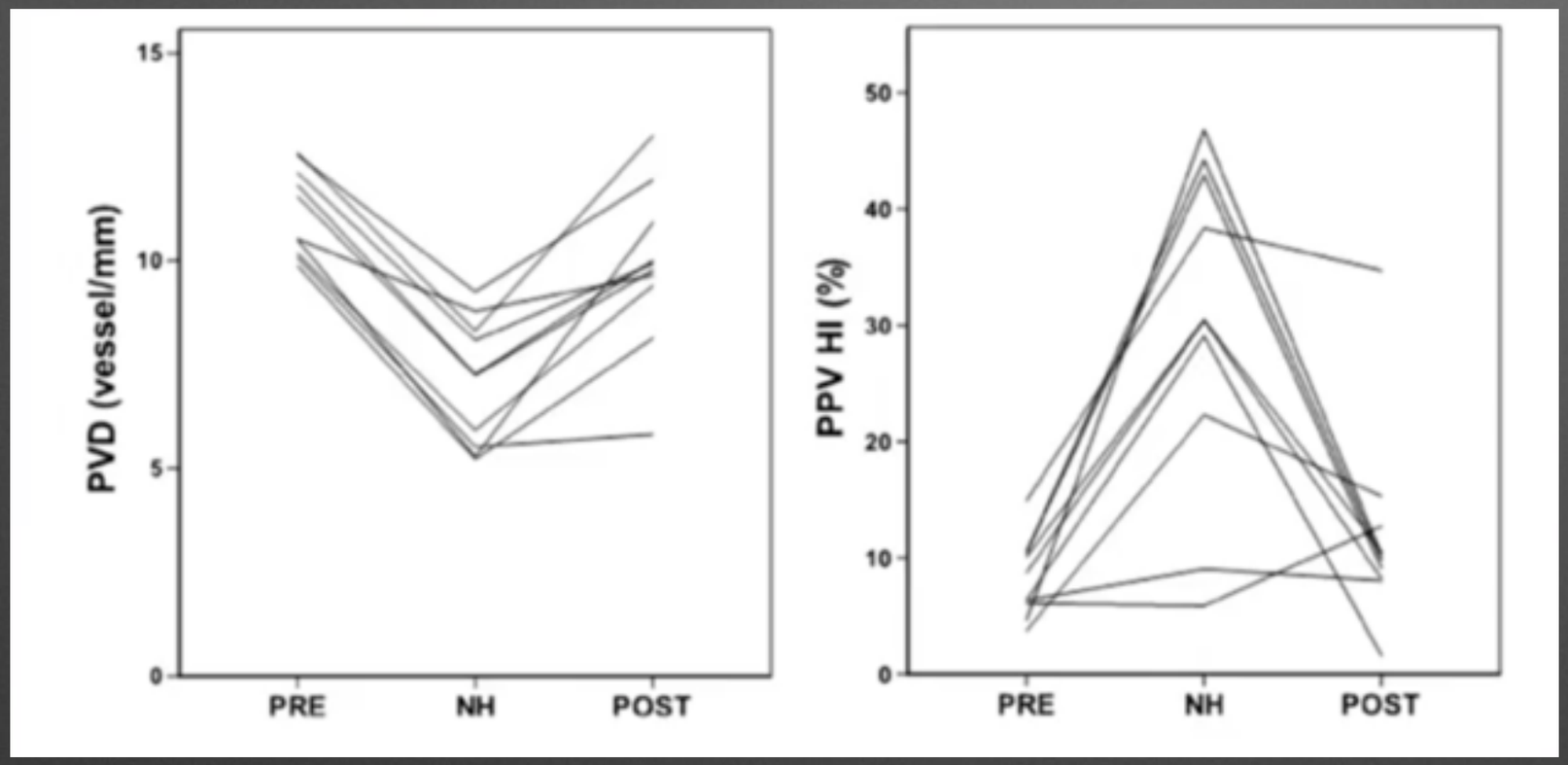
MicroC OK

Les globules rouges?



Microvascular response to red blood cell transfusion in patients with severe sepsis.
Sakr Y, Chierego M, Piagnerelli M, Verdant C, Dubois MJ, Koch M, Creteur J, Gullo A, Vincent JL, De Backer D.
Crit Care Med. 2007 Jul;35(7):1639-44.

L’oxygène?



NIRS variables during the two-day experiment in 22 volunteers.

	CONTROL DAY	DIRECT O_2	*p*
StO_2 base (%)	80 (78–83)	83 (81–86)	0.02
THI base (au)	15 (13.9–15.7)	14 (12.6–15.4)	0.01
StO_2 max (%)	94 (93–95)	97 (95–98)	<0.01
Desc slope (%/min)	10.7 (9.1–12.1)	9.4 (7.5–11.1)	0.02
Asc slope (%/s)	4.5 (4.1–5.2)	4.7 (3.9–5.3)	0.84
NIRS VO_2 (au)	150 (133–174)	115 (102–139)	<0.01

Normobaric hyperoxia alters the microcirculation in healthy volunteers.
Orbegozo Cortés D, Puflea F, Donadello K, Taccone FS, Gottin L, Creteur J, Vincent JL, De Backer D.
Microvasc Res. 2015 Mar;98:23-8. doi: 10.1016/j.mvr.2014.11.006.

