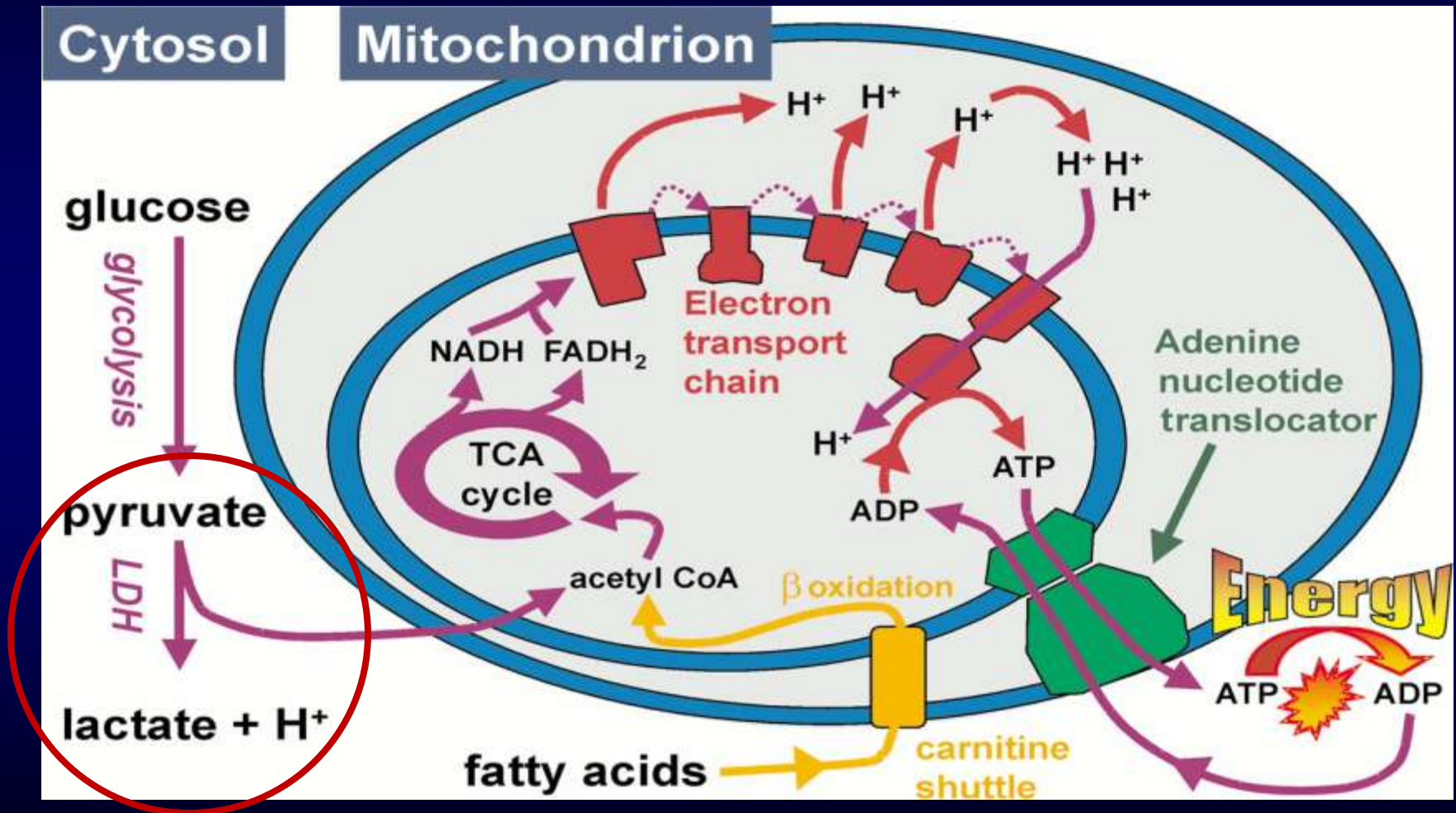


AÇIK KALP CERRAHİSİ SONRASI HİPERLAKTATEMİ

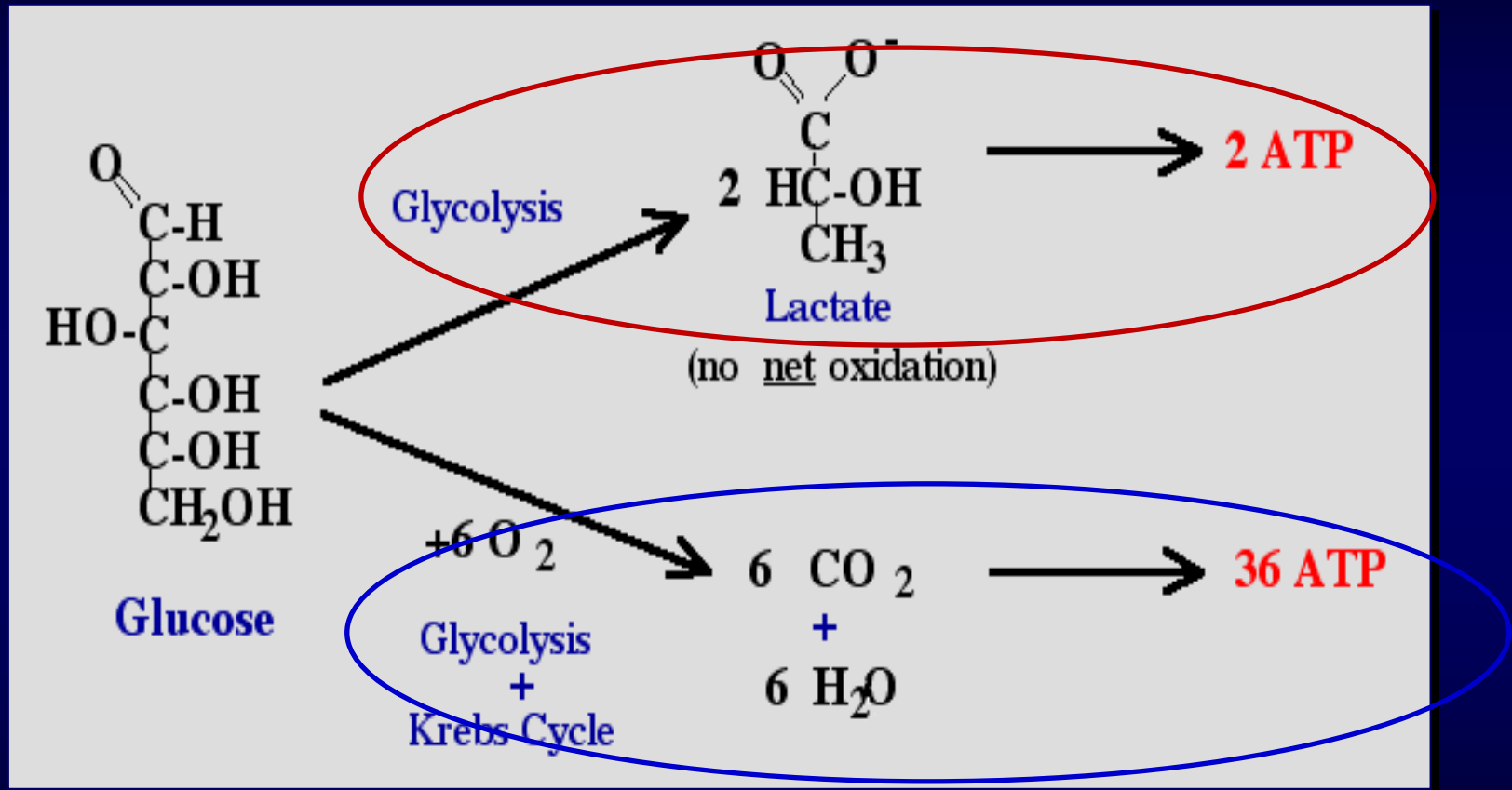
**Dr. Nurgül Yurtseven
Dr. Siyami Ersek Göğüs Kalp Damar
Cerrahisi Eğitim ve Araştırma Hastanesi**

