IX congresso nazionale
SIMEU
TORINO 6-8 NOVEMBRE 2014

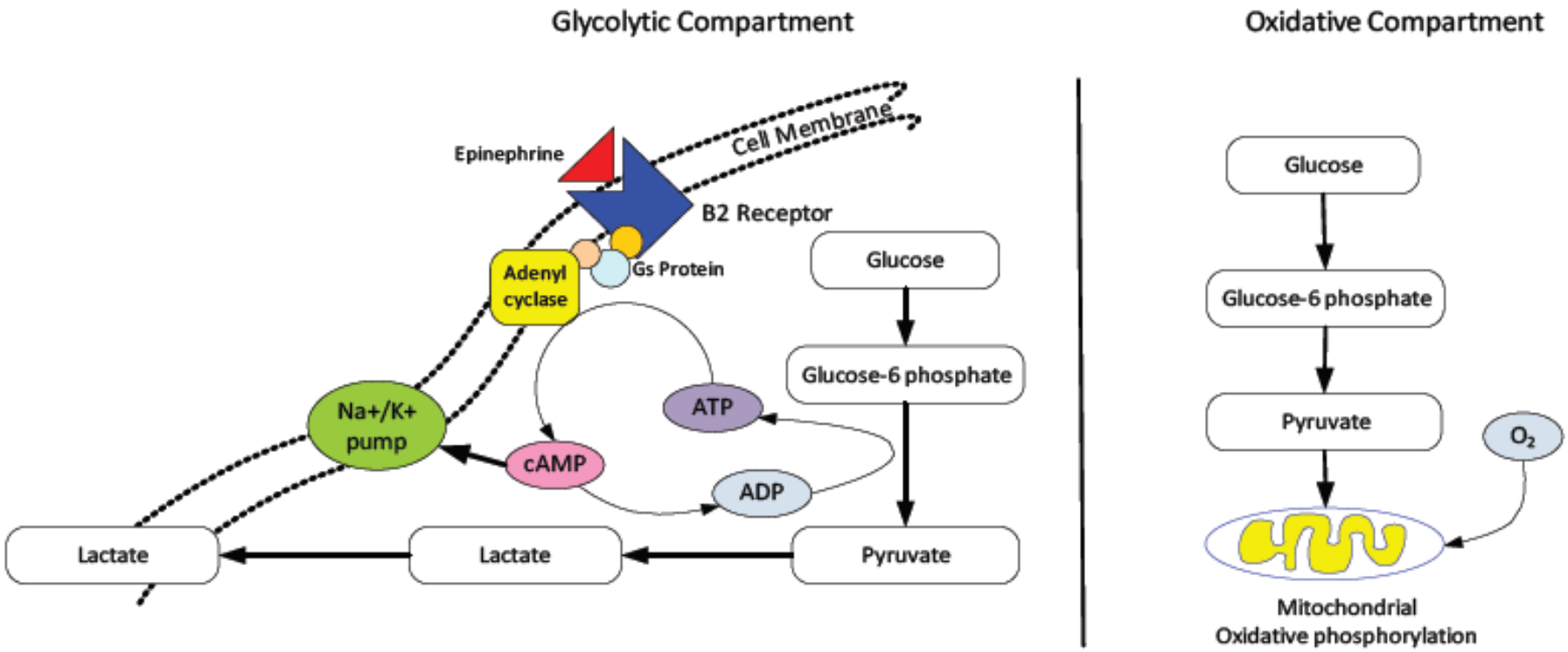
My favorite bloo gas tool: LACTATE

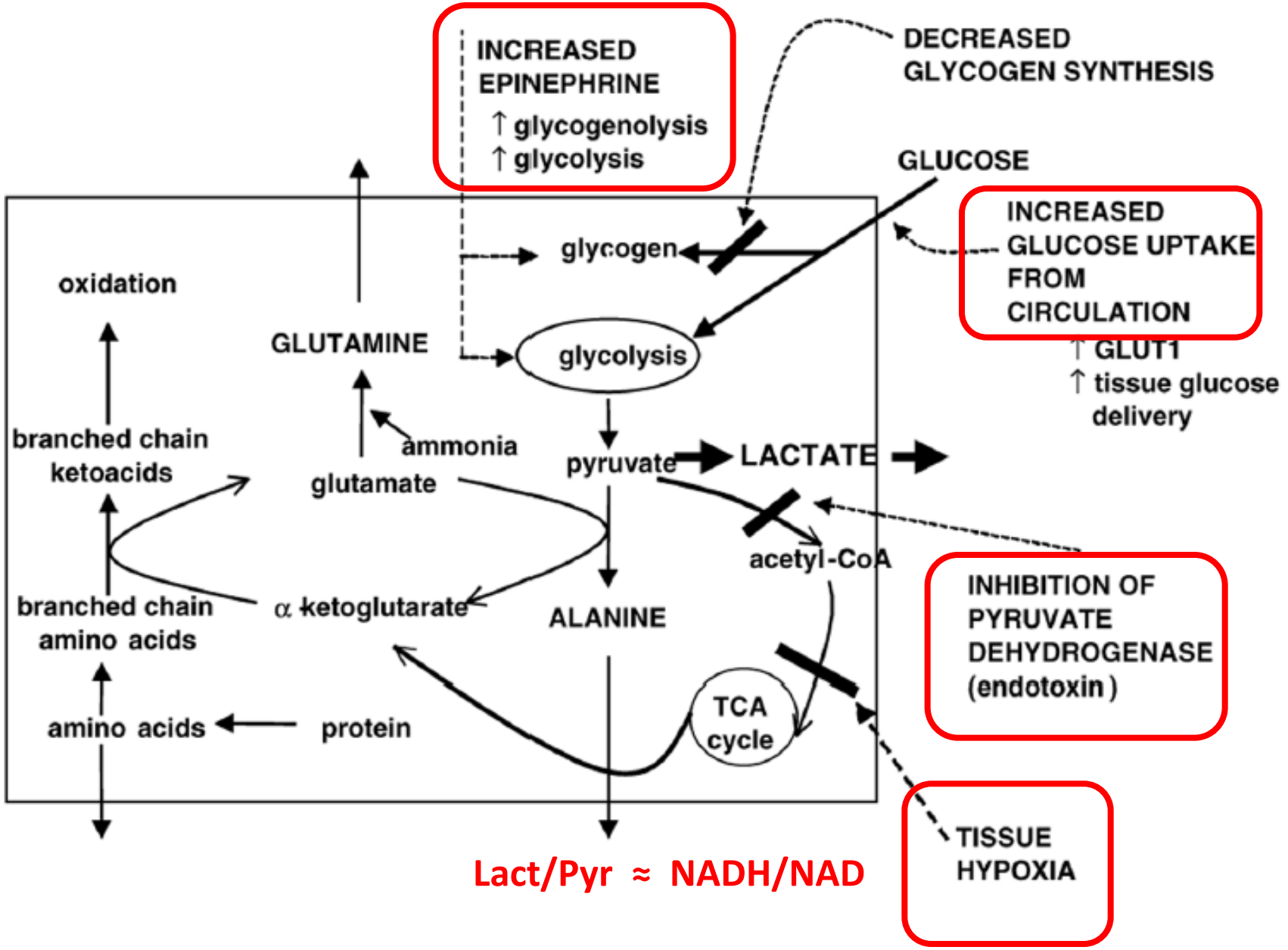
Giovanna Guiotto
Medicina d'Urgenza, OM e PS
Ospedale San Paolo - Napoli

OUR LAB


Instrumentation Laboratory
Ready
Start New Sample
Enter Information
View Last Results
GO!
GEM4000
Instrumentation Laboratory

OUR LAB


Glycolytic Compartment
Oxidative Compartment
Epinephrine
Cell Membrane
B2 Receptor
Gs Protein
Adenyl cyclase
Glucose
Glucose-6 phosphate
ATP
Na+/K+ pump
cAMP
ADP
Lactate
Lactate
Pyruvate
Glucose
Glucose-6 phosphate
Pyruvate
O2
Mitochondrial
Oxidative phosphorylation


INCREASED
EPINEPHRINE
↑ glycogenolysis
↑ glycolysis
DECREASED
GLYCOGEN SYNTHESIS
GLUCOSE
INCREASED
GLUCOSE UPTAKE
FROM
CIRCULATION
↑ GLUT1
↑ tissue glucose
delivery
glycogen
oxidation
GLUTAMINE
glycolysis
branched chain
ketoacids
ammonia
glutamate
pyruvate
LACTATE
acetyl-CoA
branched chain
amino acids
α ketoglutarate
ALANINE
INHIBITION OF
PYRUVATE
DEHYDROGENASE
(endotoxin)
TCA
cycle
amino acids
protein
TISSUE
HYPOXIA
Lact/Pyr ≈ NADH/NAD

SUPPLY SIDE (DO_2)

