



# Laktát jako hemodynamický parametr

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12. kongres ČSIM  
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nemám střet zájmů

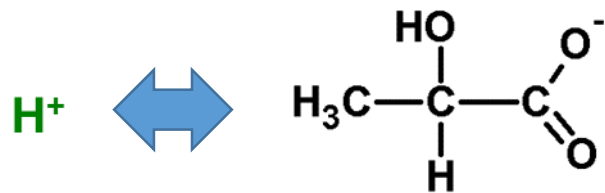


# struktura přednášky

- Historie – the BAD, the GOOD
- Postavení laktátu v buněčném metabolismu
- Postavení laktátu v metabolismu organismu
- Laktát jako prognostický faktor na ICU
- Kinetika laktátu jako prognostický faktor
- Závěr – reformulace názvu přednášky

# Historie – lactate the BAD I – lactic acid

*Staphylococcus epidermis* has also been shown to produce lactic acid that contribute to sweat odor (Sawano 2000).



**pKa = 3,86**

## THE EFFECT OF HYDROGEN-ION CONCENTRATION ON THE RECOVERY PROCESS IN MUSCLE.

BY W. HARTREE<sup>1</sup> AND A. V. HILL.

*(From the Departments of Physiology, Cambridge, and  
University College, London.)*

J Physiol. **1924** May 23;58(6):470-

Muscular exercise, lactic acid and the supply and utilisation of oxygen.— Parts VII–VIII

A. Y. Hill, F. R. S., C. N. H. Long, H. Lupton

Published 1 December **1924**. DOI: 10.1098/rspb.1924.0048,

Proc R Soc Lond B Biol Sci 16:84-137

**MAC je způsobena tvorbou H<sup>+</sup> při hydrolýze ATP a absenci ATP tvorby a ne disociací kyseliny mléčné**

# Historie – lactate the BAD II – lactate acidosis type A

- 39. Huckabee WE: Abnormal resting blood lactate. I. The significance of hyperlactatemia in hospitalized patients. *Am J Med* 1961, 30:840–848.
- 40. Weil MH, Afifi AA: Experimental and clinical studies on lactate and pyruvate as indicators of the severity of acute circulatory failure (shock). *Circulation* 1970, 41:989–1001.

**Zvýšená hladina laktátu je spojena s kyslíkovým dluhem, a je proto třeba ji léčit zvýšením DO<sub>2</sub>**

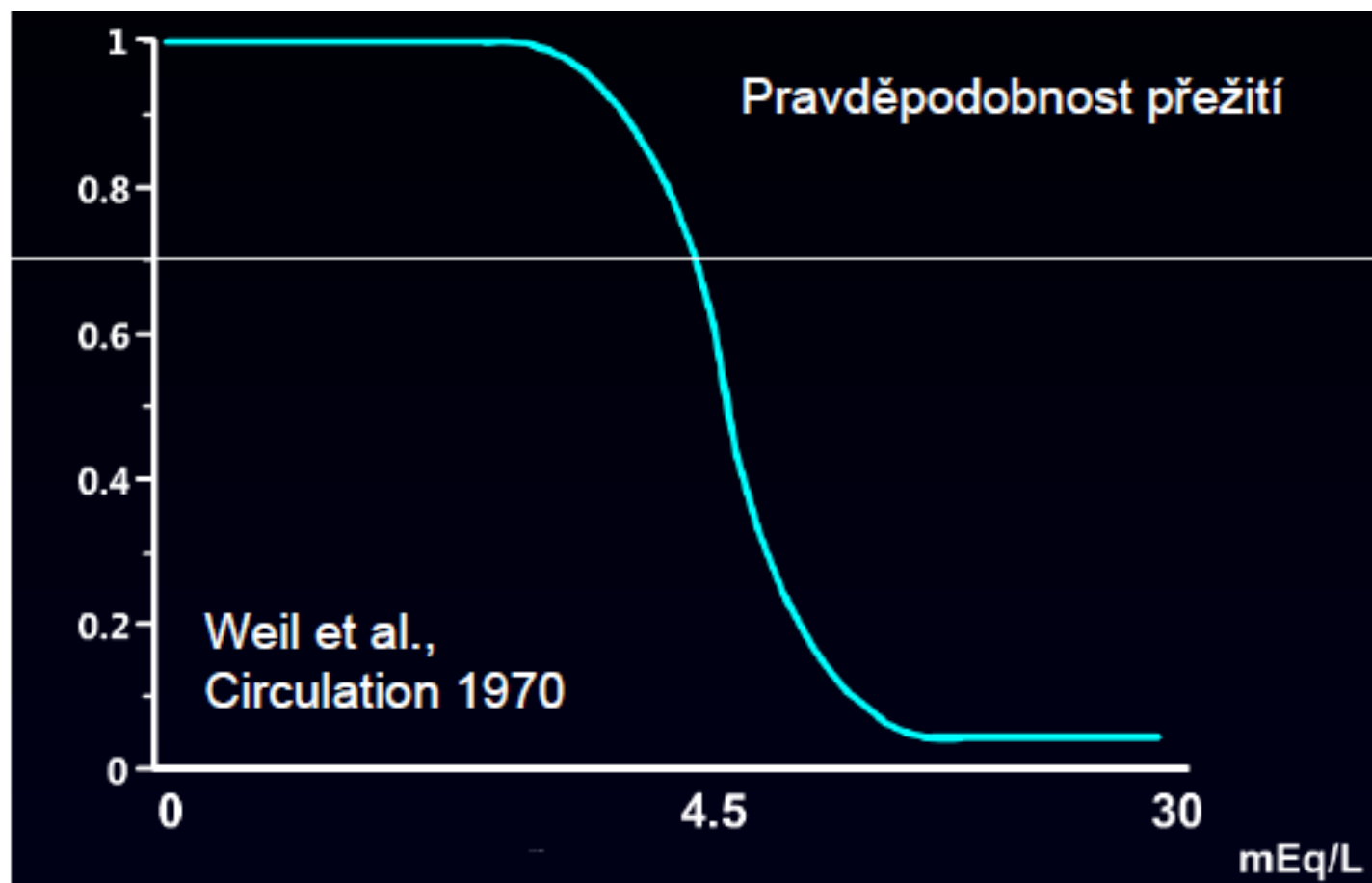
Intensive Care Med (2007) 33:1863–1865  
DOI 10.1007/s00134-007-0679-y