Glikoliz



Glikoliz

Anaerobik metabolizma



Aerobik metabolizma

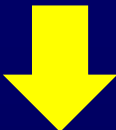
Glikojenoliz

Glukagon

Adrenalin

**fosforilazı aktive
ederek glikojen
yıkımına ve glukoz
oluşumuna sebep
olur**



- **Laktat 15-20 mmol/kg/gün**
- **Metabolizma karaciğer, böbrek**
- **Normal serum değeri 2 mmol/L** 
- **Laktik asidoz**
 - **Laktat > 5 mmol/L**
 - **Ph < 7.35**

Tip A Hiperlaktatemi

**Doku hipoksisi ve
hipoperfüzyonu
nedeniyle oksidatif
fosforilasyonun azalması
(Şok, kalp yetmezliği,
hipovolemi)**

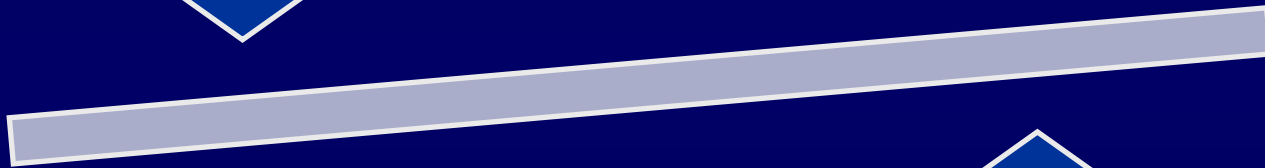
Tip B Hiperlaktatemi

**İlaç veya toksin aracılı
sellüler yetersizlik
(metformin, nitroprussid,
siyanid)
PDH inaktivasyonu**

Hiperlaktatemi



**Laktat
klirensi**



**Üretim
artışı**

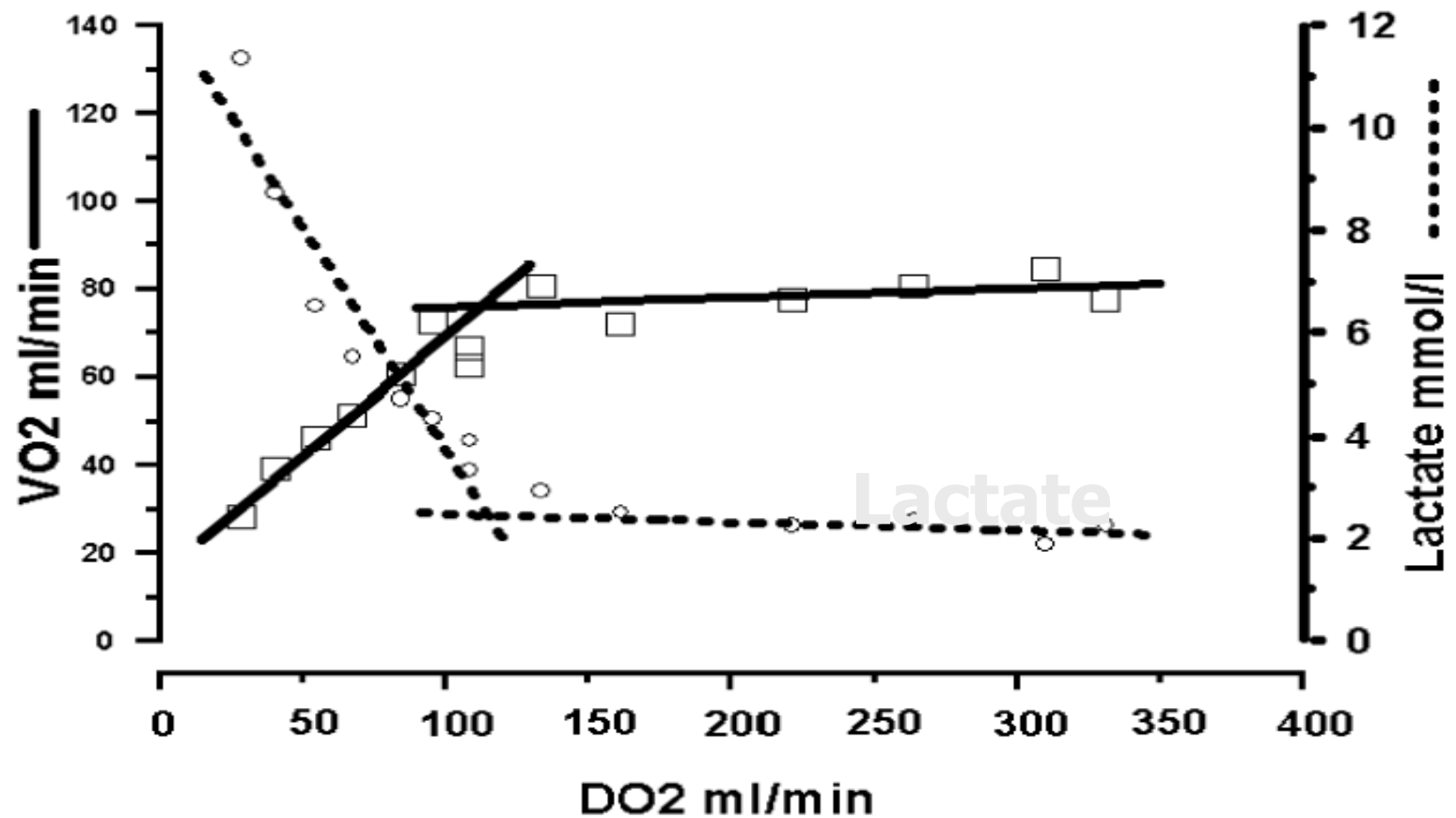


- **Kardiyak cerrahi sonrası görülme oranı %10-20**
Erken hiperlaktatemi %21
Geç hiperlaktatemi %17

Jean-Michel Maillet Chest 2003, 123:1361-1366

Oxygen transport— the oxygen delivery controversy

Intensive Care Med (2004) 30:1990–1996



A)Azalmış O2 sunumu

1) Koroner kan akımının azalması:

- Taşikardi
- Hipotansiyon
- Önyükün artması
- Hipokapni
- Koroner arter spazmı ve koroner darlık

2) O2 içeriğinin azalması:

- Hipoksemi
- Anemi
- Hemoglobinden O2 salınımının azaldığı durumlar

B)Artmış O2 tüketimi

Tü 1) Taşikardi

2) Artmış duvar gerilimi:

- a) Önyük artışı,
- b) Ardyük artışı,
- c) Miyokardial kontraktilitenin artması

Preoperatif Faz

Anestezi ve cerrahi gibi travma oluşturacak uygulamalardan önce, maksimal O₂ dağılımını ve tüketimini düzenlemek.

(Anti-anginal tedavi, heparinizasyon, mobilizasyon kısıtlaması vs.)

Outcome With High Blood Lactate Levels During Cardiopulmonary Bypass in Adult Cardiac Operation

Philippe Demers, MD, Stéphane Elkouri, MD, Raymond Martineau, MD, André Couturier, MSc, and Raymond Cartier, MD

Variable	Lactates		<i>p</i> Value
	< 4.0 mmol/L (n = 1,032)	≥ 4.0 mmol/L (n = 227)	
Age (years)	60.8 ± 11.1	63.7 ± 11.0	0.004
Sex			
Men	77.2%	45.8%	< 0.001
Women	22.8%	54.2%	
CHF	22.8%	48.9%	< 0.001
Hypertension	40.9%	45.4%	0.22