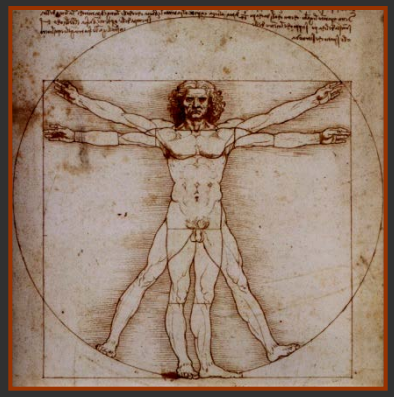
DEMAND SIDE

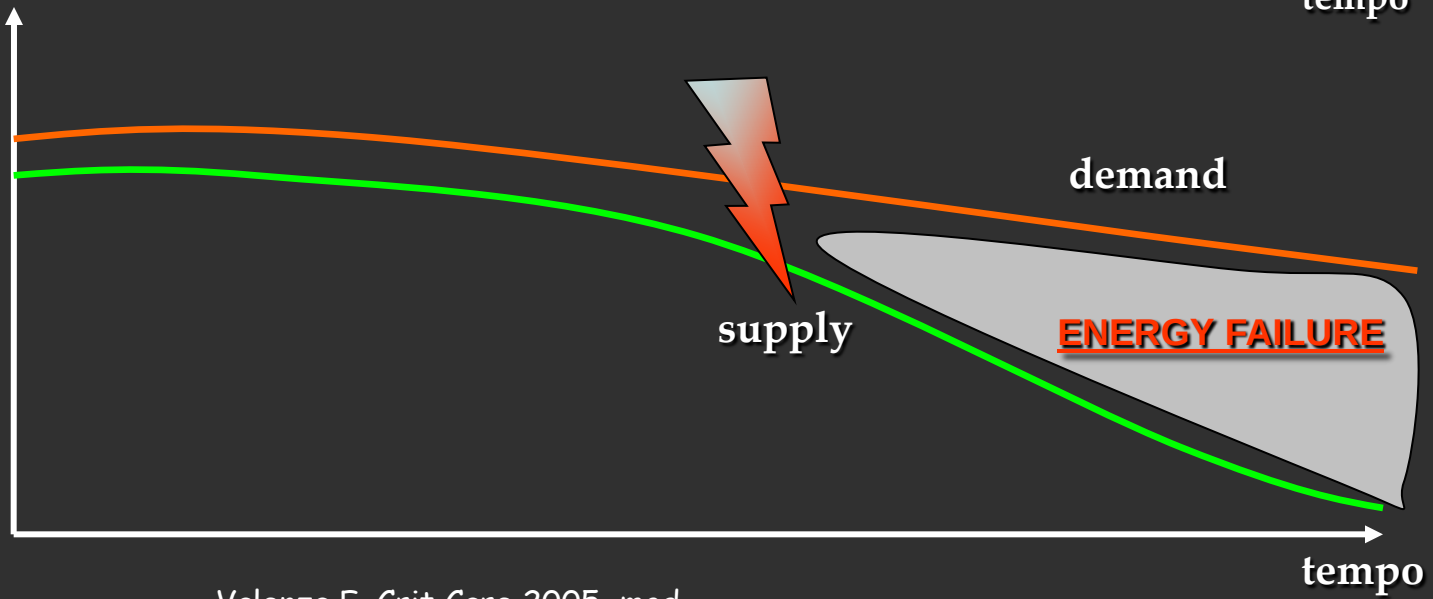
O_2 UPTAKE (VO_2)

VO_2/DO_2 IN THE CRITICALLY ILL

O_2 conformers

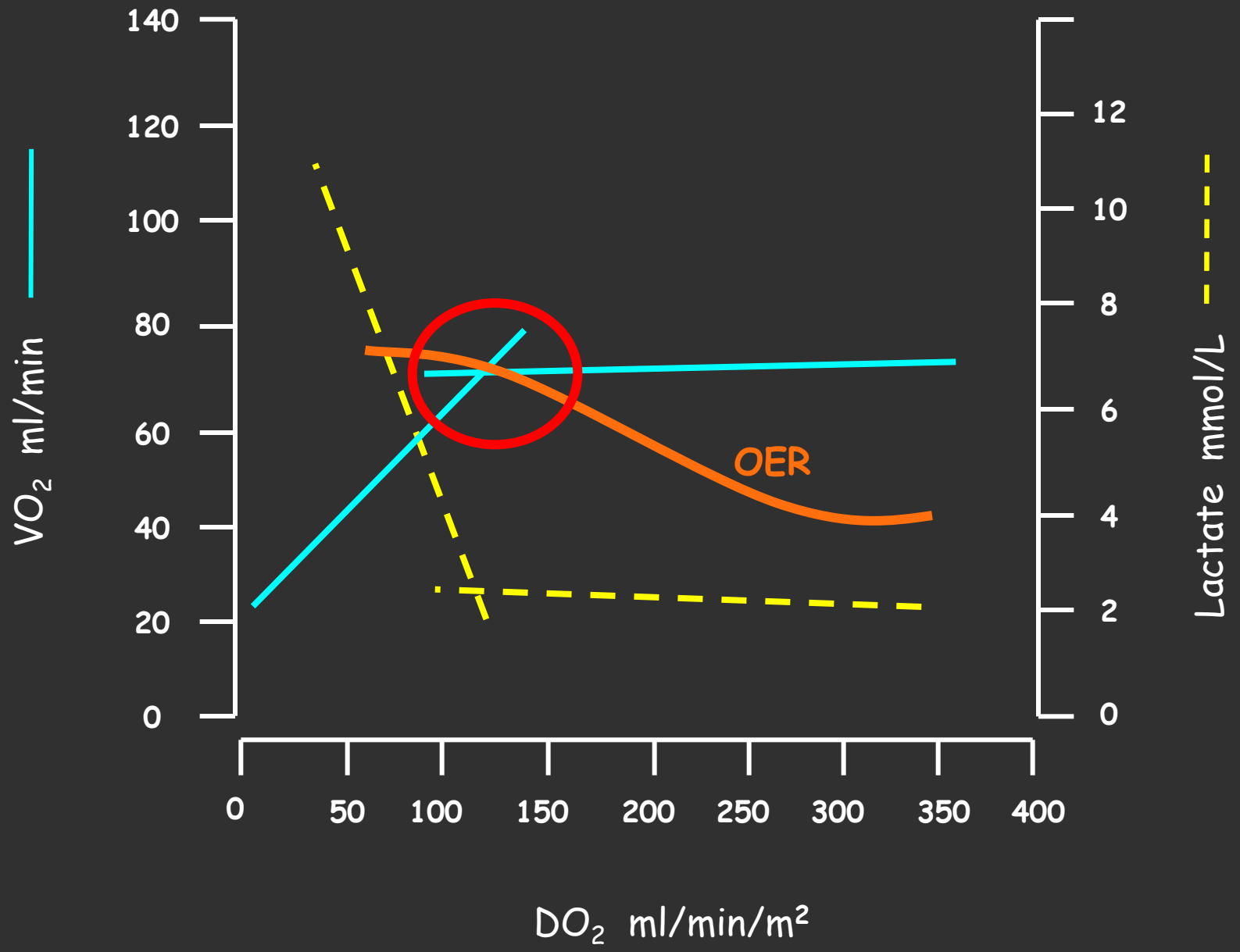
O_2 not conformers





Valenza F. Crit Care 2005, mod

The Supply-Dependency



Intensive Care Med (2007) 33:1967–1971
DOI 10.1007/s00134-007-0788-7

ORIGINAL

E. J. O. Kompanje
T. C. Jansen
B. van der Hoven
J. Bakker

The first demonstration of lactic acid in human blood in shock by Johann Joseph Scherer (1814–1869) in January 1843

Chemische und mikroskopische

Untersuchungen

zur Pathologie

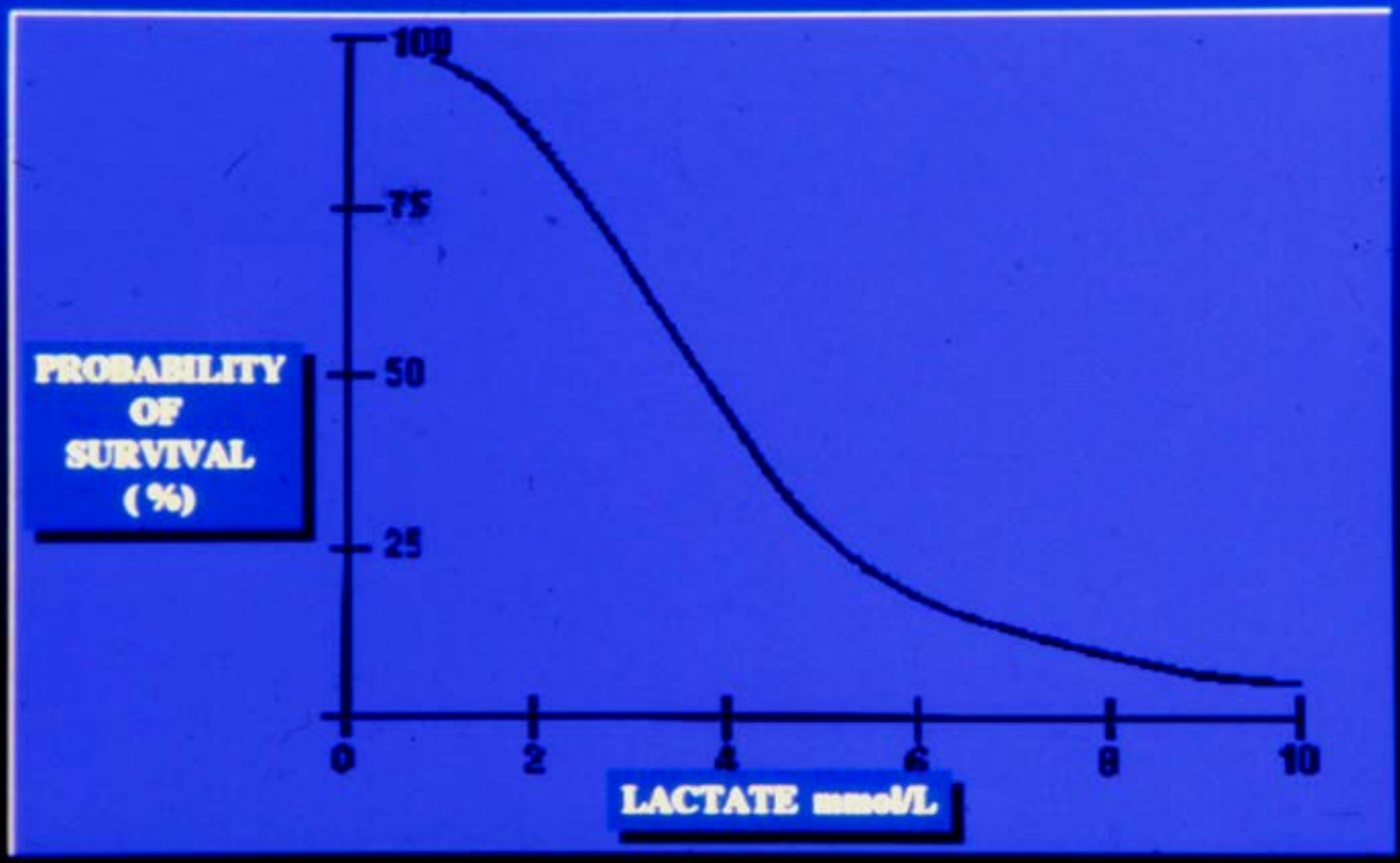
angestellt an den

Kliniken des Julius-Hospitales zu Würzburg,

von

Dr. Joh. Jos. Scherer,
Professor extraordinarius der medizinischen Fakultät.