EDITORIAL

Jan Bakker  
Tim C. Jansen

**Don't take vitals, take a lactate**

# laktát a prognóza



# Historie – lactate the GOOD ?

## Lactate in the intensive care unit: pyromaniac, sentinel or fireman?

Xavier M Leverve

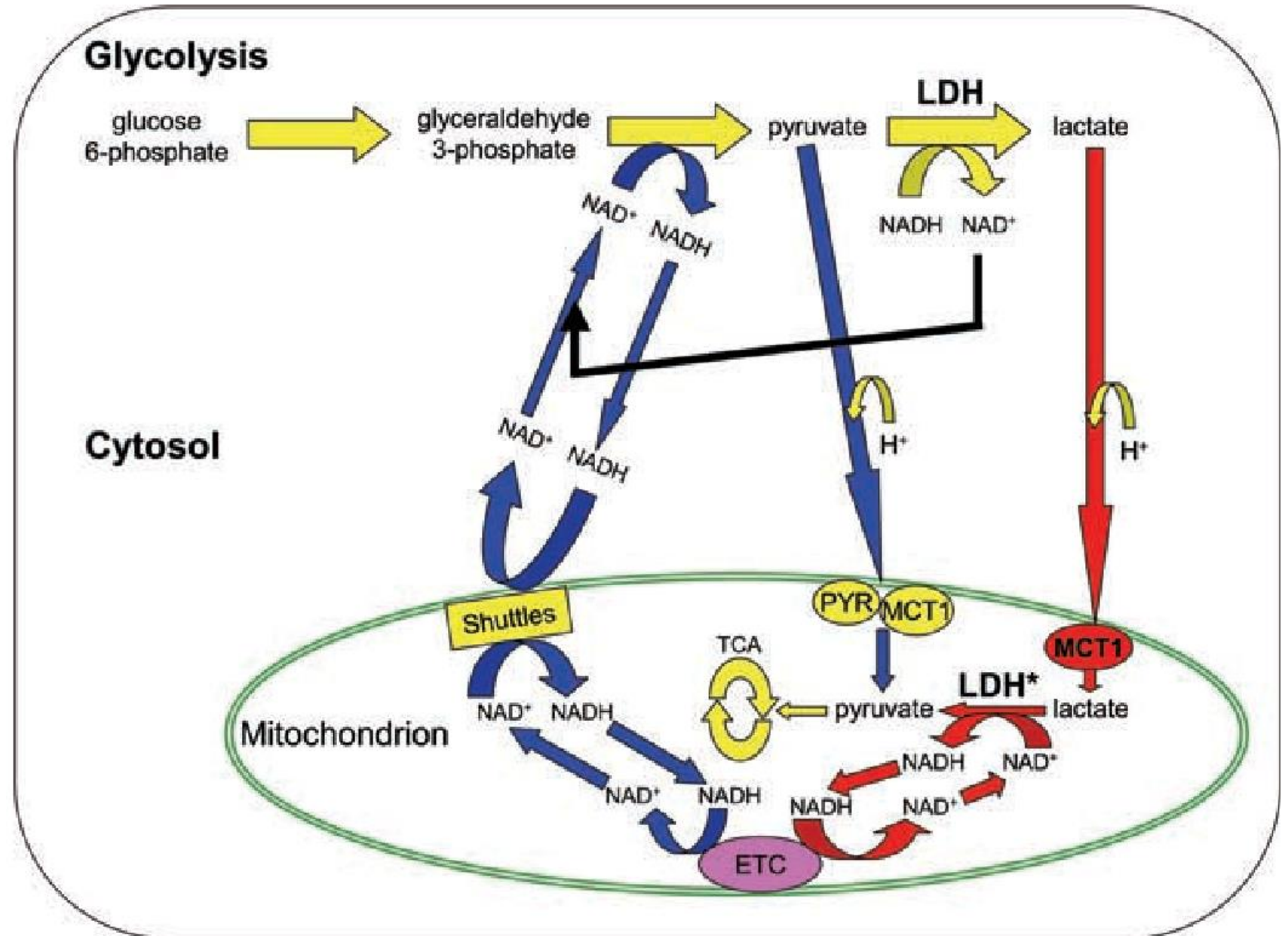
*Critical Care* 2005, 9:622-623 (DOI 10.1186/cc3935)