Atherosclerosis	17.4%	24.2%	0.017
Diabetes	14.9%	17.7%	0.29
Preop hemoglobin (g/L)	138.3 ± 16.2	129.3 ± 17.9	< 0.001
Redo	10.3%	27.3%	< 0.001
Complex surgery	10.0%	30.4%	< 0.001
Emergency	2.4%	4.4%	0.16
LVEF <30%	7.7%	12.7%	0.034

CHF = congestive heart failure;
fraction; Preop = preoperative.

LVEF = left ventricular ejection

TABLE 1. Univariate variable screening findings

Variable	Total	Complications		P value
		No (n = 450)	Yes (n = 52)	
Age (y), mean (SD)	60 ± 12	59 ± 12	67 ± 11	<.001
Men	310 (62%)	288 (64%)	22 (42%)	.002
Body mass index (kg/m ²), mean (SD)	26 ± 4	26 ± 4	26 ± 5	.967
Comorbid conditions				
Hypertension	393 (78%)	350 (78%)	43 (83%)	.416
Diabetes	165 (33%)	144 (32%)	21 (40%)	.236
Dyslipidemia	286 (57%)	253 (56%)	33 (65%)	.260
Renal disease	52 (11%)	41 (9%)	11 (22%)	.004
COPD	14 (3%)	13 (3%)	1 (2%)	1.000
Unstable angina	155 (31%)	140 (31%)	15 (29%)	.738
Previous myocardial infarction	175 (35%)	158 (35%)	17 (33%)	.784
Heart failure, NYHA classification				
I	17 (6%)	11 (5%)	5 (14%)	.313
II	110 (39%)	76 (37%)	14 (39%)	
III	94 (33%)	99 (48%)	15 (42%)	
IV	61 (22%)	19 (9%)	2 (6%)	
LVEF (%)				
<40	69 (14%)	53 (12%)	16 (31%)	.001
40-59	151 (30%)	137 (30%)	14 (27%)	
≥ 60	282 (56%)	260 (58%)	22 (42%)	
Reoperation	68 (14%)	60 (13%)	8 (15%)	.682
EuroSCORE, median (IQR)	4 (3-6)	4 (3-6)	7 (5-9)	<.001
Preoperative laboratory values, mean (SD)				
Hemoglobin (g/dL)	12.6 ± 1.7	13.3 ± 1.7	12.6 ± 2.1	.009
Hematocrit (%)	39 ± 5	40 ± 5	39 ± 6	.071
Prothrombin time (s)	11.1 ± 1.6	11.1 ± 1.6	11.4 ± 1.4	.248
Platelet count (×10 ³ /μL)	223 ± 66	224 ± 66	218 ± 67	.526
Creatinine level (mg/dL)	1.12 ± 0.35	1.11 ± 0.35	1.21 ± 0.37	.081
Leukocyte count (/μL)	7635 ± 2065	7640 ± 2084	7596 ± 1918	.889
Preoperative drug exposure				
Aspirin	197 (39%)	176 (39%)	21 (40%)	.868
Heparin	5 (1%)	5 (1%)	0 (0%)	1.000

SD, Standard deviation; COPD, chronic obstructive pulmonary disease; NYHA, New York Heart Association; LVEF, left ventricular ejection fraction; EuroSCORE, European System for Cardiac Operative Risk Evaluation; IQR, interquartile range.