Les inotropes

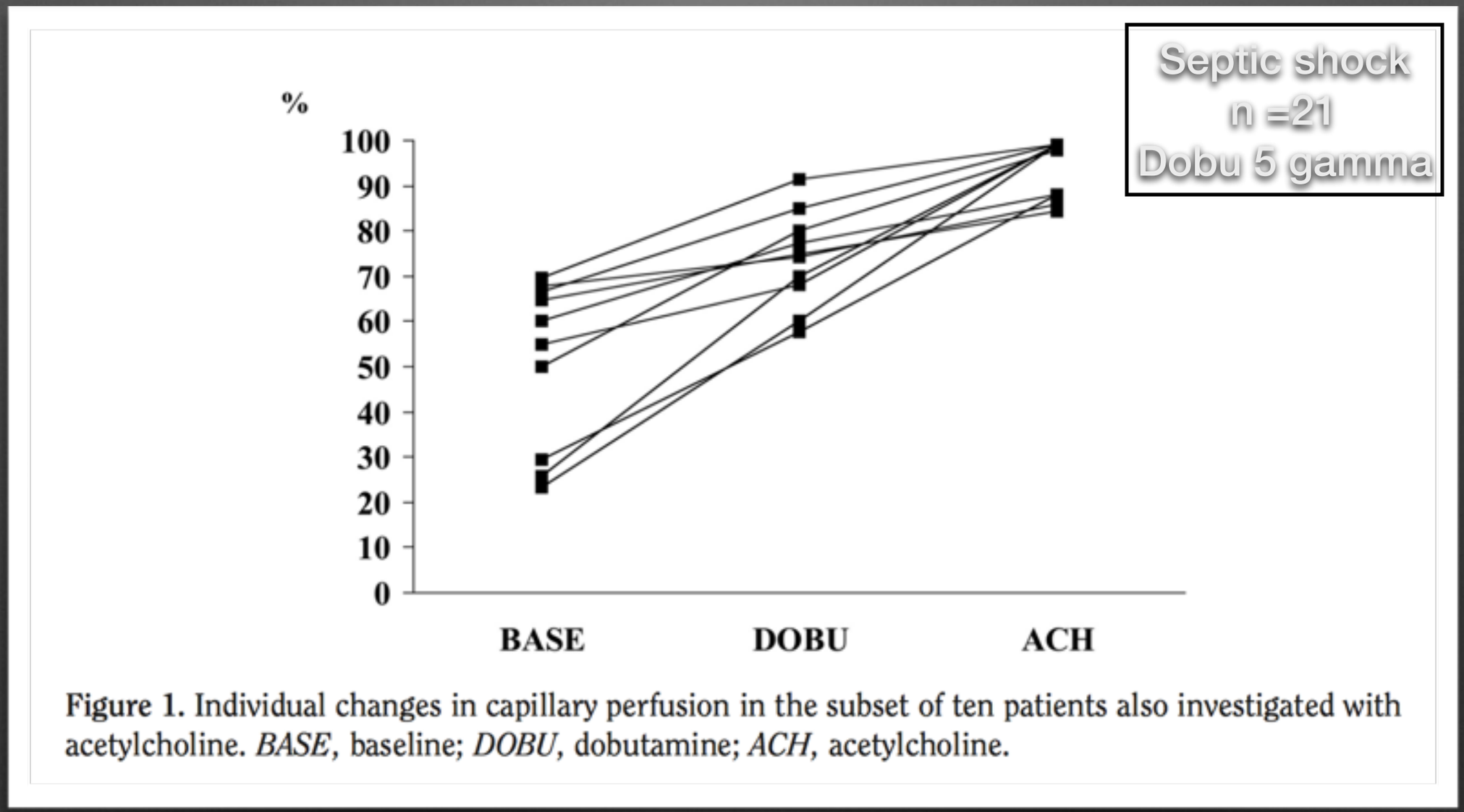
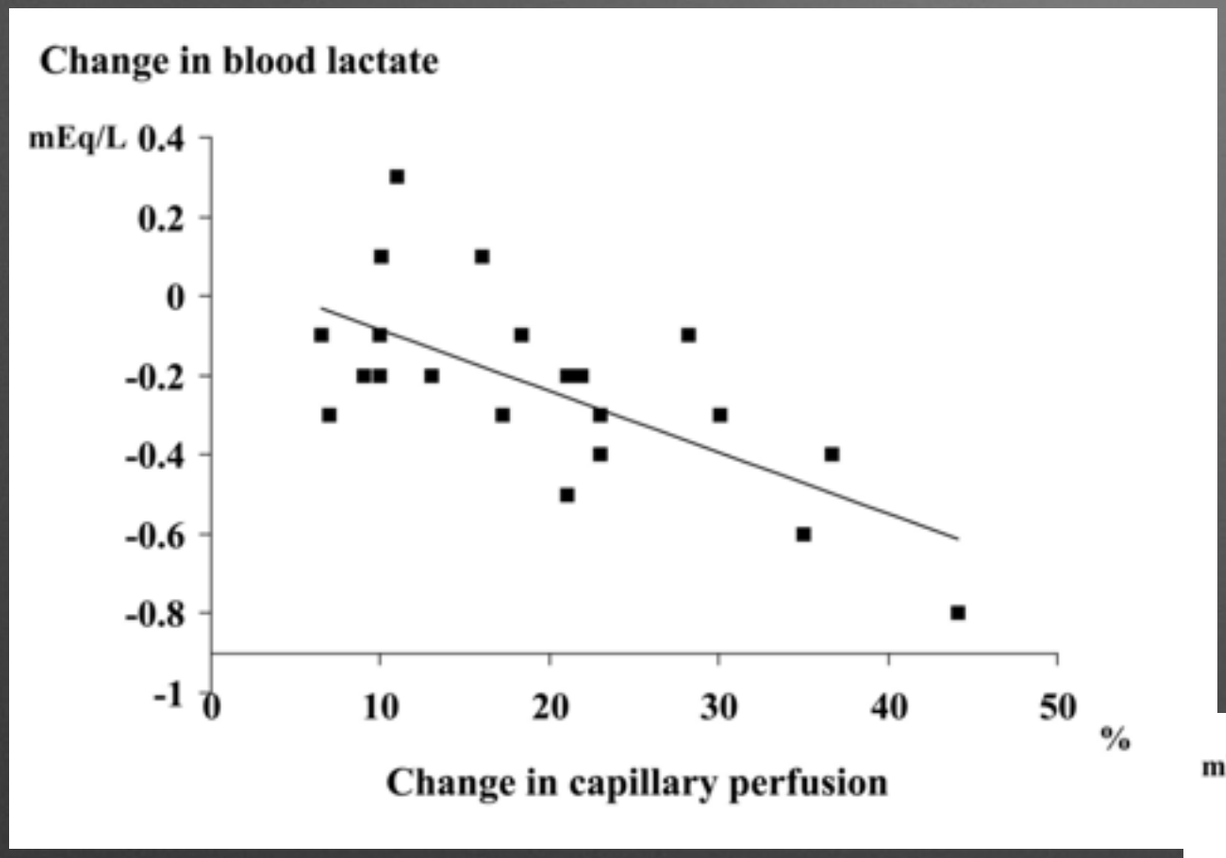