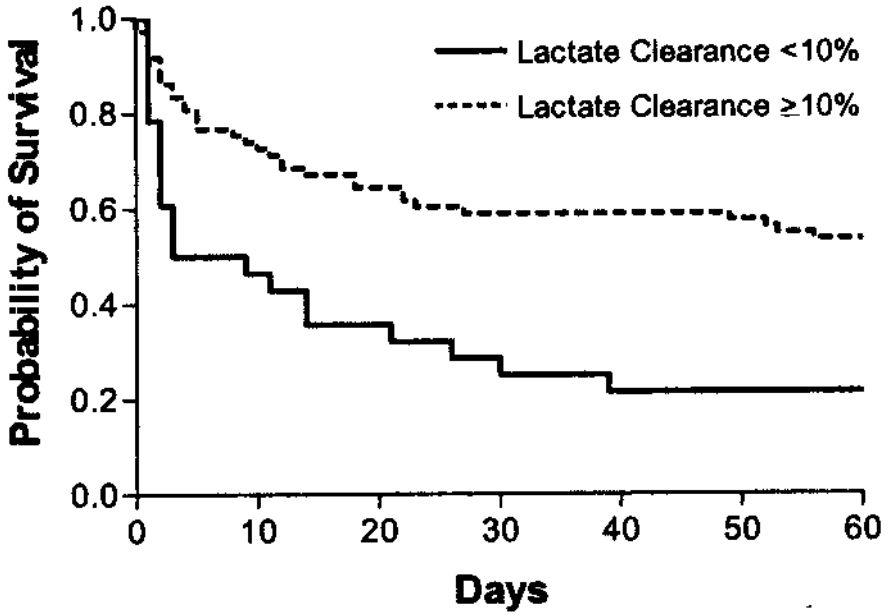
Heidelberg,
Akadem. Verlagshandlung von C. F. Winter.
1843.



MH WEIL: CIRCULATION 1970; 41: 989-1001

EARLY LACTATE CLEARANCE IS ASSOCIATED WITH IMPROVED OUTCOME

$$\frac{\text{Lactate start} - \text{Lactate 6 H}}{\text{Lactate start}} \times 100$$



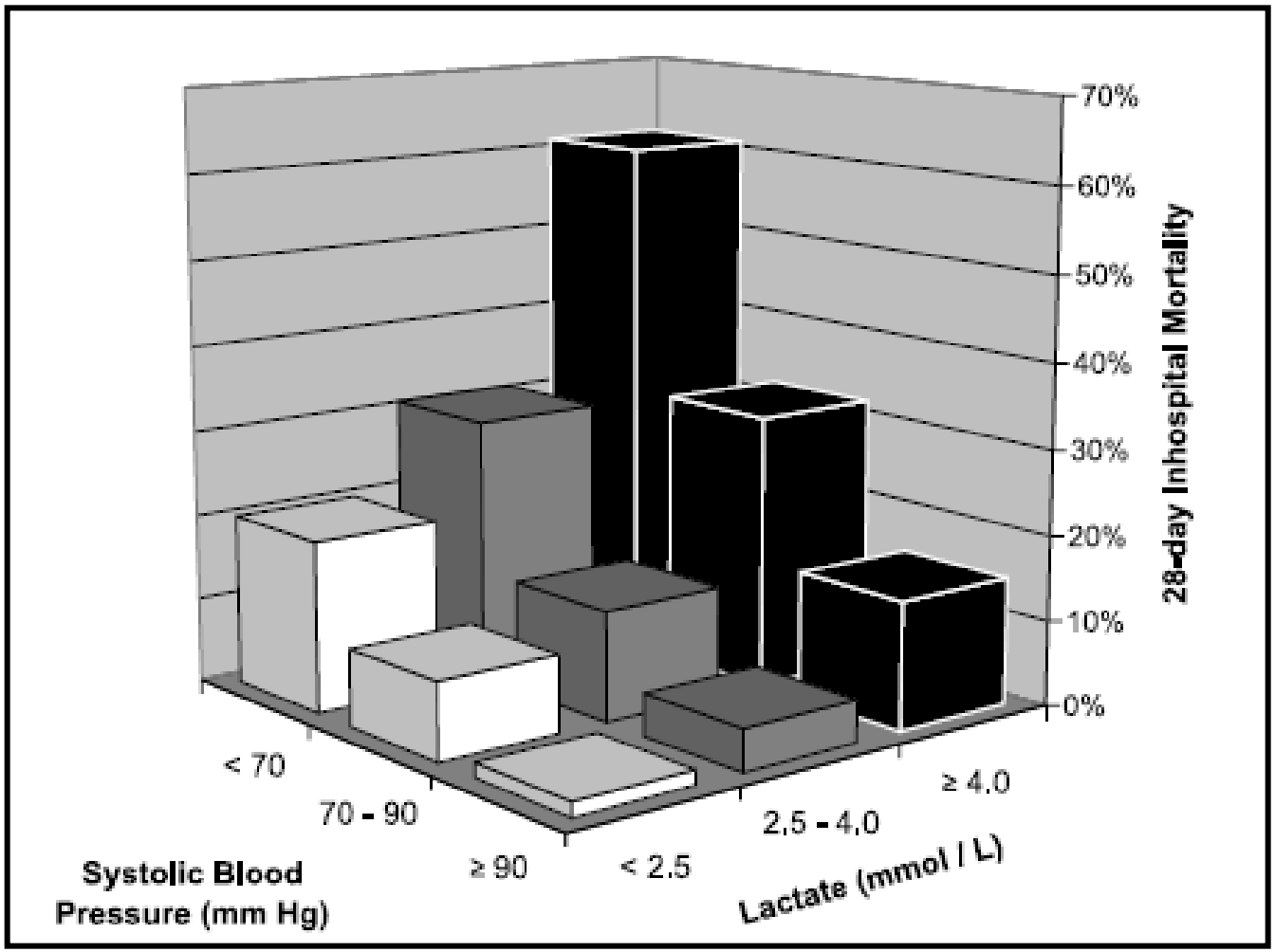
NGUYEN HB, RIVERS EP (2004) CCM 32;8:1637-42

Intensive Care Med (2007) 33:1892–1899
DOI 10.1007/s00134-007-0680-5

ORIGINAL

Michael D. Howell
Michael Donnino
Peter Clardy
Daniel Talmor
Nathan I. Shapiro

Occult hypoperfusion and mortality in patients with suspected infection



Research

Open Access

The prognostic value of blood lactate levels relative to that of vital signs in the pre-hospital setting: a pilot study

Tim C Jansen[1], Jasper van Bommel[1], Paul G Mulder[2], Johannes H Rommes[3], Selma JM Schieveld[3] and Jan Bakker[1]

[1]Department of Intensive Care, Erasmus MC University Medical Center, PO Box 2040, 3000 CA, Rotterdam, The Netherlands
[2]Department of Epidemiology & Biostatistics, Erasmus MC University Medical, PO Box 2040, 3000 CA, Rotterdam, The Netherlands
[3]Department of Intensive Care, Gelre Hospital, location Lukas, PO Box 9014, 7300 DS Apeldoorn, The Netherlands

Corresponding author: Jan Bakker, jan.bakker@erasmusmc.nl

Received: 29 Sep 2008 Revisions requested: 6 Nov 2008 Accepted: 17 Dec 2008 Published: 17 Dec 2008

124 pts **SBP < 100** **RR <10 or > 29/min** **GCS < 14**

Conclusions: In a cohort of patients that required urgent ambulance dispatching, pre-hospital blood lactate levels were associated with in-hospital mortality and provided prognostic information superior to that provided by the patient's vital signs. There is potential for early detection of occult shock and prehospital resuscitation guided by lactate measurement.

Intensive Care Med (2007) 33:1863–1865
DOI 10.1007/s00134-007-0679-y

EDITORIAL

Jan Bakker
Tim C. Jansen

Don't take vitals, take a lactate

"LACTIME"
?