- Yaş
- Kadın cinsiyet
- KKY
- Preop Hb Düşüklüğü
- EuroSCORE >6
- Cerrahi girişimin tipi

Postoperatif Laktat yüksekliği ile ilişkili

Aortik kros klemp konduktan sonra

- 1.Aerobik metabolizma durur.**
- 2.Anaerobik metabolizma başlar**
- 3.ATP ve kreatin fosfat (CP) depoları tükenir.**
- 4.Anoksik metabolizma ürünlerinde artış görülür.**

Bu dönemde kalp enerjisini iki şekilde elde eder

- 1.Glukoz ve glikojenin anaerobik metabolizmasından
(% 80)**
- 2.Nonkoroner kollateral dolaşımla aerobik metabolizma
(% 20)**

AZALMIŞ KORONER KAN AKIMI

MEVCUT OKSİJENİN AZALMASI

AZALMIŞ A T P SENTEZİ

Ca DENGESİNİN BOZULMASI

Sitozolik Ca da artma

**Mitokondriye Ca
yüklenmesi**

**Bozulmuş mit.
fonksiyonu**

ATP üretiminde bozulma

AZALMIŞ ATP

**Ca ATP azların
aktivasyonu**

ATP kullanımında artış

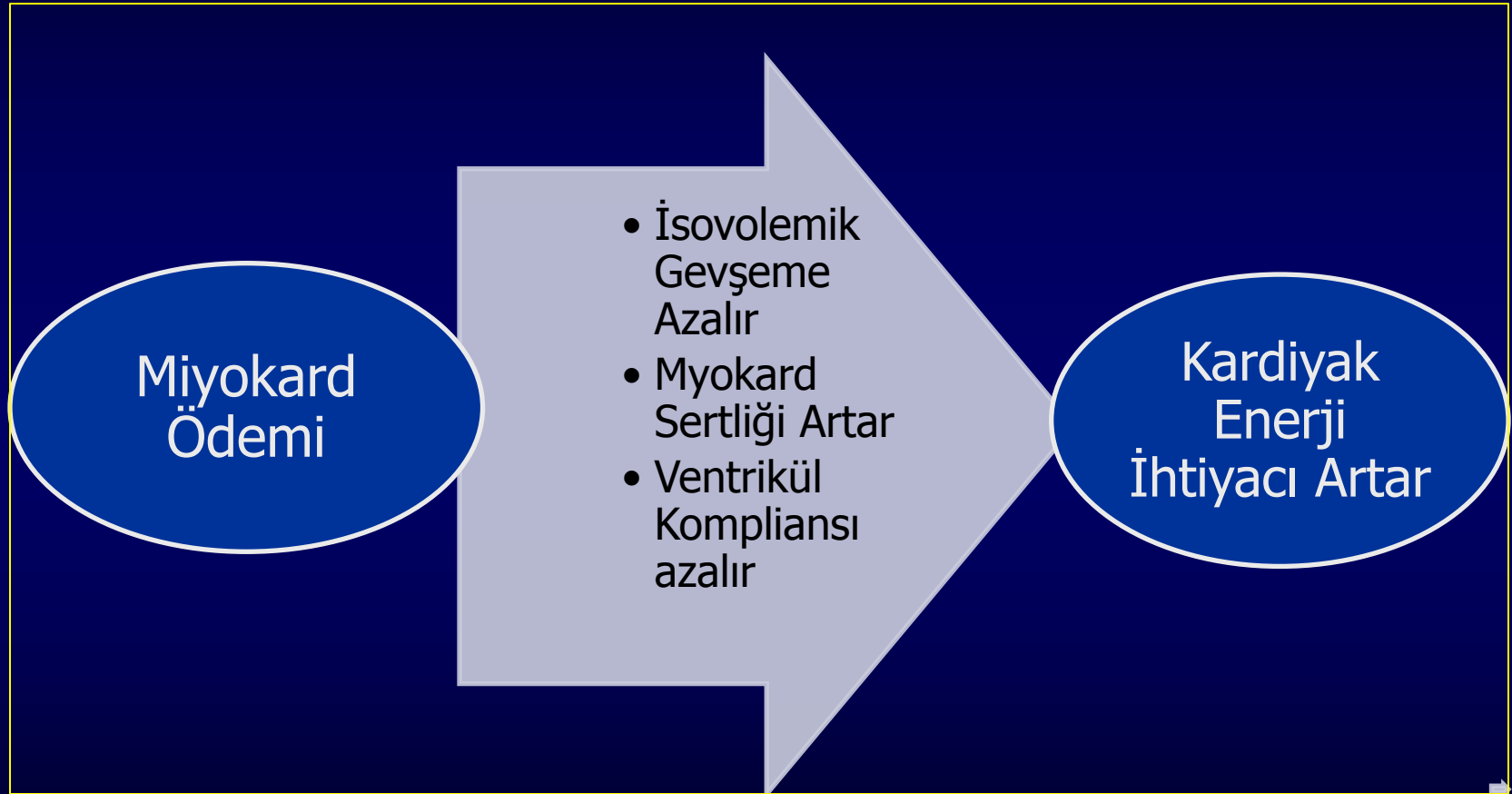
**Ca lipazların
aktivasyonu**

FONKSİYON VE YAPI KAYBI

Hemodilüsyon

- **KPB başlangıcında Priming Volüm ile Kolloid Osmotik Basıncın düşmesi İntravasküler alandan ekstrasvasküler alana sıvı geçişine neden olur.**
- **İyatrojenik miyokardial ödem gelişir.**