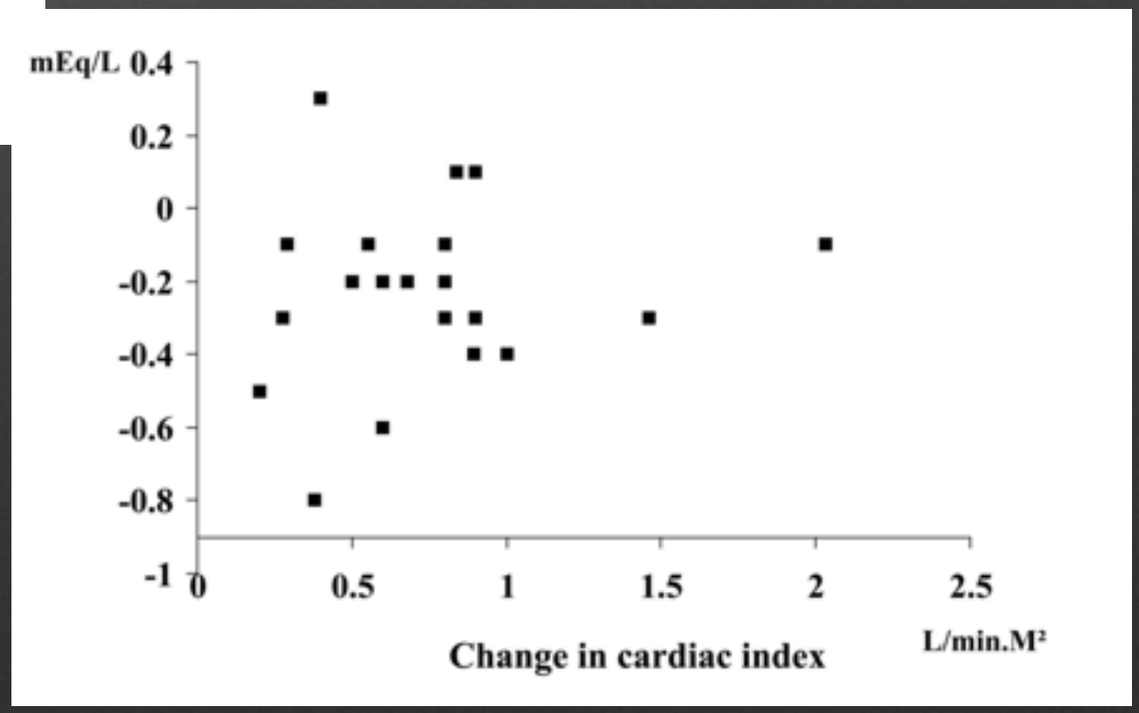
Figure 1. Individual changes in capillary perfusion in the subset of ten patients also investigated with acetylcholine. *BASE*, baseline; *DOBU*, dobutamine; *ACH*, acetylcholine.

The effects of dobutamine on microcirculatory alterations in patients with septic shock are independent of its systemic effects.
De Backer D, Creteur J, Dubois MJ, Sakr Y, Koch M, Verdant C, Vincent JL.
Crit Care Med. 2006 Feb;34(2):403-8.

Les inotropes

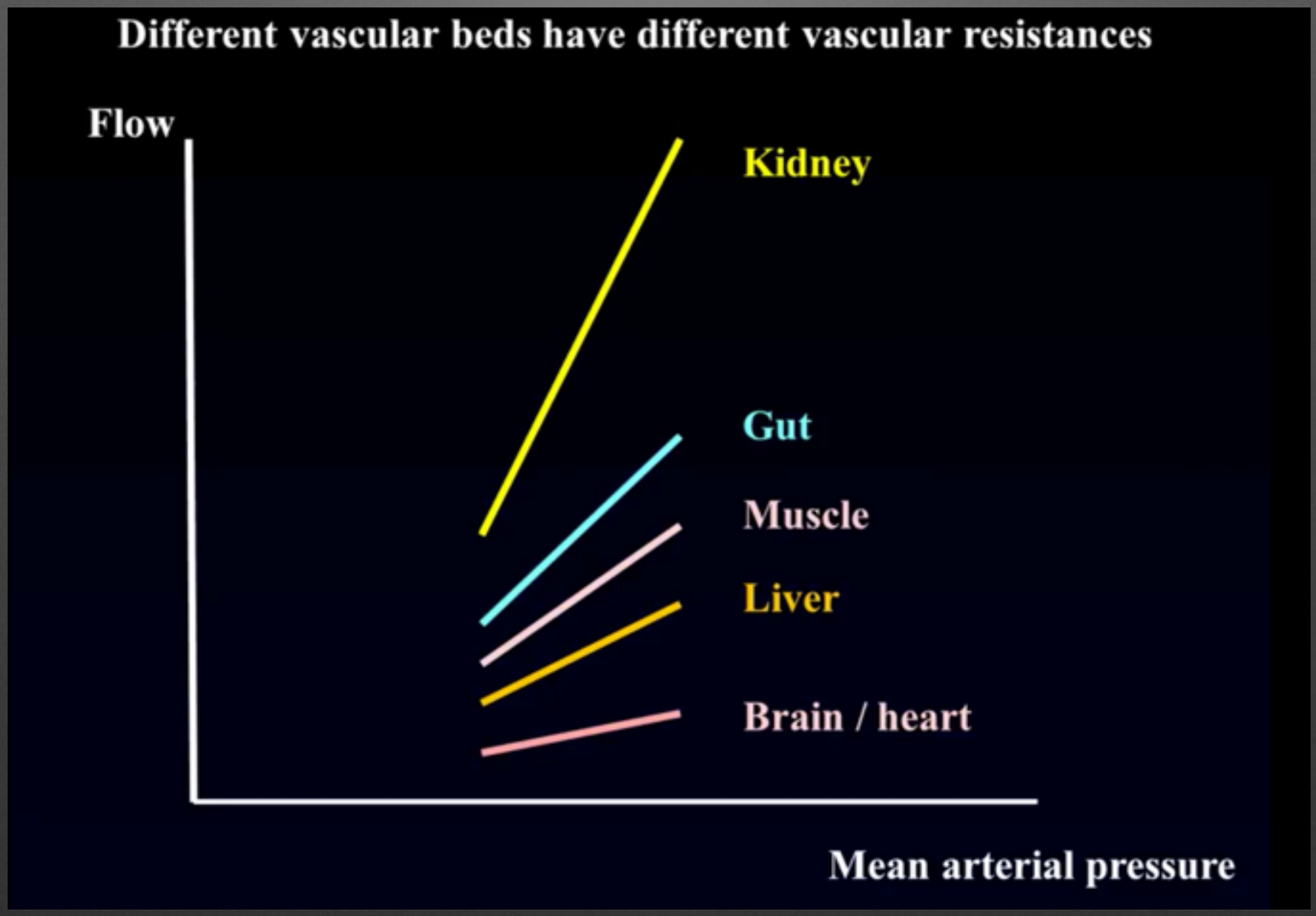


Septic shock
n =21
Dobu 5 gamma



The effects of dobutamine on microcirculatory alterations in patients with septic shock are independent of its systemic effects.
De Backer D, Creteur J, Dubois MJ, Sakr Y, Koch M, Verdant C, Vincent JL.
Crit Care Med. 2006 Feb;34(2):403-8.