"instantaneous" LACTATE CONCENTRATION

PRODUCTION

VS

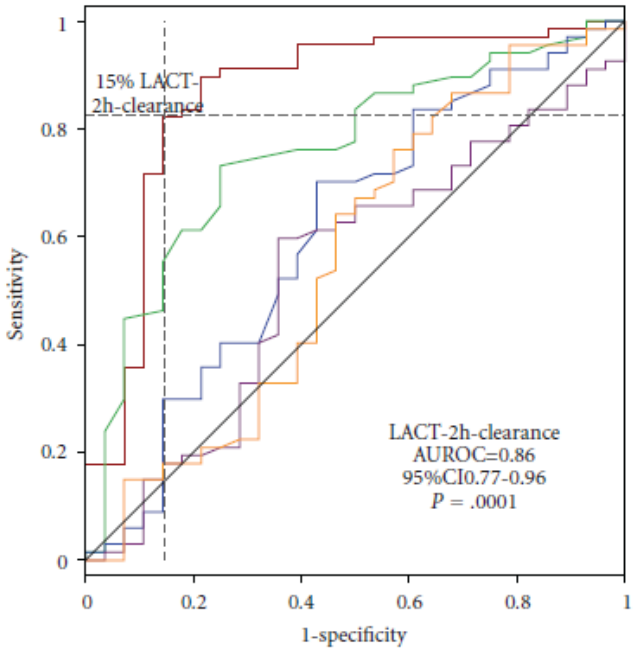
LIVER & KIDNEY METABOLISM

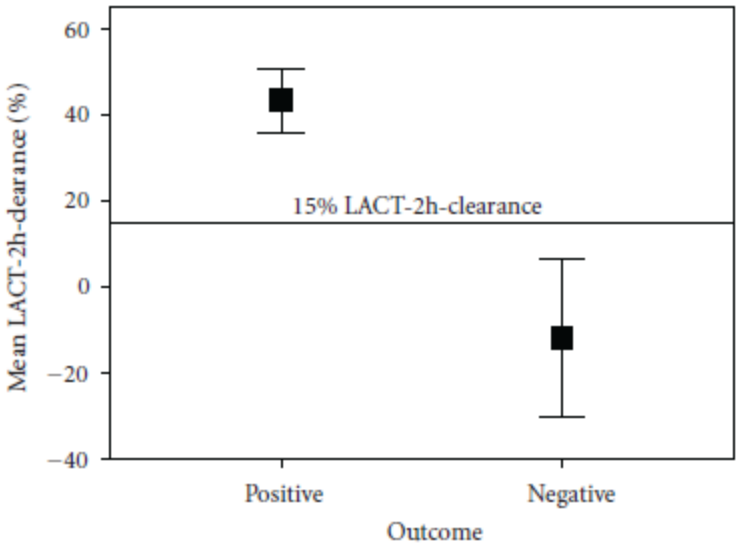
Hindawi Publishing Corporation
Critical Care Research and Practice
Volume 2010, Article ID 917053, 6 pages
doi:10.1155/2010/917053

Research Article

Two-Hour Lactate Clearance Predicts Negative Outcome in Patients with Cardiorespiratory Insufficiency

Sean Scott,[1] Vittorio Antonaglia,[2] Giovanna Guiotto,[3] Fiorella Paladino,[3] and Fernando Schiraldi[3]





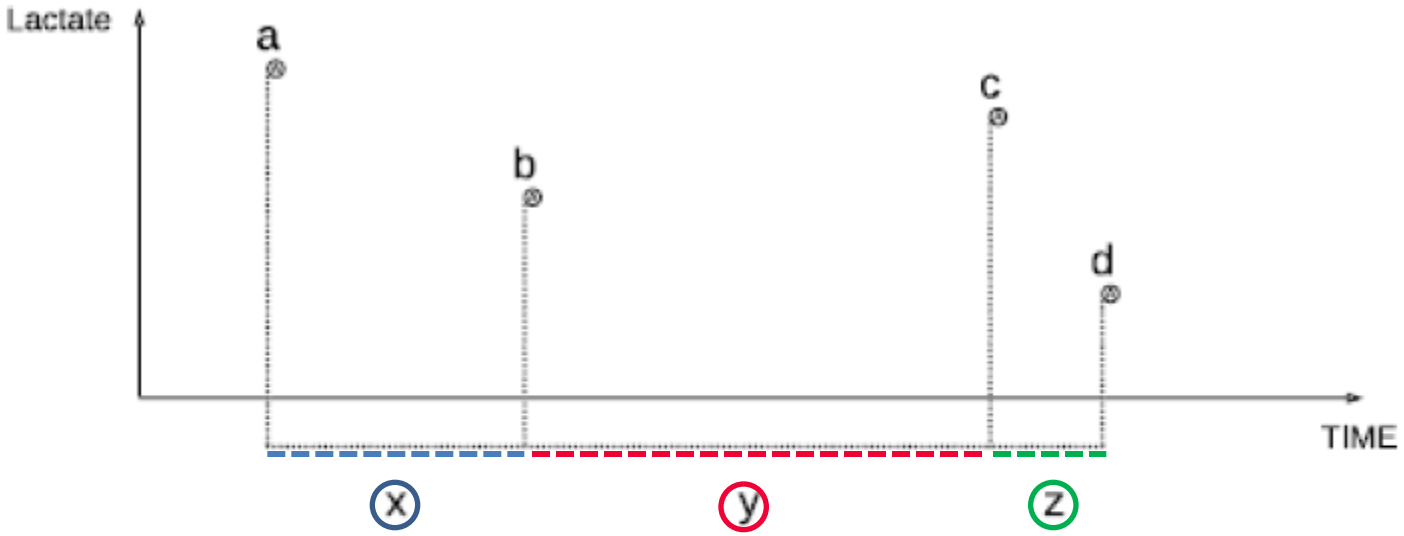
Nichol et al. Critical Care 2011, 15:R242
http://ccforum.com/content/15/5/R242

CRITICAL CARE

RESEARCH Open Access

Dynamic lactate indices as predictors of outcome in critically ill patients

Alistair Nichol[1,3], Michael Bailey[1], Moritoki Egi[2], Ville Pettila[1], Craig French[5,4], Edward Stachowski[6], Michael C Reade[4], David James Cooper[1,3] and Rinaldo Bellomo[1,4,7*]



36673 lact in 24 h
5041 pts

Time weighted average = x((a+b)/2))+y((b+c)/2)+z((c+d/2)) / (x+y+z)

Figure 1 Diagram describing the calculation of time weighted lactate (Lac_{TW}).

Low exogenous lactate clearance as an early predictor of mortality in normolactatemic critically ill septic patients

Jacques Levraut, MD; Carole Ichai, MD, PhD; Isabelle Petit, MD; Jean-Pierre Ciebiera, MD; Olivier Perus, MD; Dominique Grimaud, MD

Crit Care Med 2003 Vol. 31, No. 3

Poor lactate clearance is a significant independent predictor of increased mortality (specificity 90%)

Poor lactate clearance and low endogenous lactate production could reflect the inability of the most severely ill patients to respond to septic injury.

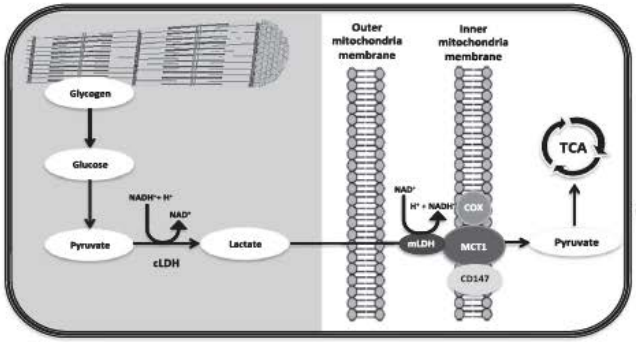
Garcia-Alvarez *et al. Critical Care* 2014, **18**:503
http://ccforum.com/content/18/4/503

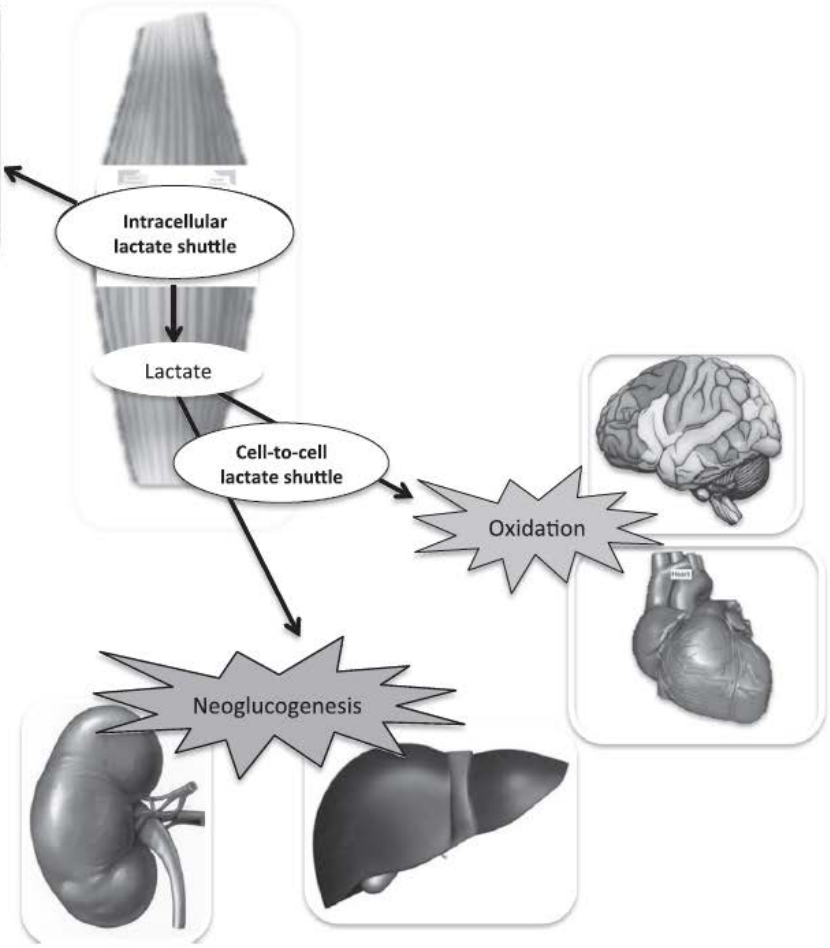
CRITICAL CARE

REVIEW

Sepsis-associated hyperlactatemia

Mercedes Garcia-Alvarez[1,2], Paul Marik[3] and Rinaldo Bellomo[2,4*]