## metabolismus laktátu – normální stav

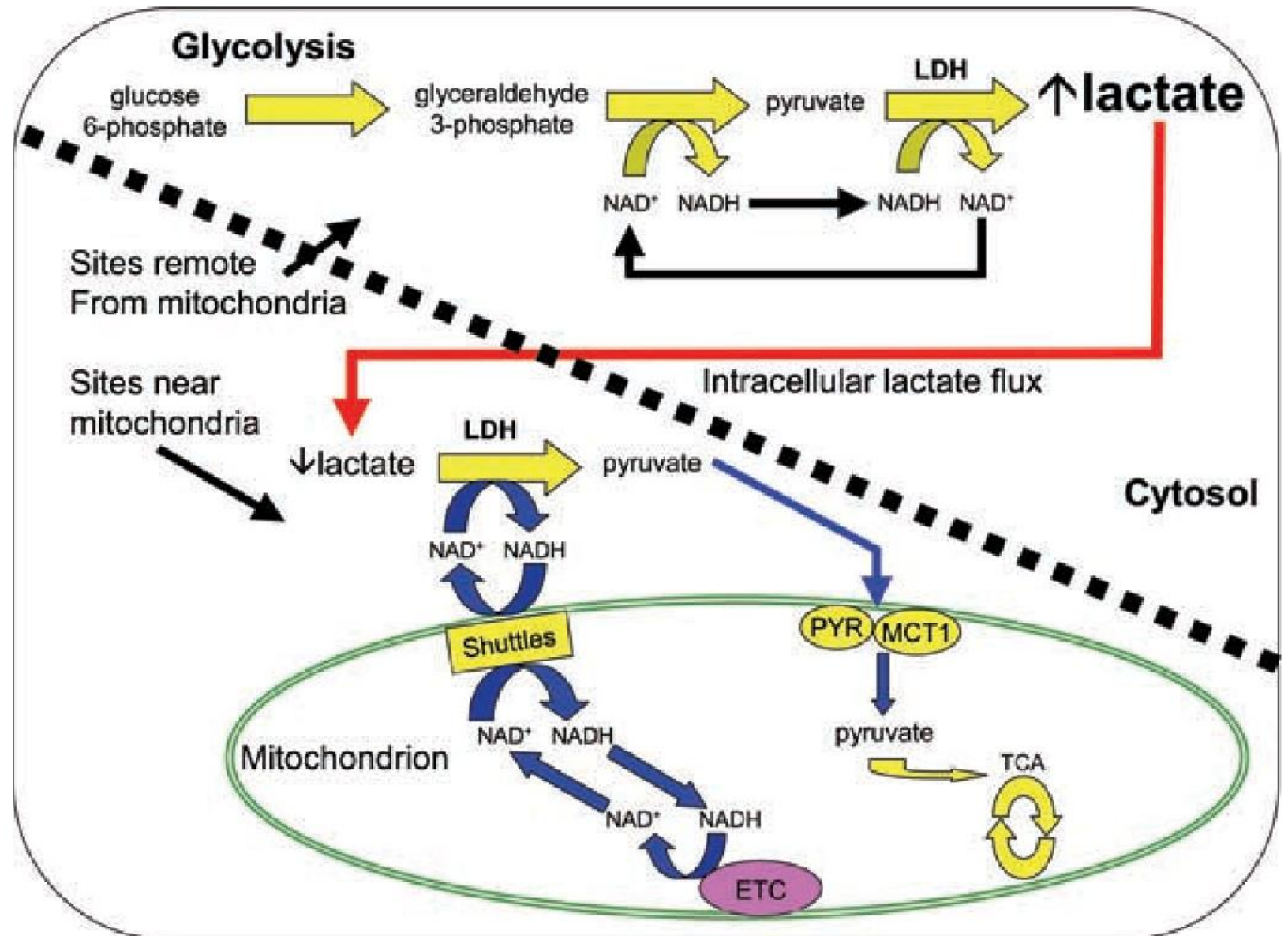
Produkce: 20 mmol/kg/d, tvorba a přestup do krve: řada orgánů; net balance každého orgánu/tkáně v klidu není známa  
Clearance 800 – 1800 ml/min → krev „očistěna během 3-4 min (při hladině 1-2 mmol/L „zmizí“ 60-120 mmol/hr