Les vasopresseurs

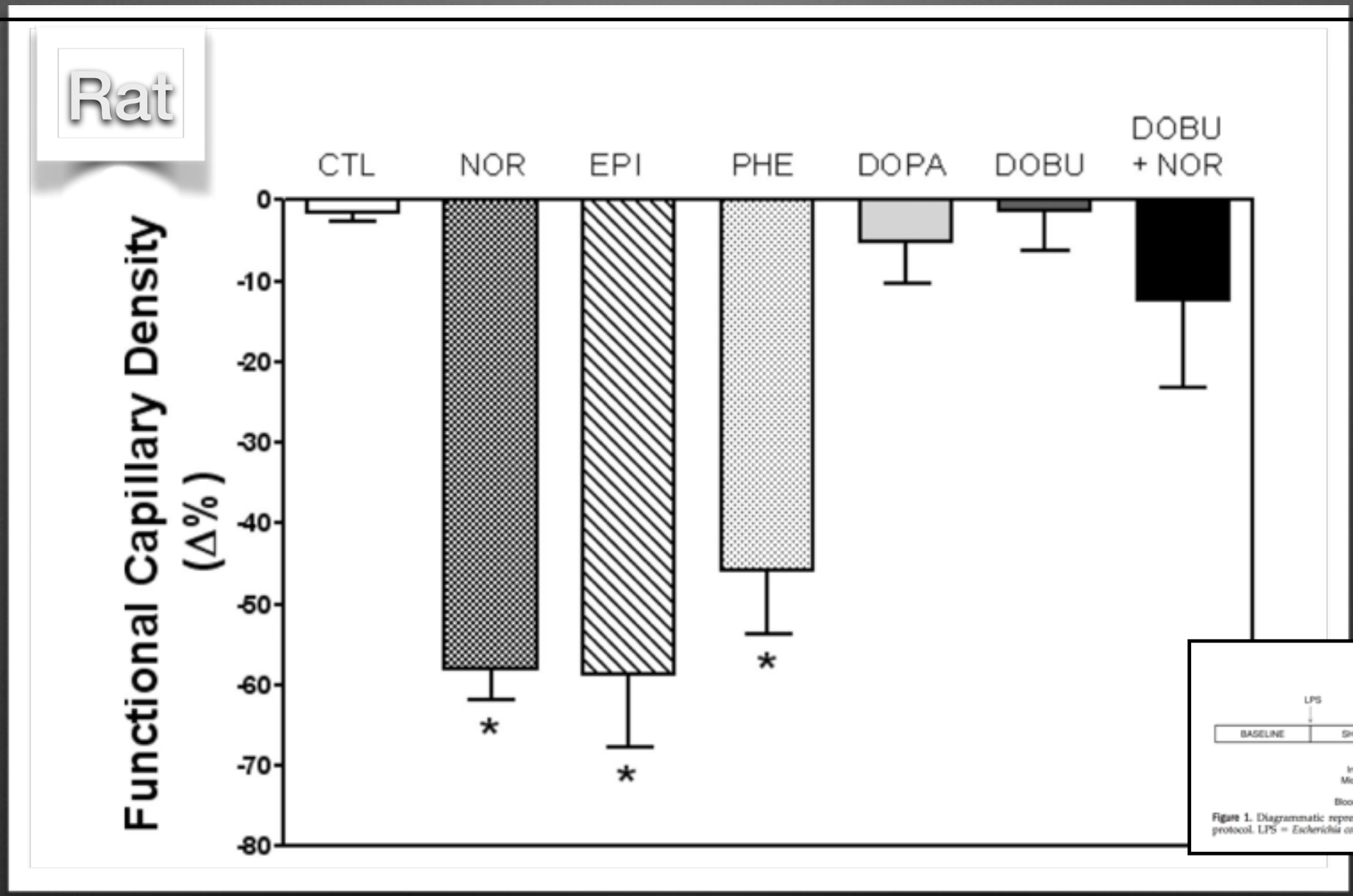


Effet de la PAM sur le débit régional

Les vasopresseurs

vasoconstricteurs

Les vasopresseurs



The effects of vasoactive drugs on intestinal functional capillary density in endotoxemic rats: intravital video-microscopy analysis.
Nacul FE, Guia IL, Lessa MA, Tibiriçá E.
Anesth Analg. 2010 Feb 1;110(2):547-54.

Les vasopresseurs

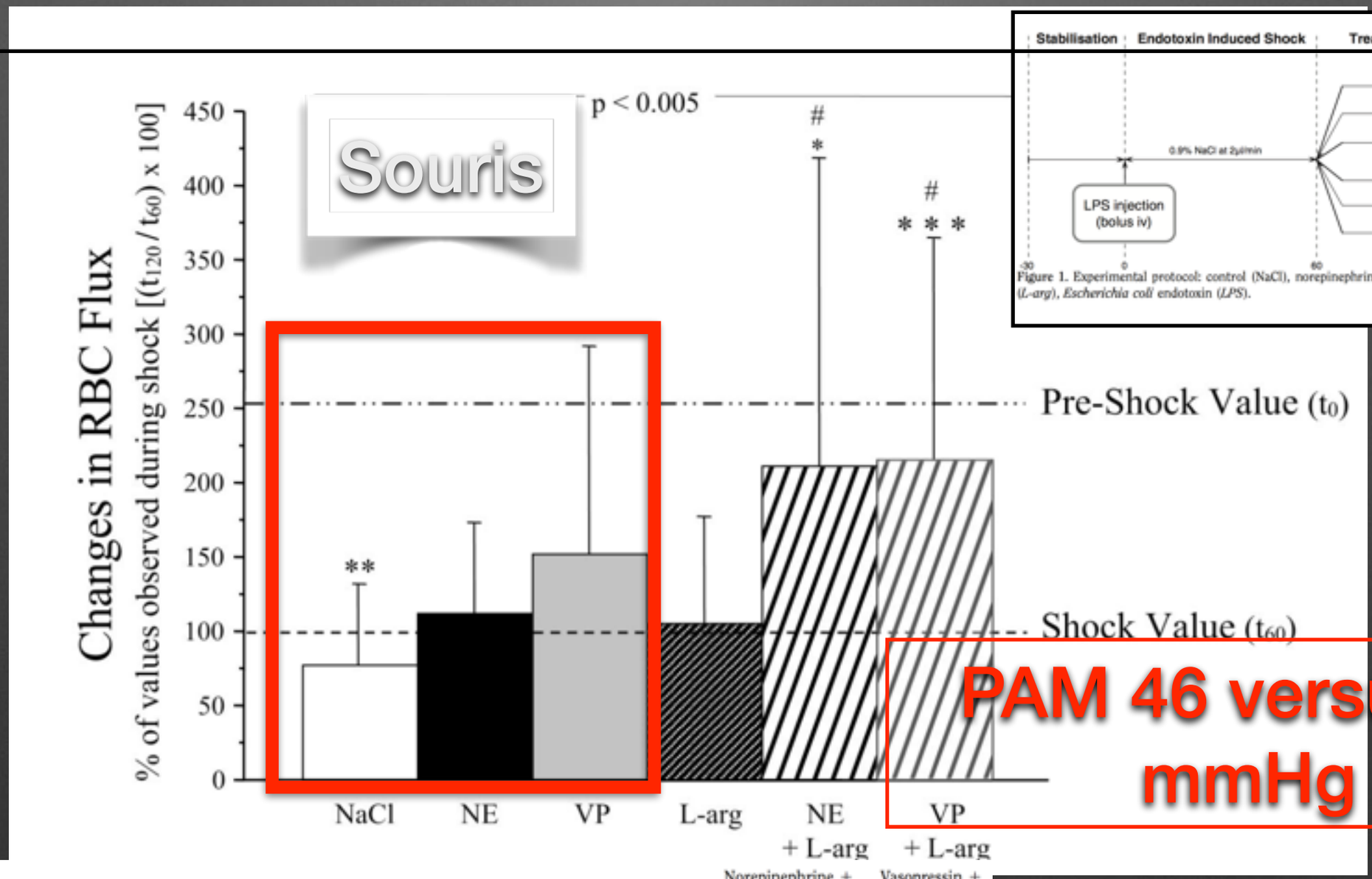


Figure 1. Experimental protocol: control (NaCl), norepinephrine (*NE*), vasopressin (*VP*), L-arginine (*L-arg*), *Escherichia coli* endotoxin (*LPS*).