Miyokardial sıvı içeriği % 3,5 artarsa KD % 40 azalır



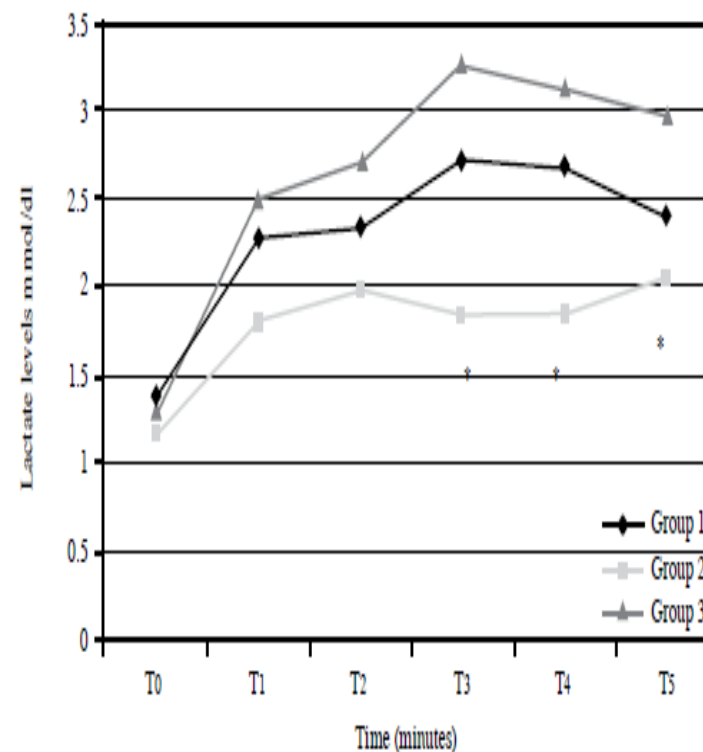
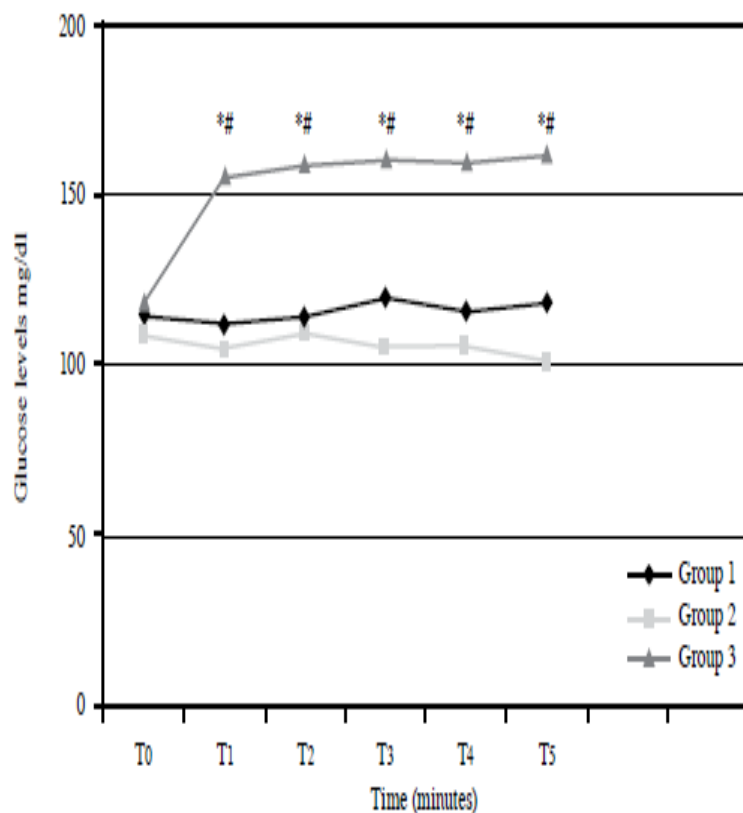
Miyokard koruması

- Elektromekaniksel aktivitenin durdurulması: **Kardiyopleji**
- Metabolizma hızının azaltılması: **Hipotermi**

Myocardial protection: standard versus insulin cardioplegia and glucose-insulin-potassium solutions

Miyokardiyal koruma: Standarda karşı insülin kardiyopleji ve glikoz-insülin-potasyum solüsyonu

Müzeyyen İyigün Kurt,¹ Nurgül Yurtseven,¹ Abdullah Kemal Tuysun,² Dilek Savaşkan,¹ Sevim Canik¹