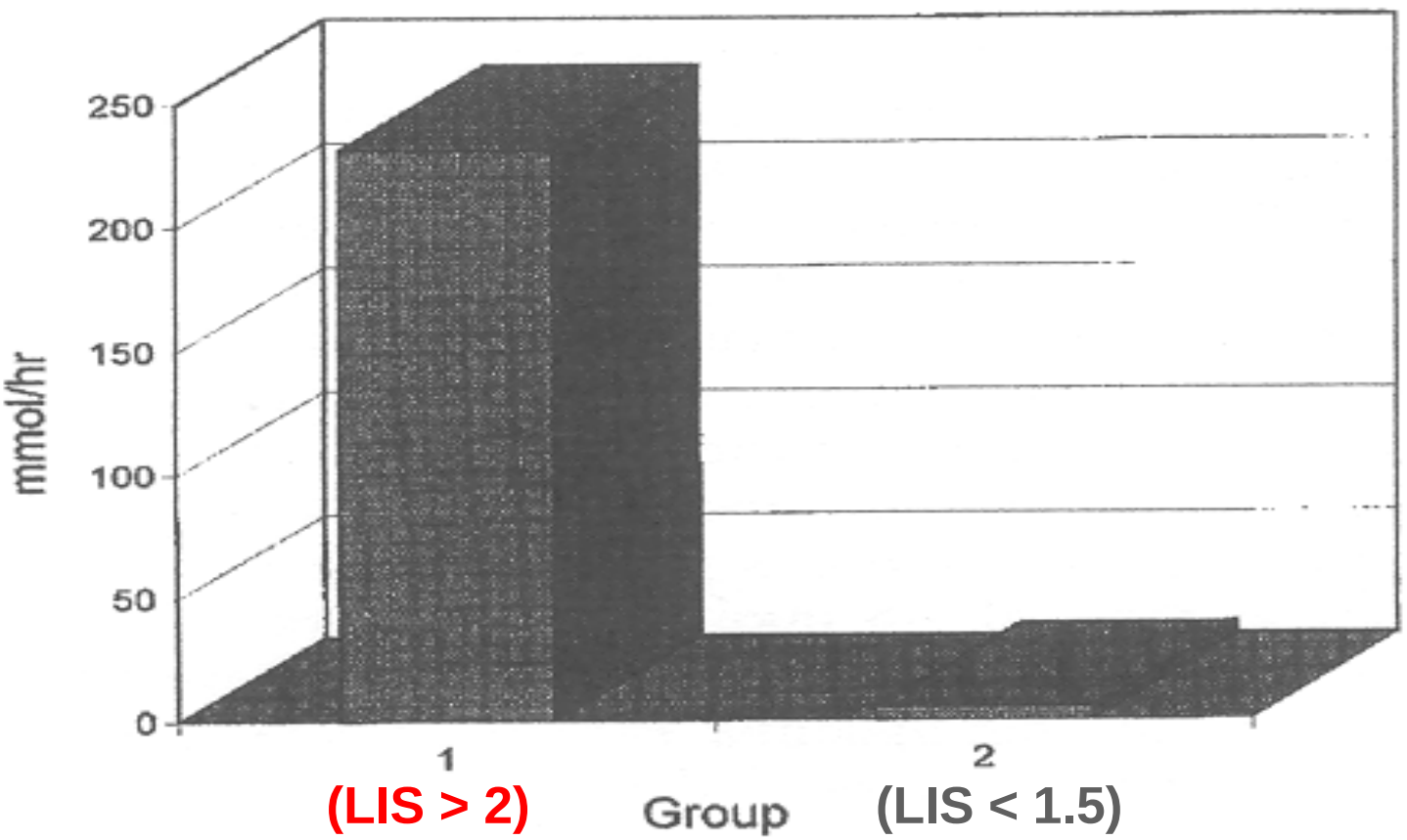


Tisssue hypoxia

vs

Bioenergetic fuel

Release of Lactate by the Lung in Acute Lung Injury*



J Kellum et al. CHEST 1997; 111:1301-05

Review

Bench-to-bedside review: Lactate and the lung

Fulvio Iscra[1], Antonino Gullo[1] and Gianni Biolo[2]

Critical Care 2002, **6**:327-329

Lactate as metabolic adaptations in response to systemic mediators .....