PAM 46 versus 70 mmHg

Group	Time, mins	Control	Norepinephrine	Vasopressin	L-Arginine	Norepinephrine + L-Arginine	Vasopressin + L-Arginine
MAP, mm Hg	0	72 ± 4	72 ± 3	72.5 ± 2	72 ± 2	72.5 ± 4	71 ± 2
	60	48 ± 5	43.5 ± 8	46.5 ± 5	48 ± 2	47 ± 4	43 ± 6
	120	46 ± 4	71 ± 2	70 ± 4	44 ± 4	74 ± 4	71 ± 4

Effects of vasopressin, norepinephrine, and L-arginine on intestinal microcirculation in endotoxemia.
Nakajima Y, Baudry N, Duranteau J, Vicaut E.
Crit Care Med. 2006 Jun;34(6):1752-7.

Les vasopresseurs

Humain
Choc septique

Intensive Care Med (2010) 36:1882–1889
DOI 10.1007/s00134-010-2013-3

ORIGINAL

Jean-François Georger
Olfa Hamzaoui
Anis Chaari
Julien Maizel
Christian Richard
Jean-Louis Teboul

Restoring arterial pressure with norepinephrine improves muscle tissue oxygenation assessed by near-infrared spectroscopy in severely hypotensive septic patients

$p<0.05$

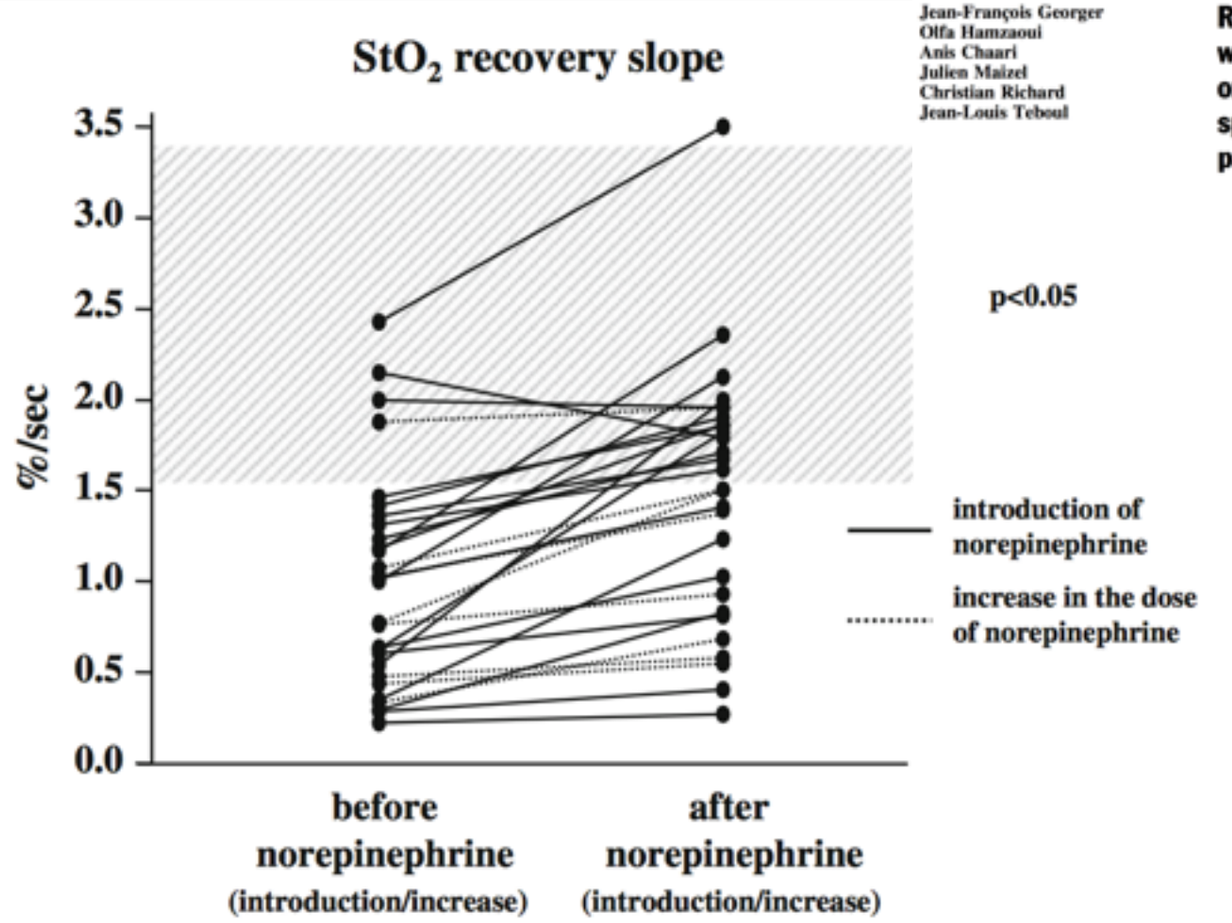


Fig. 2 Individual values of the StO_2 recovery slope before and during administration of norepinephrine in septic patients. The eight patients who had already received norepinephrine are represented by *dotted lines*. The *grey cross-hatched zone* represents the range of values of the StO_2 recovery slope measured in our group of healthy volunteers

Les vasodilatateurs

Topical Acétylcholine

TABLE 4. EFFECT OF TOPICAL ACETYLCHOLINE ADMINISTRATION IN 11 PATIENTS WITH SEPSIS

	Patients with Sepsis*,† ($n = 11$)		Volunteers ($n = 10$)
	Baseline	Acetylcholine (10^{-2} M)	
Total number of vessels, n/mm	4.9 (4.1–5.7)	6.0 (4.7–6.4)‡	5.4 (5.4–6.3)‡
Proportion of vessels perfused, %	83 (77–96)	99 (98–100)‡	98 (97–99)‡
Proportion of venules perfused, %	100 (100–100)	100 (100–100)	100 (100–100)
Proportion of capillaries perfused, %	44 (24–60)	94 (77–96)‡	94 (92–95)‡
Absent flow (capillaries), %	29 (8–44)	1 (0–3)‡	3 (2–5)‡
Intermittent flow (capillaries), %	24 (19–38)	8 (3–19)‡	5 (3–6)‡

Data are presented as medians (25th–75th percentiles).