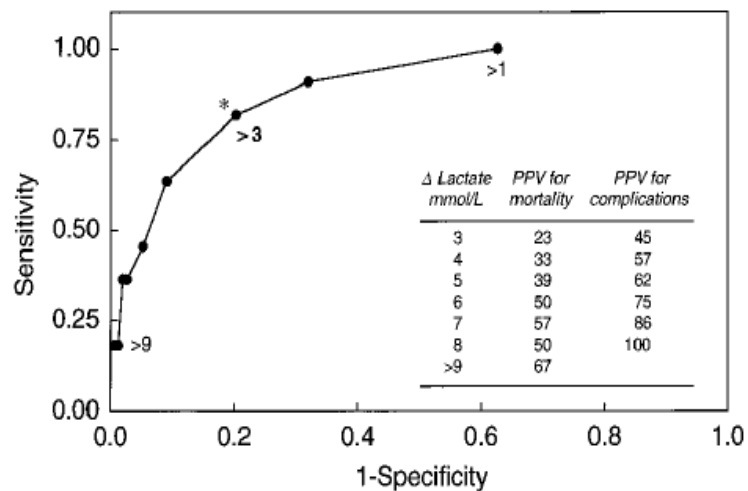
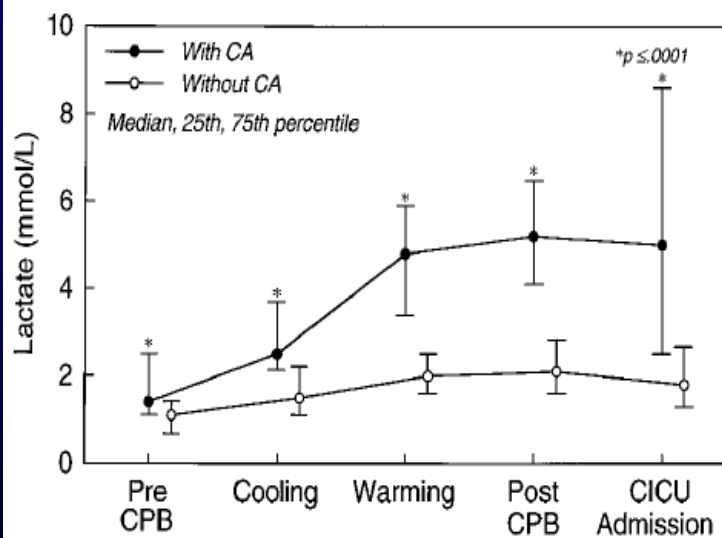
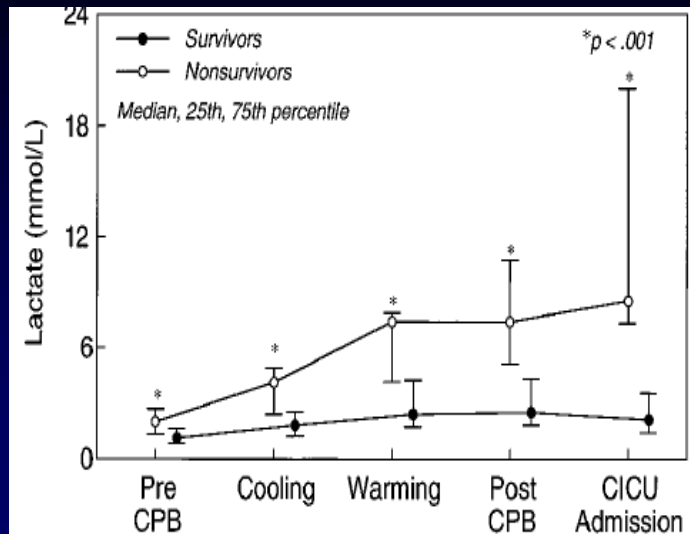
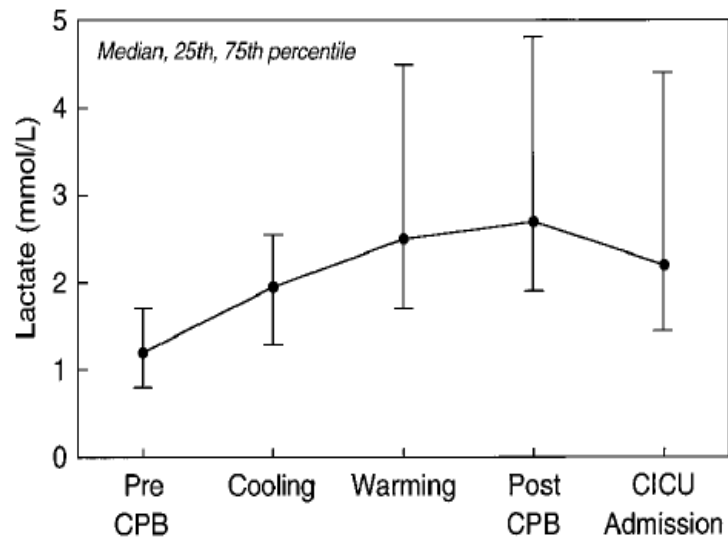


	Group 1	Group 2	Group 3	<i>p</i>
Cross-clamp time (minutes)	58.5±28.4	61.2±26.2	58.5±26.6	NS
Pump time (minutes)	98.5±40.2	92.3±34.3	89.2±28.5	NS
Entubation time (hours)	12.2±2.4	9.5±3.4	12.4±4.3	NS
Postoperative stay (hour)	28.2±8.3	27.4±11.1	31.3±14.4	NS
Hospital stay (day)	8.3±2.2	7.2±1.1	10.2±6.3	NS
Inotropic support				
Yes	5	1	9	<i>p</i> <0.05
No	35	39	31*	<i>p</i> <0.05
Defibrillation				
Yes	3	2	9	<i>p</i> <0.05
No	37	38	31*	<i>p</i> <0.05
Postoperative arrhythmias				
Yes	5	3	11	<i>p</i> <0.05
No	35	38	27*	<i>p</i> <0.05

*: The comparison of group 2 and 3 demonstrates *p*<0.05.

CHANGES IN WHOLE BLOOD LACTATE LEVELS DURING CARDIOPULMONARY BYPASS FOR SURGERY FOR CONGENITAL CARDIAC DISEASE: AN EARLY INDICATOR OF MORBIDITY AND MORTALITY

- **Anestezi ve Cerrahi Teknik**
- **Hemodilüsyonun derecesi**
- **Hipotermi derecesi**
- **KPB'a bağlı İnflamatuvar yanıt**
- **KPB ve KK zamanı**
- **Sirkülatuar arrest süresi**
- **Miyokardiyal korumanın derecesi**
- **Revaskülarizasyon durumu**
- **Ameliyathanedeki beklenmedik olaylar**



Lactic Acidosis after Cardiac Surgery Is Associated with Adverse Outcome

Fevzi Toraman, MD,¹ Serdar Evrenkaya, MD,² Murat Yuce, MD,³ Nazan Aksoy, MD,⁴ Hasan Karabulut, MD,² Yildirim Bozkulak,¹ Cem Alhan, MD²

	Low Lactate (n = 534)	High Lactate (n = 242)	P
Preoperative hematocrit, %	40 ± 8	40.5 ± 5	NS
Hematocrit during CPB	27 ± 4	26.7 ± 4	NS
Preoperative lactate level, mmol/L	1.0 ± 0.7	1.1 ± 0.7	NS
Lactate level during CPB, mmol/L	1.2 ± 0.7	1.3 ± 0.8	NS
SBE during CPB, mmol/L	0.1 ± 2	-0.1 ± 2	NS
Cross-clamp time, min	34 ± 14	48 ± 29	.0001
CPB time, min	53 ± 19	76 ± 38	.0001
No. of distal anastomoses	2.9 ± 1	3.3 ± 1	NS
Fluid balance at the end of operation, mL	44 ± 512	205 ± 729	.0001

*CPB indicates cardiopulmonary bypass; SBE, standard base excess.

	Low lactate (n = 534)	High Lactate (n = 242)	P
Postoperative hematocrit, %	34.5 ± 5.4	34.0 ± 5.2	NS
Postoperative lactate level, mmol/L	1.3 ± 0.3	2.7 ± 1.1	.001
Postoperative SBE, mmol/L	-1.8 ± 2.7	-3.4 ± 4.6	.0001
Total chest tube output, mL	599 ± 339	778 ± 523	.0001
Patients received red blood cells, %	14	21.1	.016
Intraaortic balloon pump, %	0.6	3.2	.006
Time to extubation, min	247 ± 271	376 ± 571	.001
Length of Intensive care unit stay, h	20.6 ± 11.2	25.6 ± 31.7	.02
Length of Intensive care unit stay >24 h, %	2.7	8.7	.0001
Length of hospital stay, d	5.4 ± 2.8	6.2 ± 4.5	.013
Mortality, %	0.4	2	.035

What is a normal lactate level during cardiopulmonary bypass?