## buněčná úroveň I

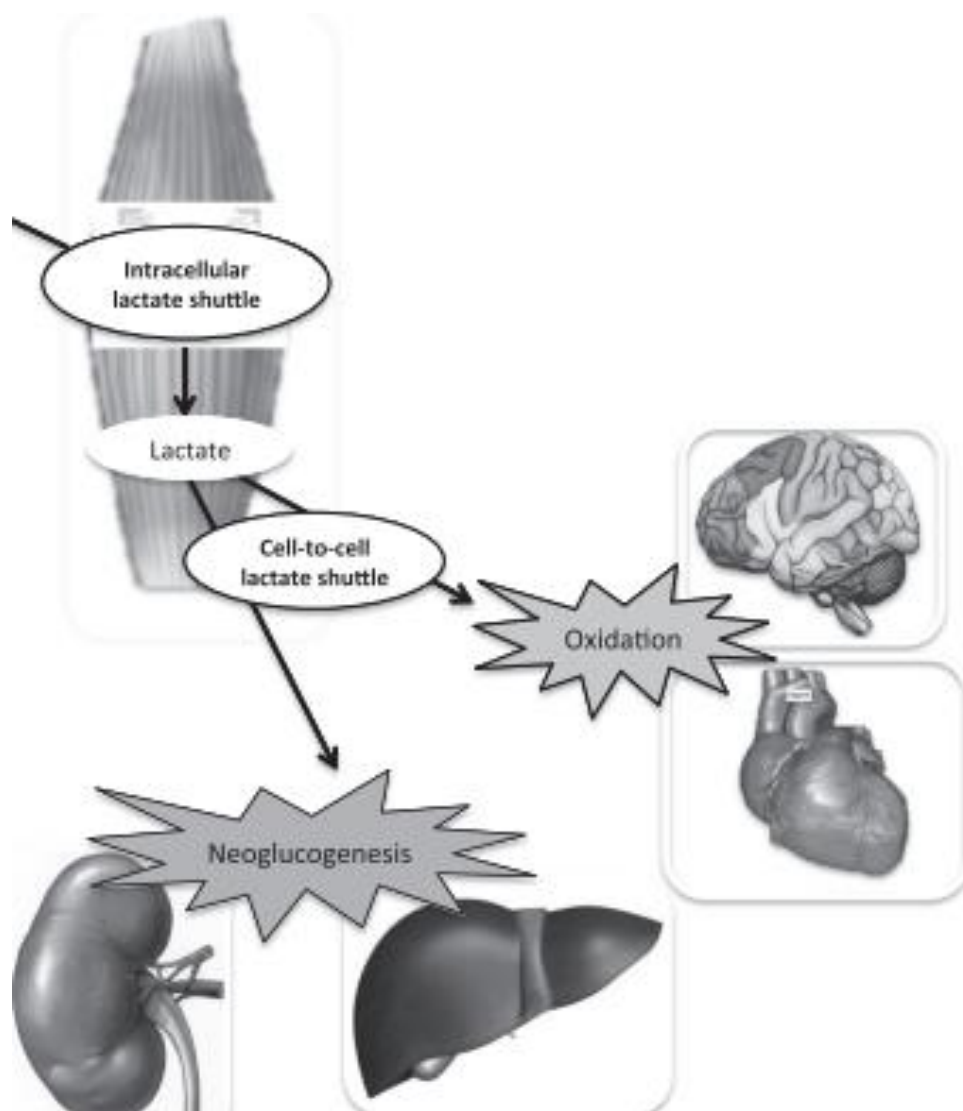




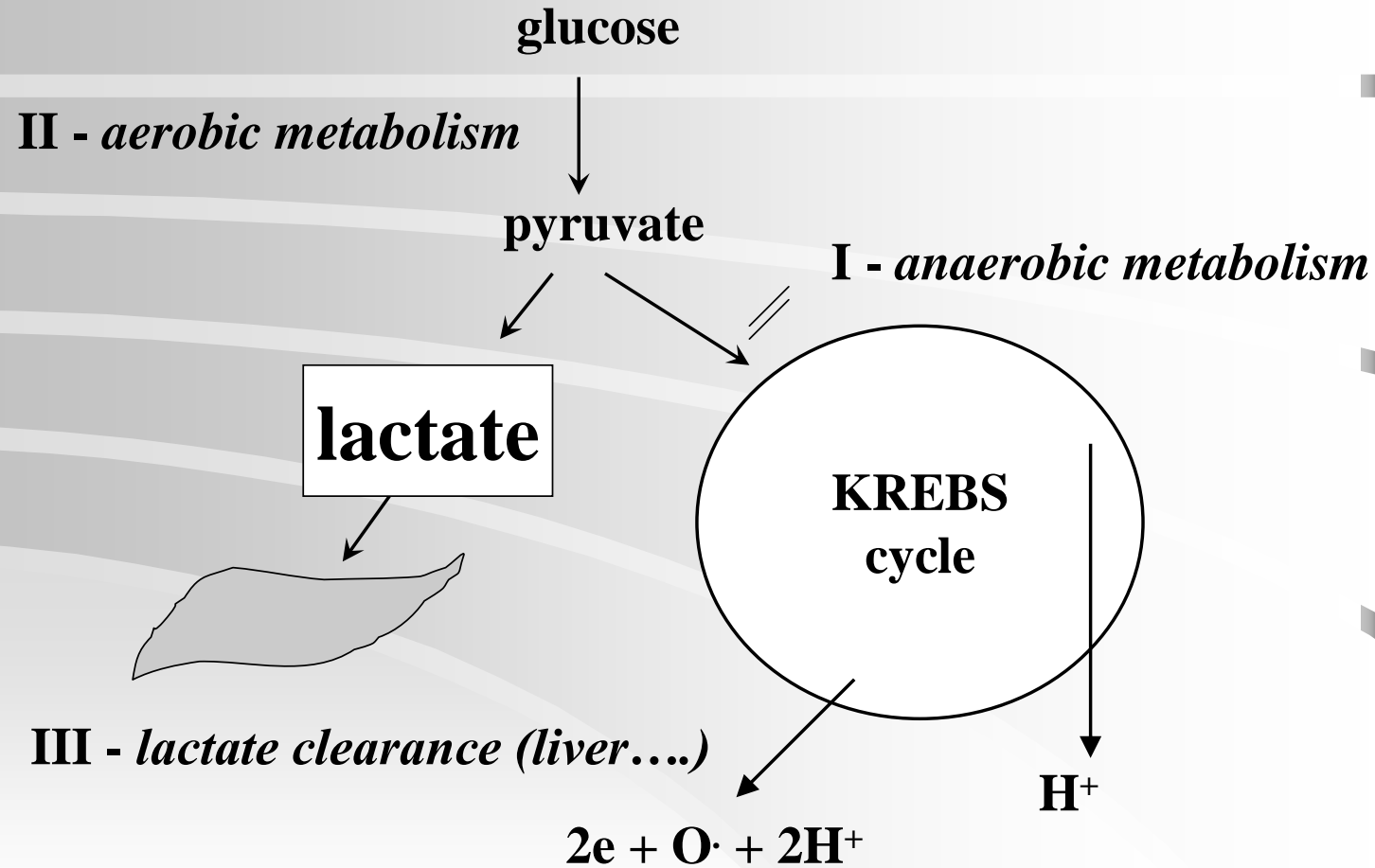
## buněčná úroveň II



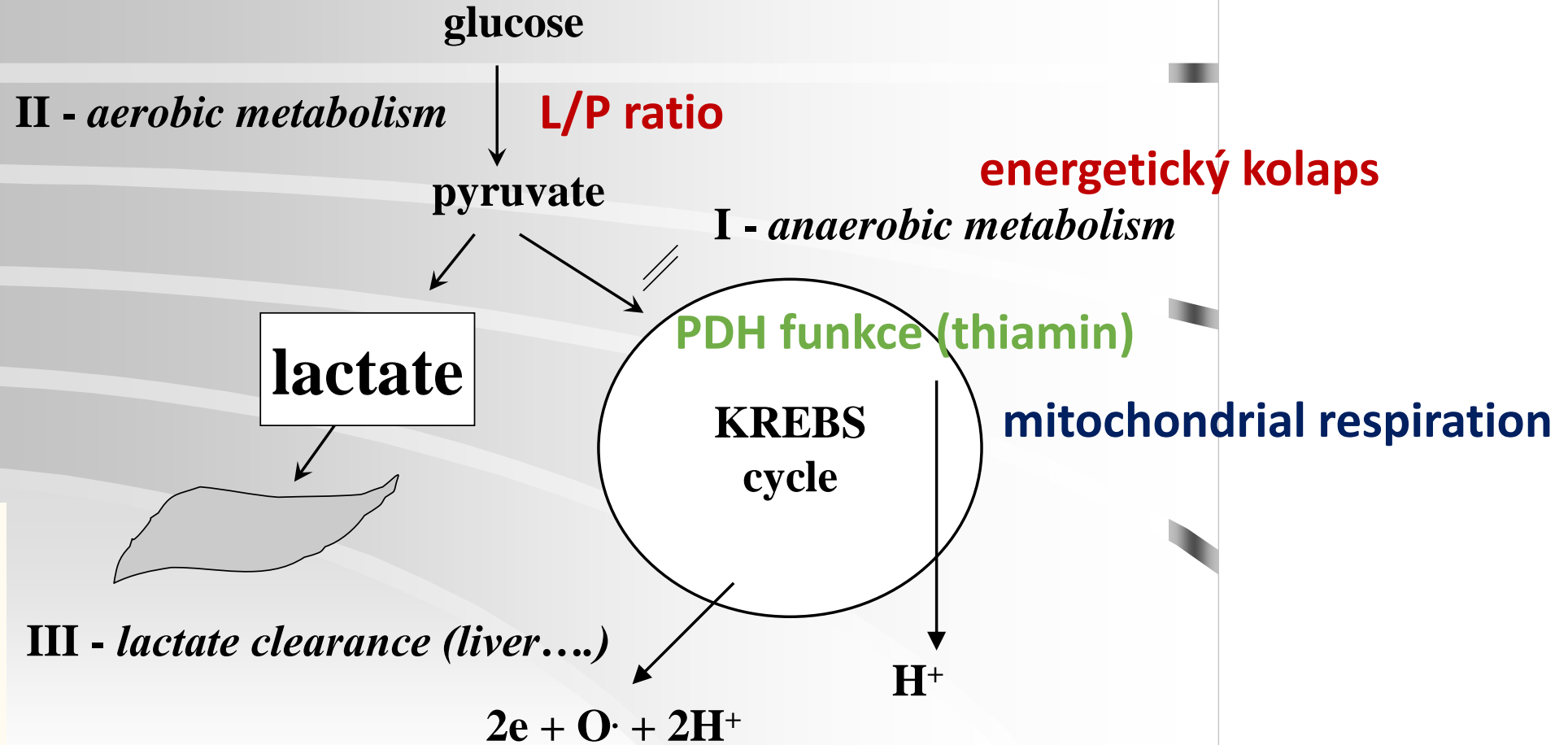
## orgánová úroveň



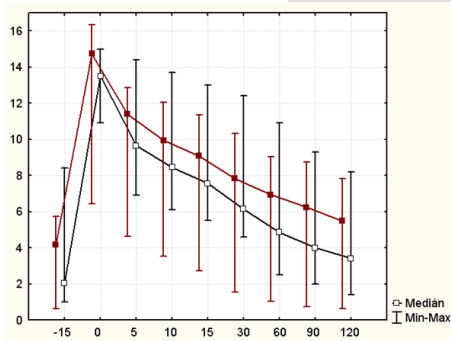
# BLOOD LACTATE LEVEL



# BLOOD LACTATE LEVEL



**laktátový test**





Prognosis of emergency department patients with suspected infection and intermediate lactate levels: A systematic review

Michael A. Puskarich, MD, Benjamin M. Illich, Alan E. Jones, MD\*

Department of Emergency Medicine, University of Mississippi Medical Center, Jackson, MS



# laktát a ICU – marker stresu

- laktát 2,1–3,9 je spojen s vyšší mortalitou (Trzeciak, ICM 2007)
- laktát 1,4-2,3 u SŠ je spojen s vyšší mortalitou (VASST subanalýza – Wacharasint, Shock 2012)
- vyšší laktát bez hypotenze spojen s vyšší mortalitou (Howell ICM, 2007)
- **ale**: hypotenze bez zvýšeného laktátu (< 2,5) má dobrou prognózu (Hernandez, Resuscitation 2011)

## ALE:

laktát >0,75 mmol/L je spojen s vyšší hospitalizační mortalitou