* All the patients with sepsis were treated with vasoactive agents (dopamine, n = 11, 20 [15–20] μg/kg · min; norepinephrine, n = 4, 1.23 [0.59–2.10] μg/kg · min; dobutamine, n = 7, 20 [5–20] μg/kg · min; epinephrine, n = 1, 0.1 μg/kg · min).

† The principal physiologic variables of the septic patients are reported in Table E2 in the online data supplement.

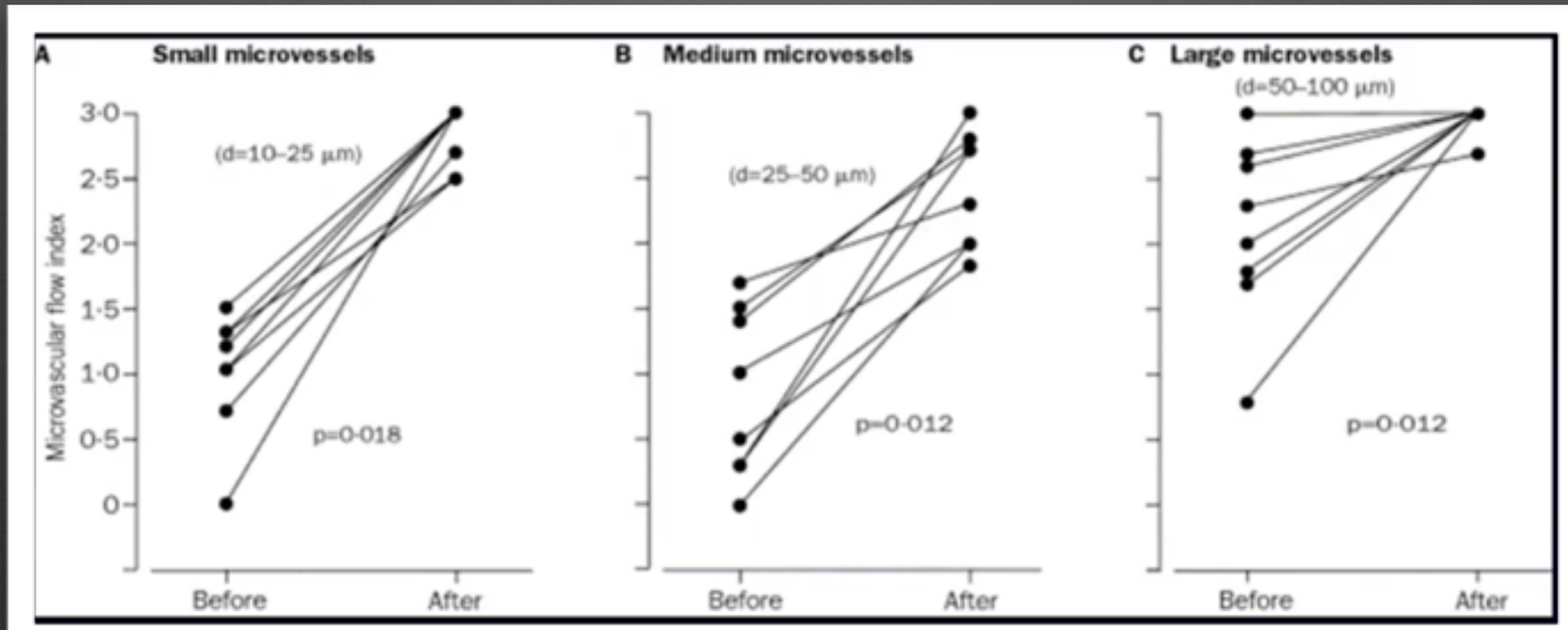
‡ $p < 0.01$ versus sepsis.

Microvascular blood flow is altered in patients with sepsis.
De Backer D, Creteur J, Preiser JC, Dubois MJ, Vincent JL.
Am J Respir Crit Care Med. 2002 Jul 1;166(1):98-104.