STAFFAN SVENMARKER¹, SÖREN HÄGGMARK¹ & MARGARETA ÖSTMAN¹

Table II. Univariate risk stratification of hyperlactatemia during cardiopulmonary bypass: continuous variables.

Risk Strata	Lactate <2 mmol/L	Lactate ≥2 mmol/L	p-value
Age (years)	66.6±10.0	64.7±12.0	0.00
Body Mass Index	26.8±3.9	27.2±4.3	0.05
CPB Duration (min)	83.0±39.3	159.6±87.1	0.00
Cross Clamp of Aorta (min)	48.8±29.1	93.9±60.2	0.00
Temperature CPB (°C)	33.6±1.9	30.3±5.6	0.00
Blood Transfusion CPB (ml)	66.3±202.7	348.3±521.3	0.00
Volume Load CPB (ml/min)	9.6±8.7	12±4	0.00
Urine Output CPB (ml/min)	6.5±3.8	5.2±3.6	0.00
Haemoglobin at CPB start (g/l)	82.6±12.6	80.4±14.7	0.02
Phenylephrine dose CPB (mg)	0.57±1.36	0.71±0.85	0.04
Higgins Score	2.4±2.3	4.3±3.5	0.00
pH at CPB start	7.37±0.04	7.34±0.06	0.00

KPB esnasında pompa akımının sınırlandırılmasına yol açan venöz dönüş problemi hiperlaktatemiye neden olur.

Venöz dönüş problemi olan hastaların % 17'sinde, olmayanların ise %7,9'unda hiperlaktatemi gelişir.

Hyperlactatemia during cardiopulmonary bypass: determinants and impact on postoperative outcome

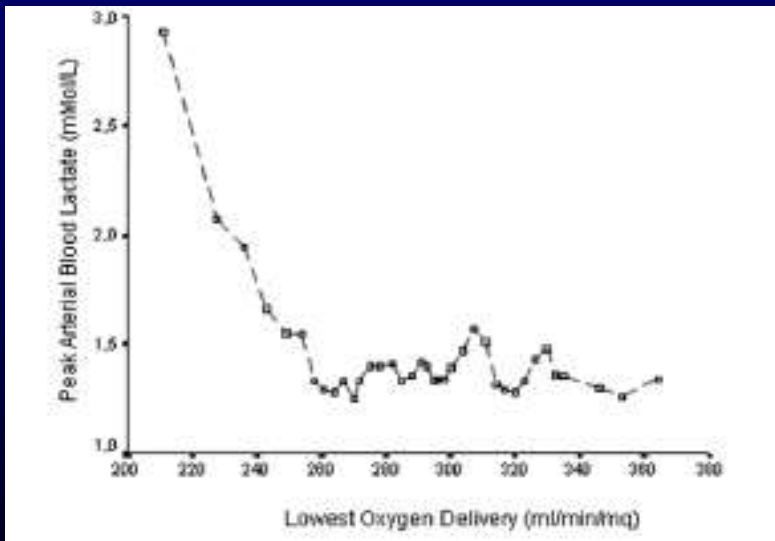
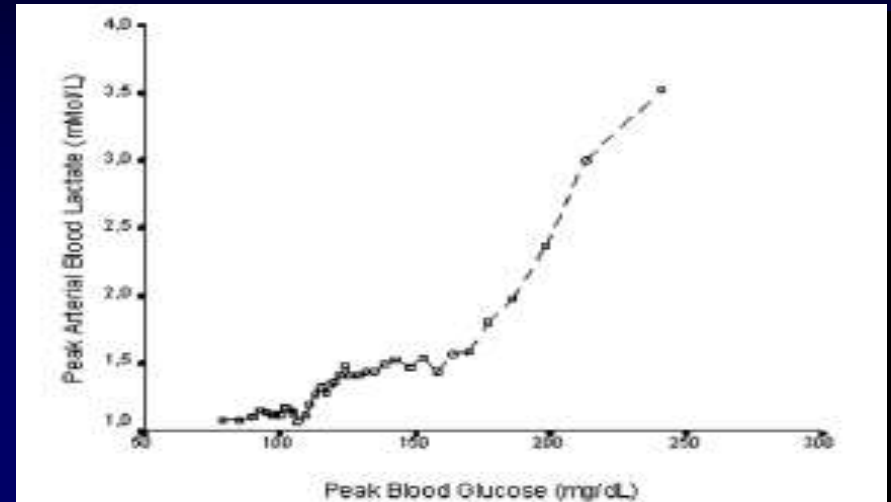
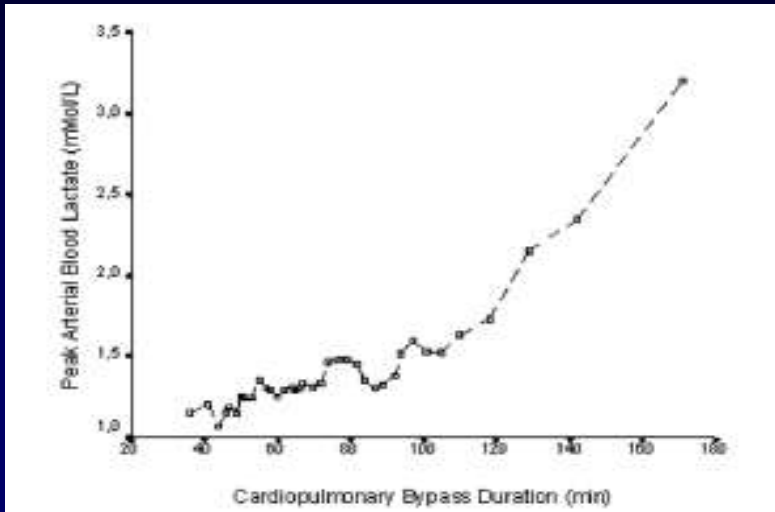
Marco Ranucci, Barbara De Toffol, Giuseppe Isgrò, Federica Romitti, Daniela Conti and Maira Vicentini