Nichol AD, Egi M, Pettila V, Bellomo R, French C, Hart G, Davies A, Stachowski E, Reade MC, Bailey M, Cooper DJ: Relative hyperlactatemia and hospital mortality in critically ill patients: a retrospective multi-centre study. *Crit Care* 2010, **14**:R25.

Wacharasint P, Nakada TA, Boyd JH, Russell JA, Walley KR: Normal-range blood lactate concentration in septic shock is prognostic and predictive. *Shock* 2012, **38**:4–10.

# laktát a ICU – marker odeznívajícího stresu

Early lactate clearance is associated with improved outcome in severe sepsis and septic shock\*

H. Bryant Nguyen, MD, MS; Emanuel P. Rivers, MD, MPH; Bernhard P. Knoblich, MD;  
Gordon Jacobsen, MS; Alexandria Muzzin, BS; Julie A. Ressler, BS; Michael C. Tomlanovich, MD



111 pts from ED

Lactate clearance 0-6 hrs;

S vs NS: 38+/-35% vs 12 +/- 52%

+10% clearance vs – 11% mortality

(Crit Care Med 2004; 32:1637–1642)

11. Arnold RC, Shapiro NI, Jones AE, Schorr C, Pope J, Casner E, Parrillo JE, Dellinger RP, Trzeciak S, Emergency Medicine Shock Research Network (EMShockNet) Investigators. Multicenter study of early lactate kinetics as a determinant of survival in patients with presumed sepsis. *Shock*. 2009;32(1):35–9.