Les vasodilatateurs

Nitroglycerin

Choc septique
0,5 mg IV

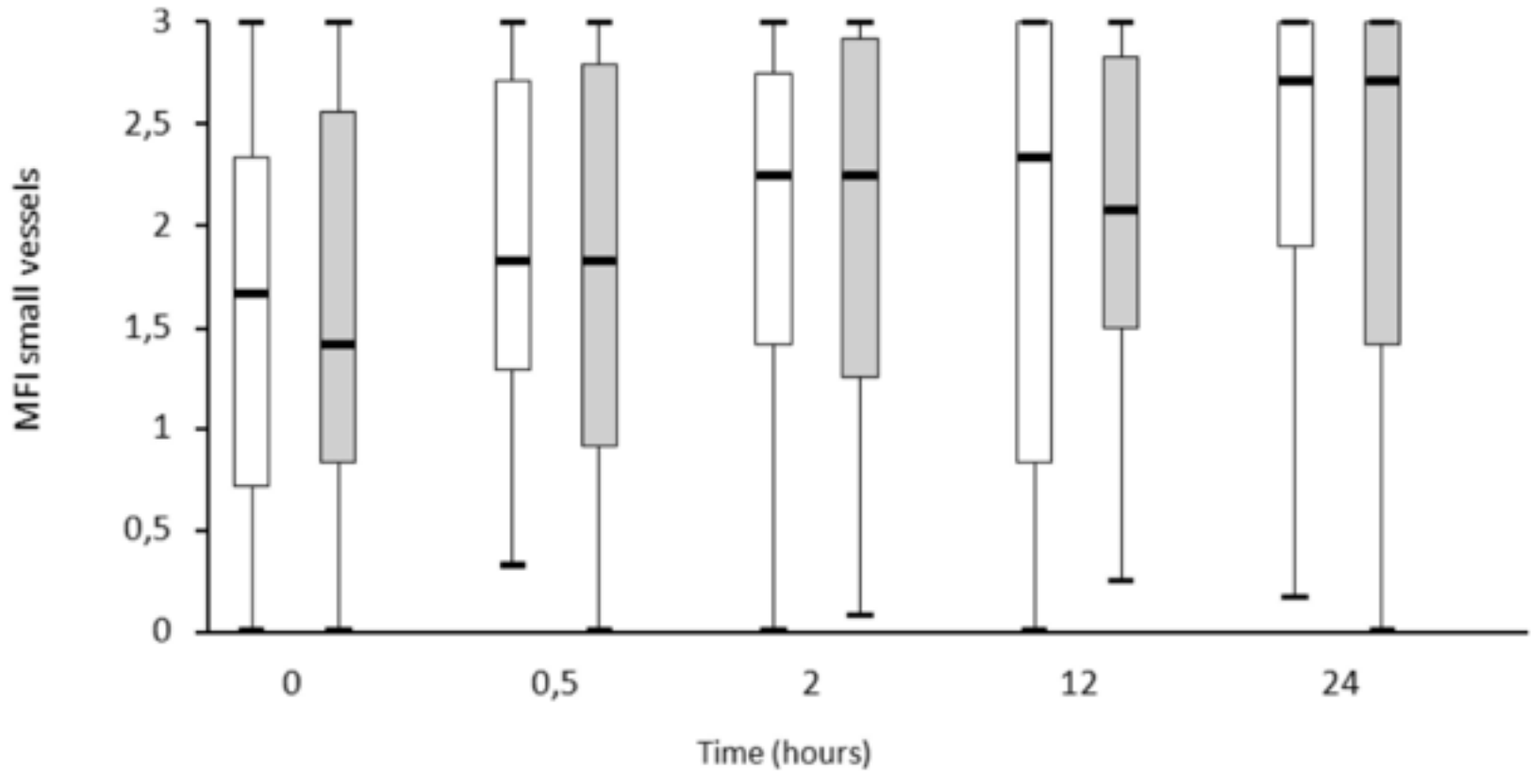


Nitroglycerin in septic shock after intravascular volume resuscitation.
Spronk PE, Ince C, Gardien MJ, Mathura KR, Oudemans-van Straaten HM, Zandstra DF.
Lancet. 2002 Nov 2;360(9343):1395-6.

Les vasodilatateurs

Nitroglycerin

Sepsis
n =70
2 mg/hr



Variables	Baseline NTG (n = 35)
MFI small vessels	1.67 (0.67–2.42)
MFI medium vessels	2.33 (1.83–2.83)
MFI large vessels	2.92 (2.75–3)
TVD, mm/mm^2	14 (12.8–15.6)
PPV, %	98 (93–100)
PVD, 1/mm	9.1 (8.3–10.5)
Heterogeneity index	1.76 (0.88–2.84)

Figure 2. Box plots of sublingual microvascular flow index (*MFI*) in small vessels (<20 μm) during the 24-hr study period. *White boxes*, nitroglycerin, *gray boxes*, placebo.

Effects of nitroglycerin on sublingual microcirculatory blood flow in patients with severe sepsis/septic shock after a strict resuscitation protocol: a double-blind randomized placebo controlled trial.
Boerma EC, Koopmans M, Konijn A, Kaiferova K, Bakker AJ, van Roon EN, Buter H, Bruins N, Egbers PH, Gerritsen RT, Koetsier PM, Kingma WP, Kuiper MA, Ince C.
Crit Care Med. 2010 Jan;38(1):93-100.

Les vasodilatateurs

NO inhalé

TABLE 3. Outcome Measures

	All Patients ($n = 49$)	Inhaled Nitric Oxide ($n = 26$)	Sham ($n = 23$)	p
Δ Microcirculatory flow index (0–2 hr)	−0.06 (−0.17 to 0.07)	−0.06 (−0.20 to 0.03)	−0.03 (−0.14 to 0.15)	0.37
Lactate clearance (%) (0–2 hr)	−9 (−15 to 0)	−9 (−16 to 12)	−9 (−15 to 0)	0.59
Δ SOFA score (0–6 hr)	0 (−1 to 0)	0 (−1 to 0)	0 (−1 to 0)	0.96
Δ SOFA score (0–24 hr)	−1 (−2 to 0)	−1 (−2 to 0)	−1 (−1 to 0)	0.30
Organ dysfunction responder,[a] *n* (%)	13 (27)	8 (31)	5 (22)	0.48
In-hospital mortality, *n* (%)	15 (31)	9 (35)	6 (26)	0.52

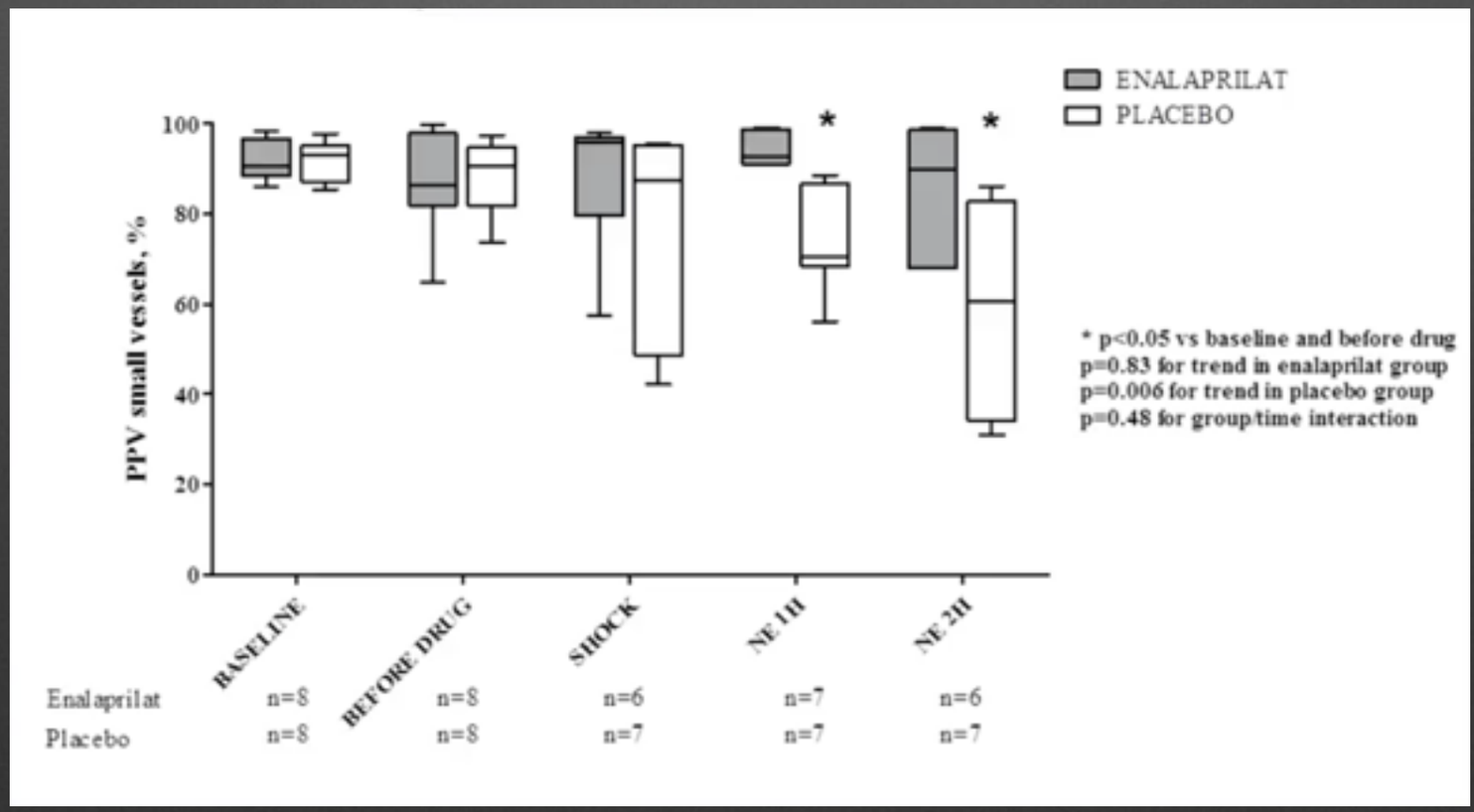
SOFA = Sequential Organ Failure Assessment.
[a]Defined as a reduction in SOFA score of two or more points over 0–24 hours.
Data are expressed as median and interquartile range except where indicated otherwise.