not only hypoxia

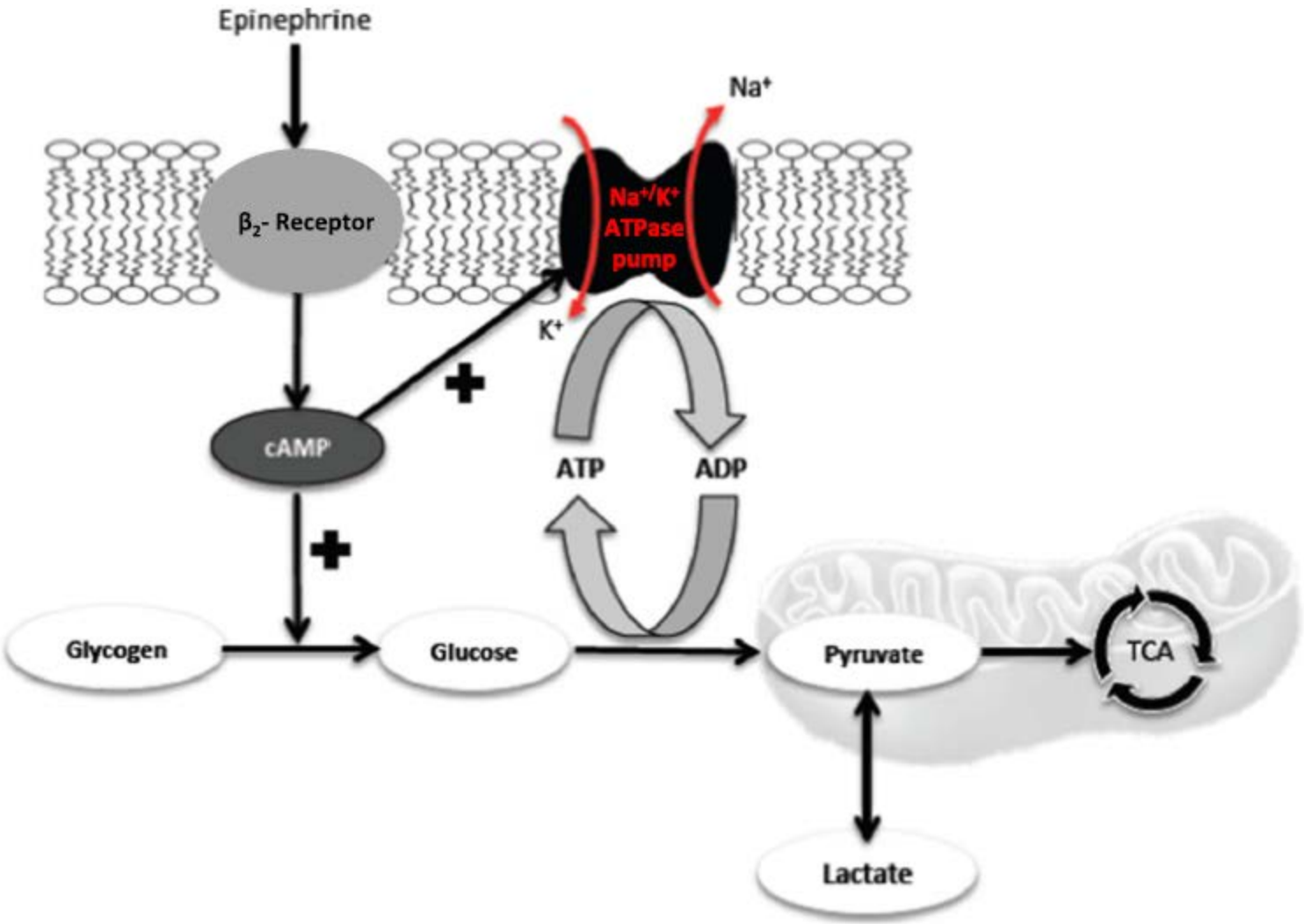
ALI/ARDS → ↑↑ lactate

- P/F
- Pulmonary injury score

HYPERLACTATEMIA

VS

LACTIC ACIDOSIS

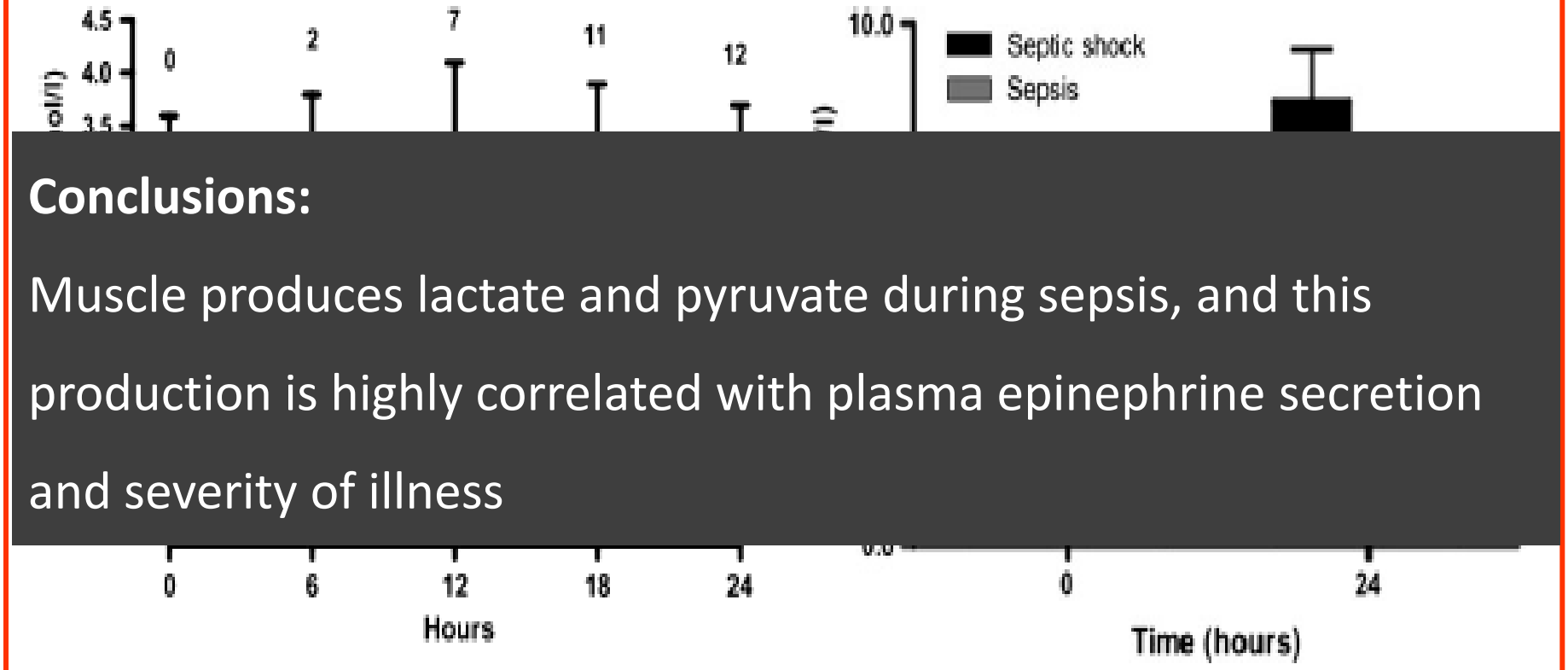

Epinephrine
Na+
β2- Receptor
Na+/K+ ATPase pump
K+
cAMP
ATP
ADP
Glycogen
Glucose
Pyruvate
TCA
Lactate

Intensive Care Med (2010) 36:1703–1709
DOI 10.1007/s00134-010-1938-x

ORIGINAL

Bruno Levy
Pierre Perez
Sebastien Gibot
Alain Gerard

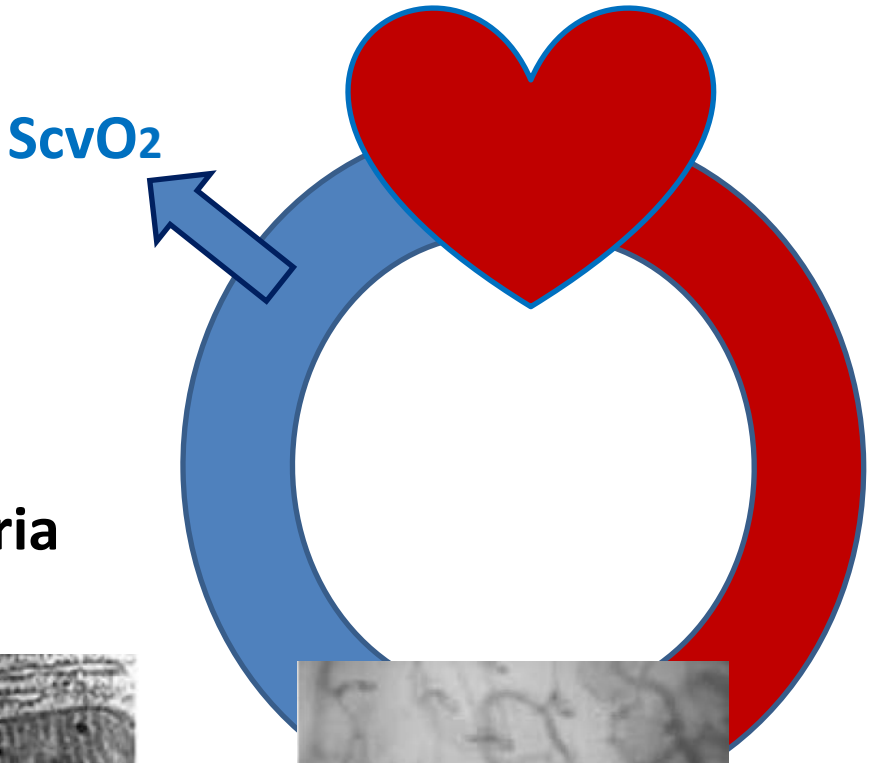
Increased muscle-to-serum lactate gradient predicts progression towards septic shock in septic patients



Conclusions:

Muscle produces lactate and pyruvate during sepsis, and this production is highly correlated with plasma epinephrine secretion and severity of illness

Oxygen utilization



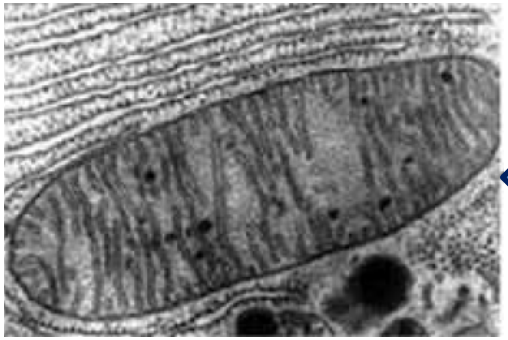
Macrocirculation

O2 supply

DO2 = CO × Hb × SaO2

Mitochondria

O2 use



Microcirculation

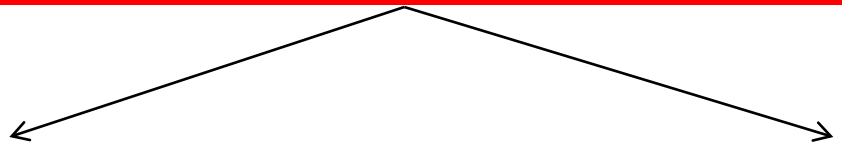
O2 diffusion/extraction

Lactate Clearance vs Central Venous Oxygen Saturation as Goals of Early Sepsis Therapy