13. Puskarich MA, Trzeciak S, Shapiro NI, Arnold RC, Heffner AC, Kline JA, Jones AE, Emergency Medicine Shock Research Network (EMSHOCKNET). Prognostic value and agreement of achieving lactate kinetics or central venous oxygen saturation goals during early sepsis resuscitation. *Acad Emerg Med*. 2012;19(3):252–8.
14. Jones AE, Shapiro NI, Trzeciak S, Arnold RC, Claremont HA, Kline JA, Emergency Medicine Shock Research Network (EMShockNet) Investigators. Lactate kinetics vs central venous oxygen saturation as goals of early sepsis therapy: a randomized clinical trial. *JAMA*. 2010;303(8):739–46.



## Lactate Clearance vs Central Venous Oxygen Saturation as Goals of Early Sepsis Therapy: A Randomized Clinical Trial

Dr. Alan E. Jones, MD, Dr. Nathan I. Shapiro, MD, MPH, Dr. Stephen Trzeciak, MD, MPH, Dr. Ryan C. Arnold, MD, Ms. Heather A. Claremont, BFA, and Dr. Jeffrey A. Kline, MD for the Emergency Medicine Shock Research Network (EMShockNet) Investigators

### Abstract

**Context**—Goal-directed resuscitation for severe sepsis and septic shock has been reported to reduce mortality when applied in the emergency department.