Randomized controlled trial of inhaled nitric oxide for the treatment of microcirculatory dysfunction in patients with sepsis*.
Trzeciak S, Glaspey LJ, Dellinger RP, Durflinger P, Anderson K, Dezfulian C, Roberts BW, Chansky ME, Parrillo JE, Hollenberg SM.
Crit Care Med. 2014 Dec;42(12):2482-92.

Les vasodilatateurs

IEC

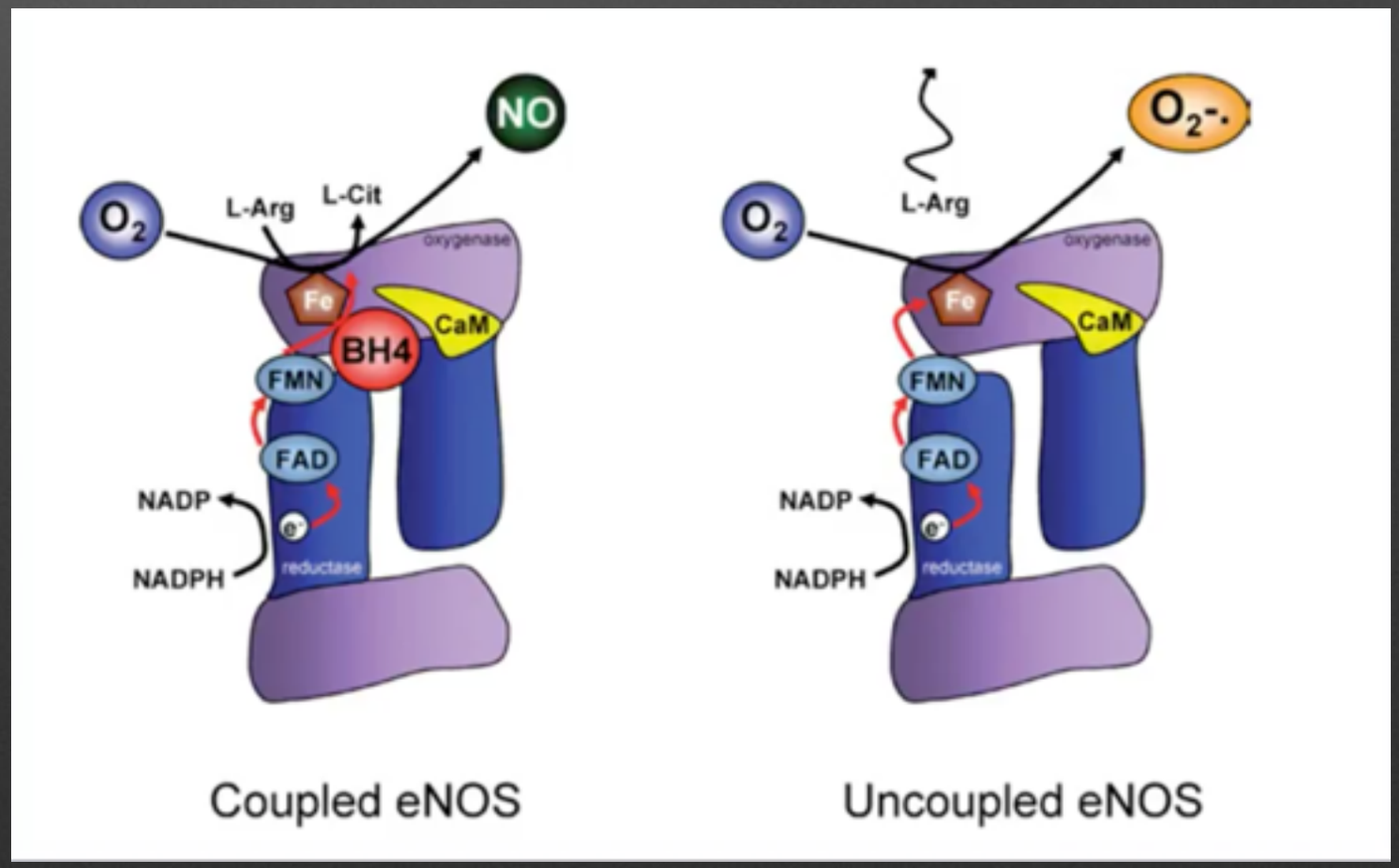
Mouton
Pas d'impact sur devenir



Sublingual microcirculatory effects of enalaprilat in an ovine model of septic shock.
Salgado DR, He X, Su F, de Sousa DB, Penaccini L, Maciel LK, Taccone F, Rocco JR, Silva E, De Backer D, Vincent JL.
Shock. 2011 Jun;35(6):542-9.

Modulation de la fonction endothéliale

- Vitamine C (étude animale)
- (BH4) Tétrahydrobiopterin (étude animale)



Conclusions

- La micro-circulation est une cible importante dans le traitement du choc et du sepsis
- Le monitoring de la microC
  - a une valeur pronostique
  - permet dans certains cas de guider le traitement
  - vidéomicroscopie?
- Nos outils thérapeutiques restent limités en 2016

Jacob *et al. Critical Care* (2016) 20:319
DOI 10.1186/s13054-016-1485-0

Critical Care

REVIEW Open Access

Regulation of blood flow and volume exchange across the microcirculation

Matthias Jacob[1*], Daniel Chappell[2] and Bernhard F. Becker[3]

Le transport en oxygène

$$DO_2 = DC \times CaO_2$$

Hb

SaO_2

PaO_2

O2 TRANSPORT

$DO_2 = Cl \times CaO_2 \times 10$

$= Cl \times Hb \times SaO_2 \times 13.9$

"normal" =	3	x 12 x	0.96	x	13.9	= 500 ml/min.M²
anemia =	6	x 6 x	0.96	x	13.9	= 500 ml/min.M²
hypoxemia =	6	x 12 x	0.48	x	13.9	= 500 ml/min.M²
low CO =	1.5	x 12 x	0.96	x	13.9	= 250 ml/min.M²