A Randomized Clinical Trial

JAMA. 2010;303(8):739-746

No significantly different in-hospital mortality



150

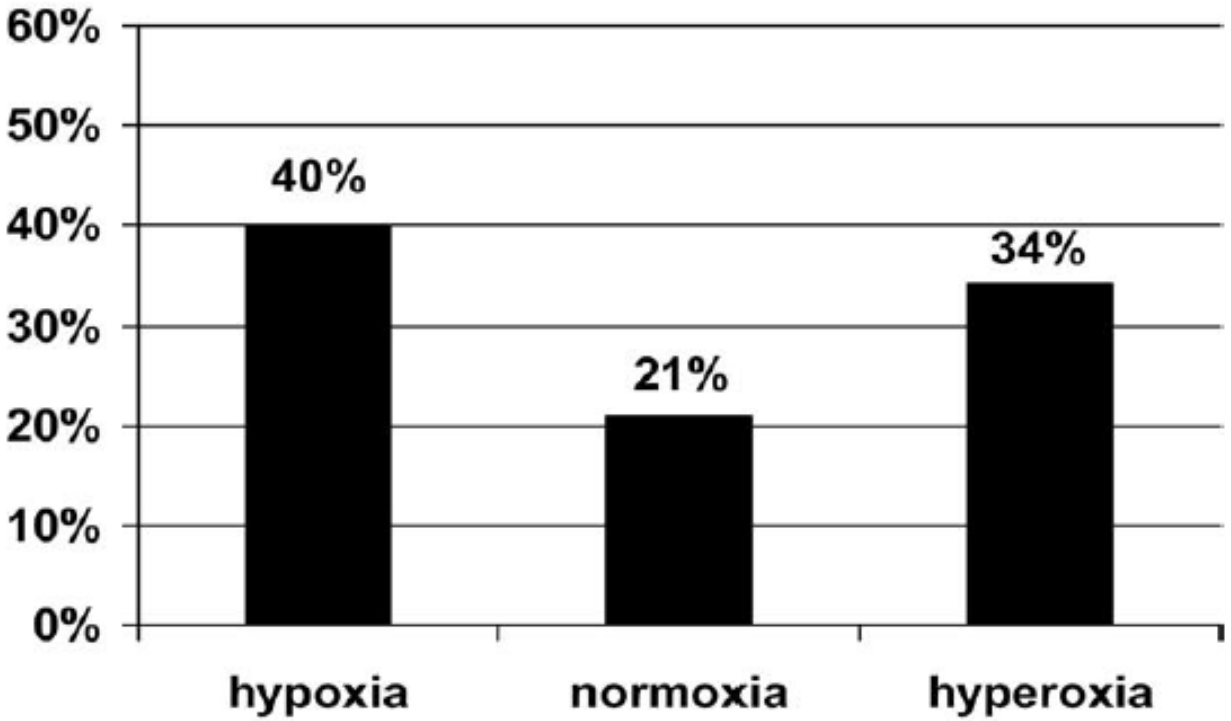
150

CVP ≥ 8
MAP ≥ 65
ScvO2 ≥ 70%

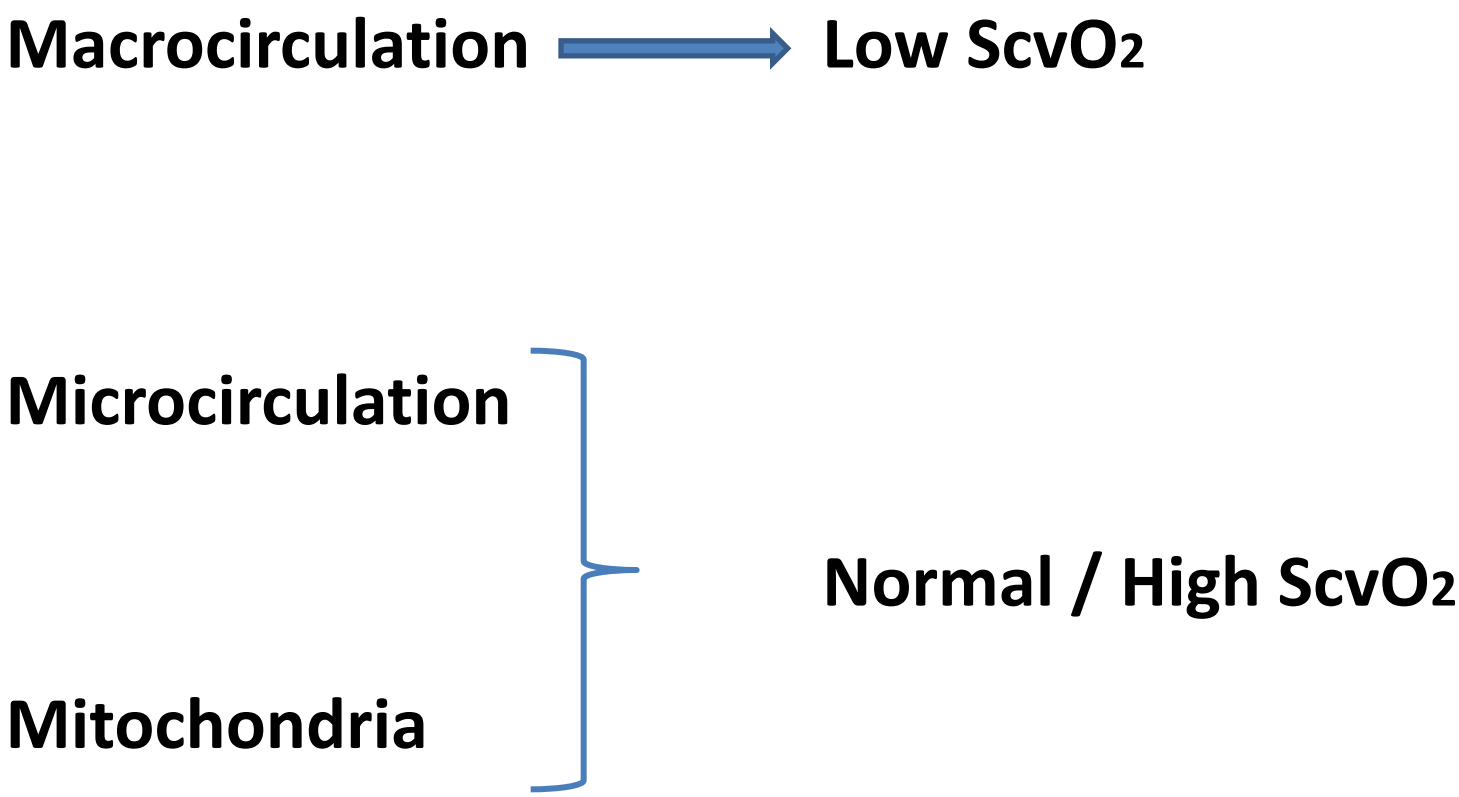
CVP ≥ 8
MAP ≥ 65
Lactate Cl ≥ 10%

Multicenter Study of Central Venous Oxygen Saturation ($ScvO_2$) as a Predictor of Mortality in Patients With Sepsis

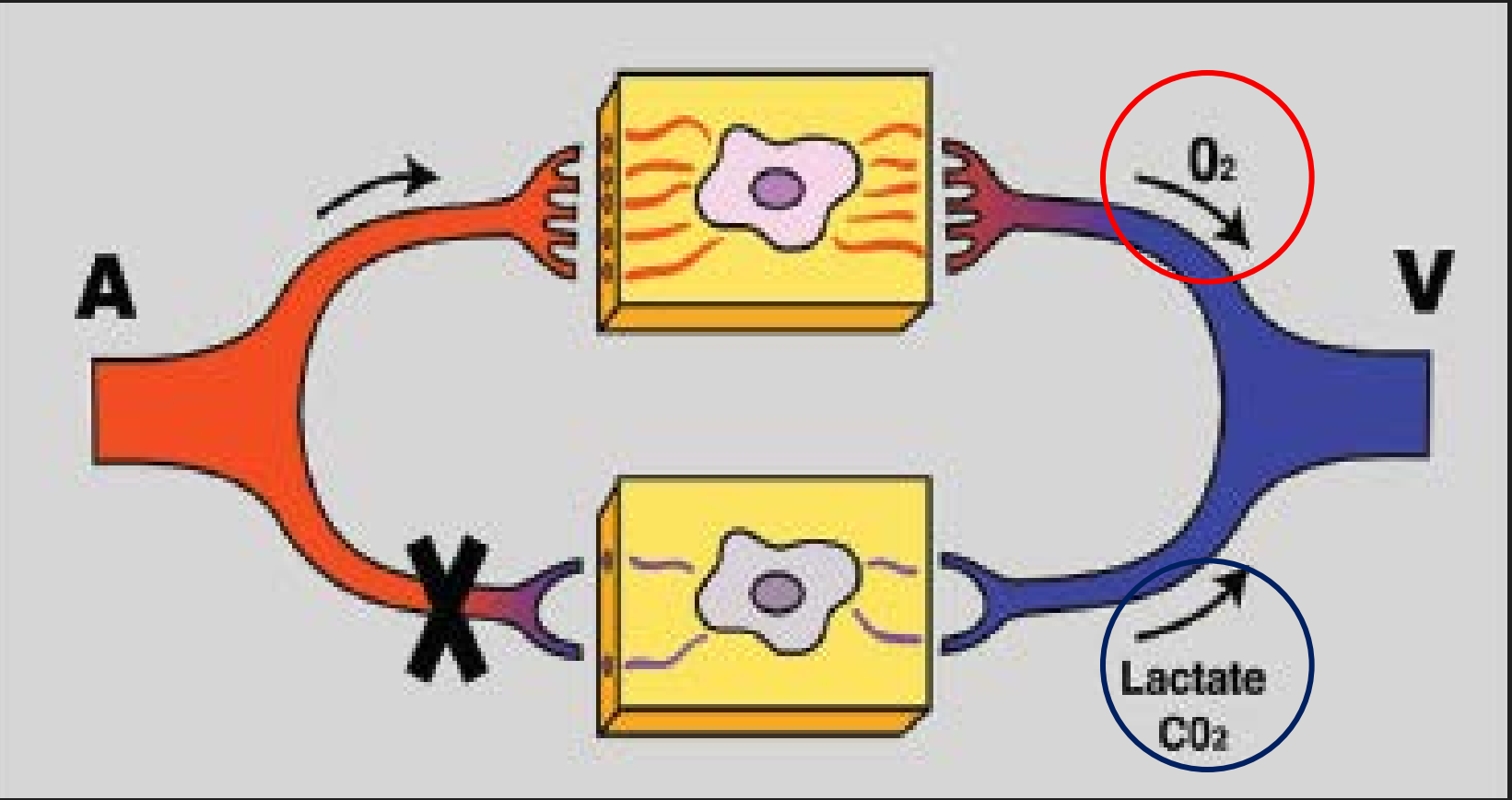
Jennifer V. Pope, MD
Alan E. Jones, MD
David F. Gaieski, MD
Ryan C. Arnold, MD
Stephen Trzeciak, MD,
Nathan I. Shapiro, MD