**Objective**—To test the hypothesis of noninferiority between lactate clearance and central venous oxygen saturation (ScvO<sub>2</sub>) as goals of early sepsis resuscitation.

**Design, Setting, and Patients**—Multicenter randomized, noninferiority trial involving patients with severe sepsis and evidence of hypoperfusion or septic shock who were admitted to the emergency department from January 2007 to January 2009 at 1 of 3 participating US urban hospitals.

**Interventions**—We randomly assigned patients to 1 of 2 resuscitation protocols. The ScvO<sub>2</sub> group was resuscitated to normalize central venous pressure, mean arterial pressure, and ScvO<sub>2</sub> of at least 70%; and the lactate clearance group was resuscitated to normalize central venous pressure, mean arterial pressure, and lactate clearance of at least 10%. The study protocol was continued until all goals were achieved or for up to 6 hours. Clinicians who subsequently assumed the care of the patients were blinded to the treatment assignment.

**Main Outcome Measure**—The primary outcome was absolute in-hospital mortality rate; the noninferiority threshold was set at  $\Delta$  equal to  $-10\%$ .

**Results**—Of the 300 patients enrolled, 150 were assigned to each group and patients were well matched by demographic, comorbidities, and physiological features. There were no differences in treatments administered during the initial 72 hours of hospitalization. Thirty-four patients (23%) in the ScvO<sub>2</sub> group died while in the hospital (95% confidence interval [CI], 17%–30%) compared with 25 (17%; 95% CI, 11%–24%) in the lactate clearance group. This observed difference between mortality rates did not reach the predefined  $-10\%$  threshold (intent-to-treat analysis: 95% CI for the 6% difference,  $-3\%$  to  $15\%$ ). There were no differences in treatment-related adverse events between the groups.

**Conclusion**—Among patients with septic shock who were treated to normalize central venous and mean arterial pressure, additional management to normalize lactate clearance compared with management to normalize ScvO<sub>2</sub> did not result in significantly different in-hospital mortality.

**laktát > 4 (3) mmol/L  
clearance >10-20% za 2 hod (6-8 hod)**



# clearance laktátu

Early Lactate-Guided Therapy in ICU Patients: A Multicenter, Open-Label, Randomized, Controlled Trial. Am J Resp Crit Care Med 2010 May 12. [Epub ahead of print]

[Jansen TC, et al Bakker J. for the LACTATE Study Group.](#)

**OBJECTIVE:** To assess the effect of lactate monitoring and resuscitation directed at decreasing lactate levels in ICU patients admitted with a lactate level of  $\geq 3.0$  mEq/l.

- **METHODS:** to decrease lactate by  $\geq 20\%$  per two hours for the initial 8 hours of ICU stay....
- **MEASUREMENTS AND MAIN RESULTS:** The lactate group received more fluids and vasodilators. However, there were no significant differences in lactate levels between the groups. In the intention-to-treat population (348 patients), hospital mortality in the control group was 43.5% (77/177) compared with 33.9% (58/171) in the lactate group ( $p=0.067$ ). When adjusted for predefined risk factors, **hospital mortality was lower in the lactate group (hazard ratio 0.61, 95%CI 0.43-0.87,  $p=0.006$ ).**
- **CONCLUSIONS:** In patients with hyperlactatemia on ICU admission, lactate-guided therapy significantly reduced hospital mortality when adjusting for predefined risk factors.

TABLE 2. BLOOD LACTATE LEVELS

Hours after Start of Therapy	Lactate Level (mEq/L)		P Value
	Control Group	Lactate Group	
Baseline (0 h)	4.7 (3.9–5.5)	4.6 (3.9–5.4)	0.75
8	2.7 (2.3–3.2)	2.6 (2.2–3.1)	0.59
0–8	3.3 (2.8–3.9)	3.2 (2.7–3.8)	0.80
9–72	1.7 (1.4–2.0)	1.6 (1.3–1.9)	0.17

$\Delta$ lactate $\geq 20\%$ decrease	% of patients reaching targets		
	Control group (N=177)	Lactate group (N=171)	P value
- 0-2 hours	55%	53%	0.74
- 2-4 hours	38%	39%	0.86
- 4-6 hours	48%	40%	0.19
- 6-8 hours	47%	45%	0.71



RESEARCH

Open Access



# Use of stepwise lactate kinetics-oriented hemodynamic therapy could improve the clinical outcomes of patients with sepsis-associated hyperlactatemia

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## Abstract

**Background:** Setting lactate kinetics at >30% might improve the clinical outcomes of patients with sepsis-associated hyperlactatemia. The aim of this study was to explore the outcome benefits of stepwise lactate kinetics vs central venous oxygen saturation (ScvO<sub>2</sub>)-oriented hemodynamic therapy at 6 h as the protocol goal during early resuscitation.