Ann Emerg Med. 2010;55:40-46

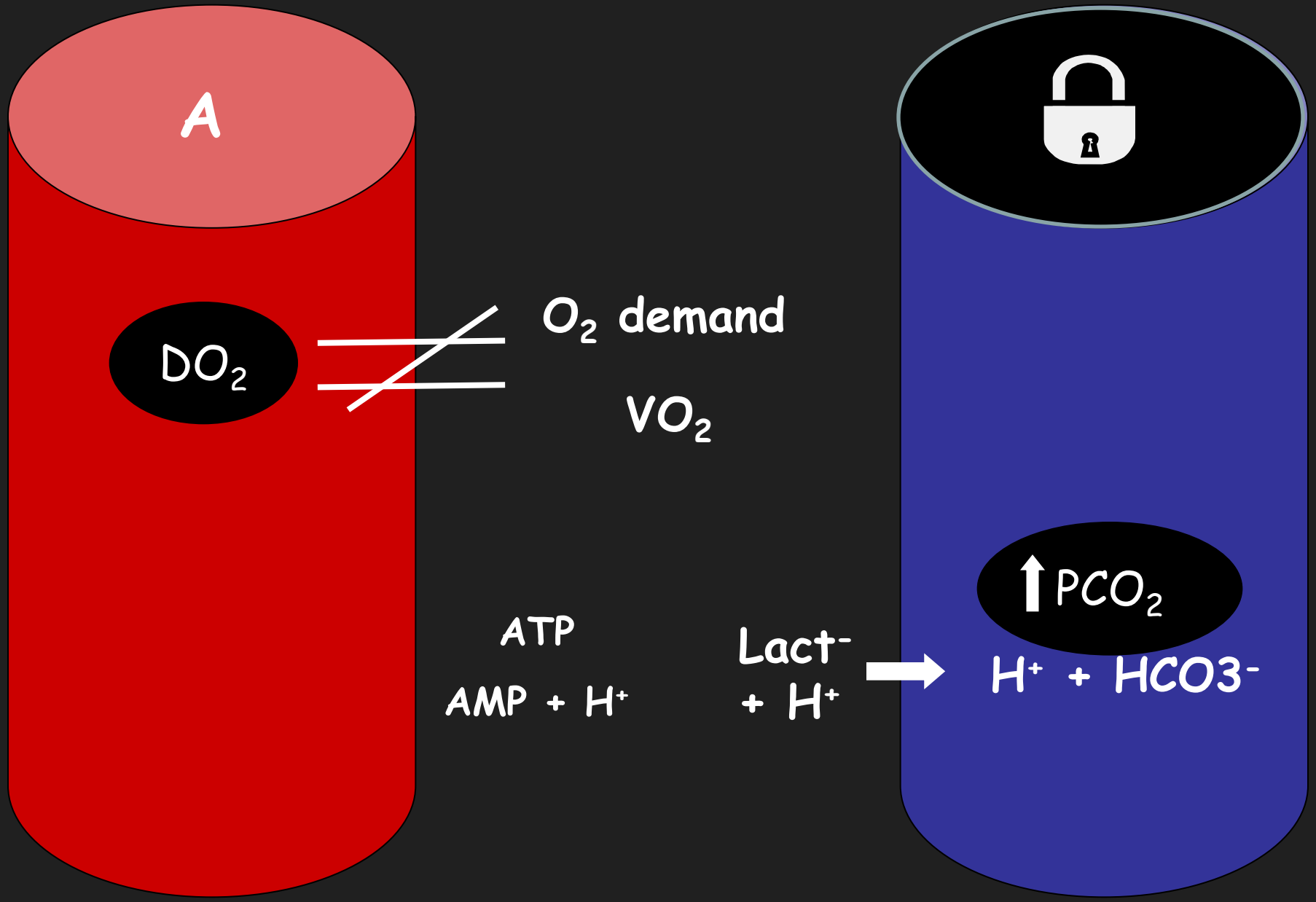

Macrocirculation
Low ScvO2
Microcirculation
Mitochondria
Normal / High ScvO2

The microcirculatory shunting model of sepsis



Trzeciak S and Rivers EP. Critical Care 2005, 9:S

V-A PCO_2 Differences & Hypoperfusion

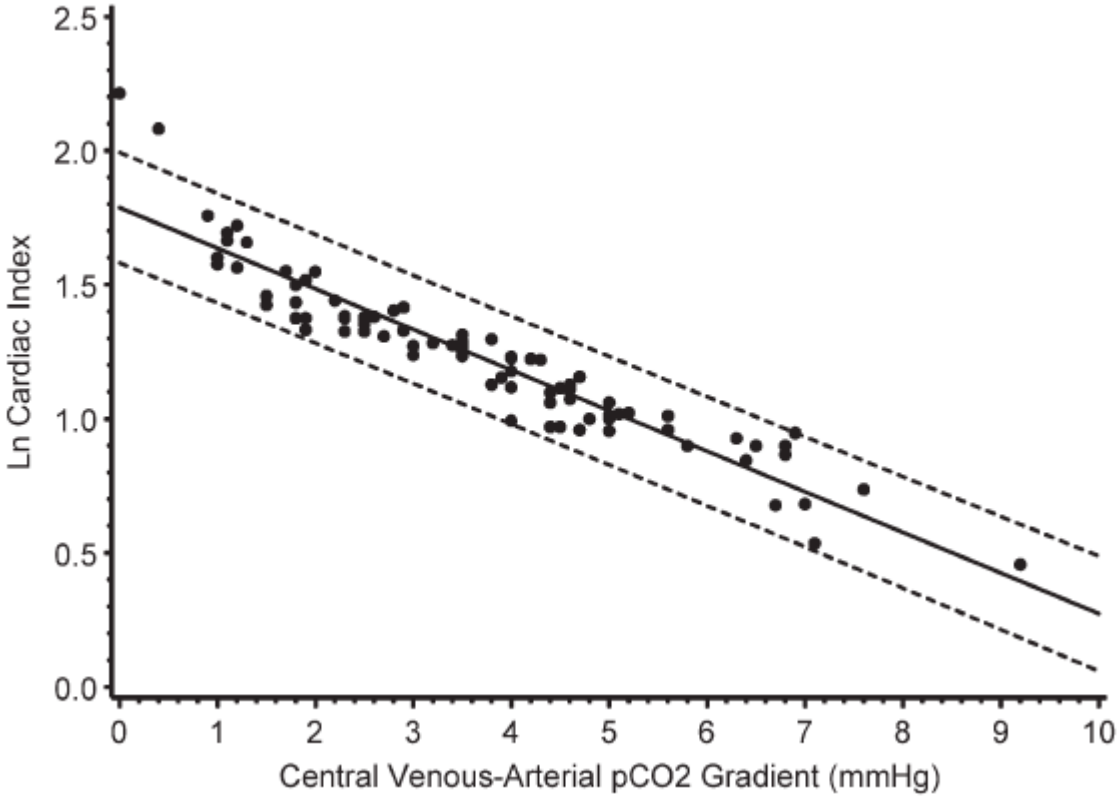


Intensive Care Med (2005) 31:818–822
DOI 10.1007/s00134-005-2602-8

ORIGINAL

Joseph Cuschieri
Emanuel P. Rivers
Michael W. Donnino
Marius Katilius
Gordon Jacobsen
H. Bryant Nguyen
Nikolai Pamukov
H. Mathilda Horst

Central venous-arterial carbon dioxide difference as an indicator of cardiac index

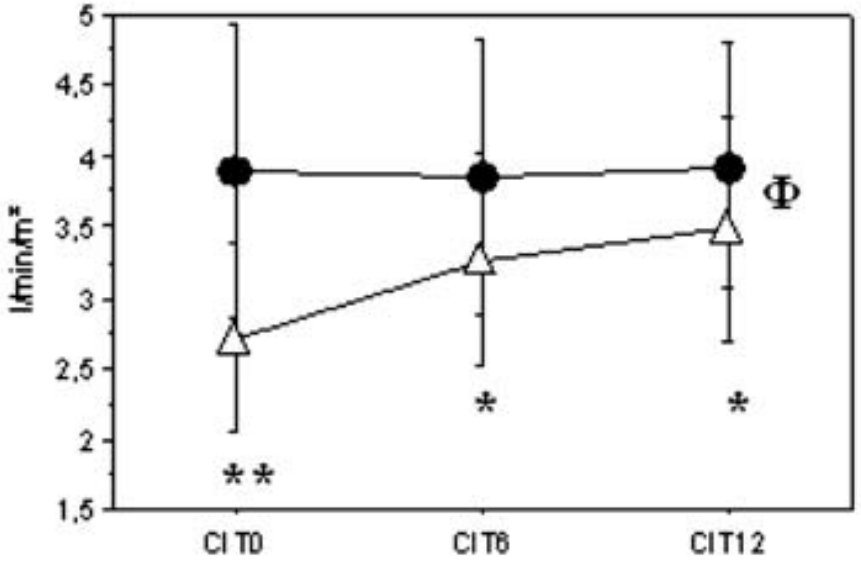


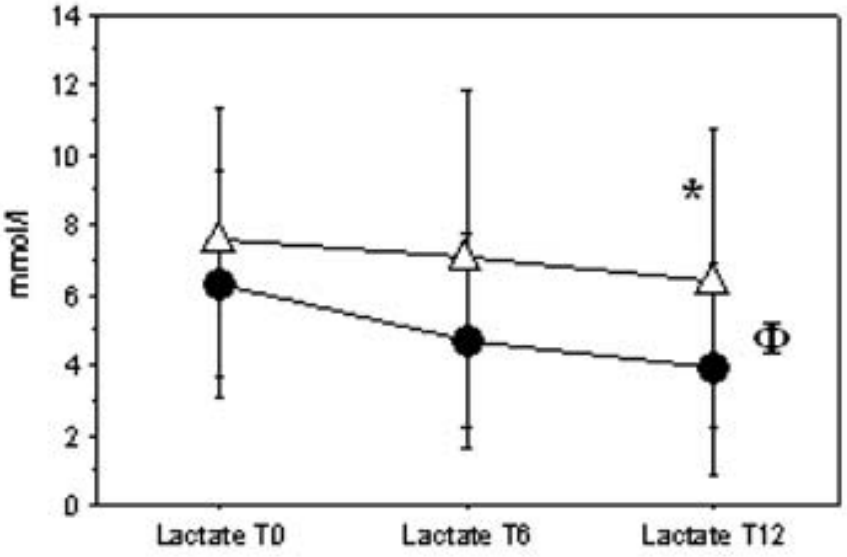
Intensive Care Med (2008) 34:2218–2225
DOI 10.1007/s00134-008-1199-0

ORIGINAL

Fabrice Vallée
Benoit 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?





When the 70% $ScvO_2$ goal value is reached, a **$P(cv\text{-}a)CO_2 > 6$ mmHg** might be a useful tool to identify patients who still remain inadequately resuscitated

SHOCK

hypovolemic	cardiogenic	septic
↓ CO	↓ CO	↑↓ CO
↓ $ScvO_2$	↓ $ScvO_2$	↑↓ $ScvO_2$

↑ *LACTATE* & ↑ *Δ* PCO_2

SUPPLY SIDE
(DO_2)

LACTATE

DEMAND SIDE

$ScvO_2$ / Δ PCO_2

Δ PCO_2

O_2 UPTAKE
(VO_2)

KEY POINTS

Micro vs Macro

Lactate “as soon as possible”

Serial Lactate better (clearance)

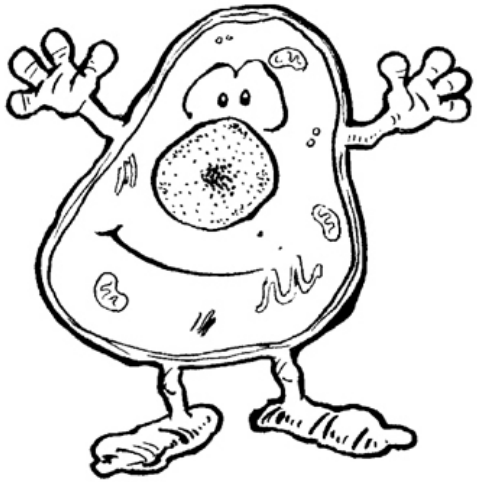
$ScvO_2$ vs Delta PCO_2 monitoring

Perspective: Lact/Pyr, pHi, Lactate Gaps……

Lactate/pyruvate

$\Delta_{(v-a)}CO_2$

happy cell



SvO_2

lactate

StO_2

pHi

$NADH/NAD^+$

O_2ER

Acetoacetate/
β-hydroxybutyrate