**Methods:** The relevant parameters and adverse events after different targets in 360 randomly assigned patients with sepsis-associated hyperlactatemia were recorded and compared.

**Results:** Heart rate (HR) at 48 h in the ScvO<sub>2</sub> group was higher than in the lactate kinetics group (105 ± 19 bpm vs 99 ± 20 bpm,  $P = 0.040$ ). The liquid balance at 4 h, 12 h, and 24 h in the lactate kinetics group was larger than in the ScvO<sub>2</sub> group (1535 (1271–1778) ml vs 826 (631–1219) ml,  $P < 0.001$ ; 1688 (1173–1923) ml vs 1277 (962–1588) ml,  $P < 0.001$ ; and 1510 (904–2087) ml vs 1236 (740–1808) ml,  $P = 0.005$ ), respectively. Mortality was higher in the ScvO<sub>2</sub> group (27.9% vs 18.3%,  $P = 0.033$ ), but there was no significant difference between the two groups in the length of stay in the ICU or mechanical ventilation. In terms of new onset organ dysfunction, there was a significant difference between the two groups in total bilirubin at 48 h and 72 h. Based on the 60-day survival curves, there was significantly more mortality in the ScvO<sub>2</sub> group than in the lactate kinetics group ( $\chi^2 = 4.133$ ,  $P = 0.042$ ). In addition, fewer adverse events occurred in the lactate kinetics group.

**Conclusions:** Stepwise lactate kinetics-oriented hemodynamic therapy can reduce mortality in patients with sepsis-associated hyperlactatemia compared with ScvO<sub>2</sub>-oriented therapy.

**Trial registration:** National Institutes of Health Clinical Trials Registry, NCT02566460. Registered on 26 September 2015.

**Keywords:** Lactate kinetics, ScvO<sub>2</sub>, Sepsis, Septic shock, Hemodynamic therapy

**Multi-center Clinical Trial of Lactate Clearance Guided**

**Fluid Resuscitation in Patients With Sepsis**

Sponsor: Nanfang Hospital of Southern Medical  
University

Central Contact Person: Chen Zhongqing, Ph.D

Appendix 1

The trial targets for the treatment arms.

Intervention group – targeted lactate clearance care		Control group – targeted central venous oxygen saturation care	
Lac% $\geq$ 10% Group	Lac% $\geq$ 20% Group	ScvO <sub>2</sub> Group	
① MAP $\geq$ 65mmHg	MAP $\geq$ 65mmHg	MAP $\geq$ 65mmHg	
*② CVP 8-12mmHg	CVP 8-12mmHg	CVP 8-12mmHg	
③ Urine output $\geq$ 0.5ml/kg/h	Urine output $\geq$ 0.5ml/kg/h	Urine output $\geq$ 0.5ml/kg/h	
④ Lac% $\geq$ 10%	Lac% $\geq$ 20%	**ScvO <sub>2</sub> $\geq$ 10%	

\*Central venous pressure (CVP) 12–15 mmHg in mechanically ventilated patients.

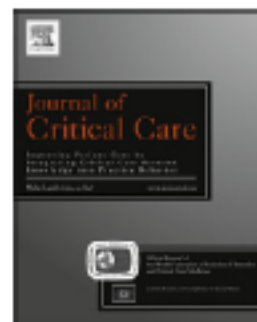
\*\* ScvO<sub>2</sub> was measured by blood-gas analysis (BGA).



Contents lists available at [ScienceDirect](#)

## Journal of Critical Care

journal homepage: [www.jccjournal.org](http://www.jccjournal.org)



The role of central venous oxygen saturation, blood lactate, and central venous-to-arterial carbon dioxide partial pressure difference as a goal and prognosis of sepsis treatment

Borwon Wittayachamnankul, MD<sup>a</sup>, Boriboon Chentanakij, MD<sup>a</sup>,  
Kamphée Sruamsiri, MD<sup>a</sup>, Nipon Chattipakorn, MD, PhD<sup>b,c,d,\*</sup>



# The Surviving Sepsis Campaign Bundle: 2018 Update

Critical Care Medicine  
Intensive Care Medicine

Hour-1 Surviving Sepsis Campaign Bundle of Care

- **Measure lactate level. Remeasure if initial lactate level > 2 mmol/L.**
- Obtain blood cultures before administering antibiotics.
- Administer broad-spectrum antibiotics.
- Begin rapid administration of 30mL/kg crystalloid for hypotension or lactate level  $\geq 4$  mmol/L.
- Apply vasopressors if patient is hypotensive during or after fluid resuscitation to maintain MAP  $\geq 65$  mm Hg.

“Time zero” or “time of presentation” is defined as the time of triage in the emergency department or, if presenting from another care venue, from the earliest chart annotation consistent with all elements of sepsis (formerly severe sepsis) or septic shock ascertained through chart review.



## ZÁVĚR

Laktát jako hemodynamický parametr – částečně

Laktát jako marker tíže kritického stavu – ANO

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# 7. SVATOMARTINSKÝ WORKSHOP



[www.hemodynamika.cz](http://www.hemodynamika.cz)

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