Univariate and multivariable analyses for pre- and intraoperative factors associated with peak blood lactate value

Univariate analysis (correlation matrix)		
Factor	Correlation coefficient	p value
Age (years)	-0.099	0.032
Ejection fraction	-0.181	0.001
Congestive heart failure	0.191	0.001
Preoperative serum creatinine value (mg/dl)	0.191	0.001
Active endocarditis	0.177	0.001
Isolated coronary operation	-0.094	0.041
CPB duration (minutes)	0.523	0.001
Lowest temperature (°C) on CPB	-0.312	0.001
Lowest hematocrit on CPB	-0.158	0.001
Lowest pump flow (l/minute per m ²) on CPB	-0.271	0.001
Lowest Do ₂ (ml/minute per m ²) on CPB	-0.276	0.001
Peak blood glucose (mg/dl) on CPB	0.517	0.001
Multivariable analysis (linear regression)		
Factor	B coefficient	p value
Constant	0.326	
Preoperative serum creatinine value (mg/dl)	0.123	0.032
Active endocarditis	0.177	0.001
CPB duration (minutes)	0.012	0.001
Lowest Do ₂ (ml/minute per m ²) on CPB	-0.004	0.004
Peak blood glucose (mg/dl) on CPB	0.009	0.001

Hyperlactatemia during cardiopulmonary bypass: determinants and impact on postoperative outcome

Marco Ranucci, Barbara De Toffol, Giuseppe Isgrò, Federica Romitti, Daniela Conti and Maira Vicentini



- **KPB süresi 96 dk**
- **Pik Glukoz 160 mg/dl**
- **DO2 260 ml/dk/m2**

Peroperatif Hiperlaktatemi

- **Perfüzyon basıncı ve flow ayarlanmalı**
- **Hipotermi derecesi,**
- **Priming solüsyon ayarlanarak aşırı hemodilüsyon ve plazma onkotik basınç değişimlerinden kaçınılmalı**
- **İnotrop ve vazodilatatörlerin uygun kullanımı**
- **SIRS'ı modifiye edecek ajanların kullanımı**

Table 2—Intraoperative and Postoperative Characteristics and Outcome According to Hyperlactatemia*

Characteristics	NHL (n = 202)	IHL (n = 67)	LHL (n = 56)	P Value
Intraoperative				
CPB duration, min	86 ± 26	127 ± 53†‡	93 ± 33†	< 0.0001
Aortic cross-clamp duration, min	63 ± 22	81 ± 35†‡	67 ± 25†	0.0007
CPB mean flow, L/min	4.6 ± 0.5	4.6 ± 0.6	4.6 ± 0.6	NS
MAP per CPB < 50 mm Hg	26 (12.9)	16 (23.9)†	14 (25.0)†	0.02
Vasopressor	72 (35.6)	51 (76.1)†‡	32 (57.1)†‡	< 0.0001
Postoperative				
MAP < 70 mm Hg	23 (11.7)	24 (38.1)†	13 (24.1)†	< 0.0001
No vasopressor	175 (86.6)	23 (34.3)†	32 (57.1)†	< 0.0001
Epinephrine	11 (5.4)	37 (55.2)†	18 (32.1)†	< 0.0001
Norepinephrine	2 (1.0)	8 (11.9)†	2 (3.6)†	0.0003
Dobutamine	15 (7.4)	16 (23.9)†	9 (16.1)†	0.0012
Dopamine	8 (4.0)	2 (3.0)	4 (7.1)	NS
Hyperglycemia	52 (26.3)	34 (53.9)†	35 (64.8)†	NS
No fluid resuscitation	40 (20.3)	10 (15.9)	7 (12.9)	NS
ALT level at hospital admission, IU/L	40.5 ± 30.4	53.5 ± 55.8	39.4 ± 23.1	NS
ALT level at day 1, IU/L	45.8 ± 69.2	99 ± 283.8	44.7 ± 40.4	NS
Outcome				
MV, h	6.4 ± 12.3	37.3 ± 61.0†	21.8 ± 35.1†	< 0.0001
ICU length of stay, d	1.9 ± 1.8	3.8 ± 4.1†	2.8 ± 2.0†	< 0.0001
Postoperative hospital stay, d	6.8 ± 5.5	7.9 ± 6.3†	8.6 ± 6.5†	0.043
Major complication	38 (19.2)	27 (50.9)†	18 (35.3)†	< 0.0001

*Data are presented as mean ± SD or No. (%). See Table 1 for expansion of abbreviation.

†p < 0.05 vs NLH group.

‡p < 0.05 between IHL and LHL groups.

Erken HL

- **Nonelektif Cerrahi**
- **KPB süresi**
- **İntraoperatif vazopressör kullanma**
- **Mortalite %14,9**

Geç HL

- **Postop epinefrin kullanımı**
- **Postop hiperglisemi**
- **Mortalite %3,6**

High lactate levels are predictors of major complications after cardiac surgery

Ludhmila A. Hajjar, MD, PhD,^a Juliano P. Almeida, MD,^a Julia T. Fukushima, MsC,^a Andrew Rhodes, MD, PhD,^b Jean-Louis Vincent, MD, PhD,^c Eduardo A. Osawa, MD,^a and Filomena R. B. G. Galas, MD, PhD^a

O-ICU admission

Lactate	AUC (95%CI)	Cut-off value	PPV	PNV
Final	0.57 (0.49 – 0.65)	3.4 mmol/L	0.13	0.92
0	0.58 (0.49 - 0.67)	4 mmol/L	0.11	0.91
6 h	0.72 (0.64 - 0.79)	3 mmol/L	0.19	0.95
12 h	0.75 (0.66 - 0.83)	2 mmol/L	0.23	0.95

Relative hyperlactatemia and hospital mortality in critically ill patients: a retrospective multi-centre study

Alistair D Nichol^{*1,3}, Moritoki Egi², Ville Pettilä¹, Rinaldo Bellomo^{1,4}, Craig French⁵, Graeme Hart⁴, Andrew Davies³, Edward Stachowski⁶, Michael C Reade⁴, Michael Bailey^{1,3} and David James Cooper^{1,3}

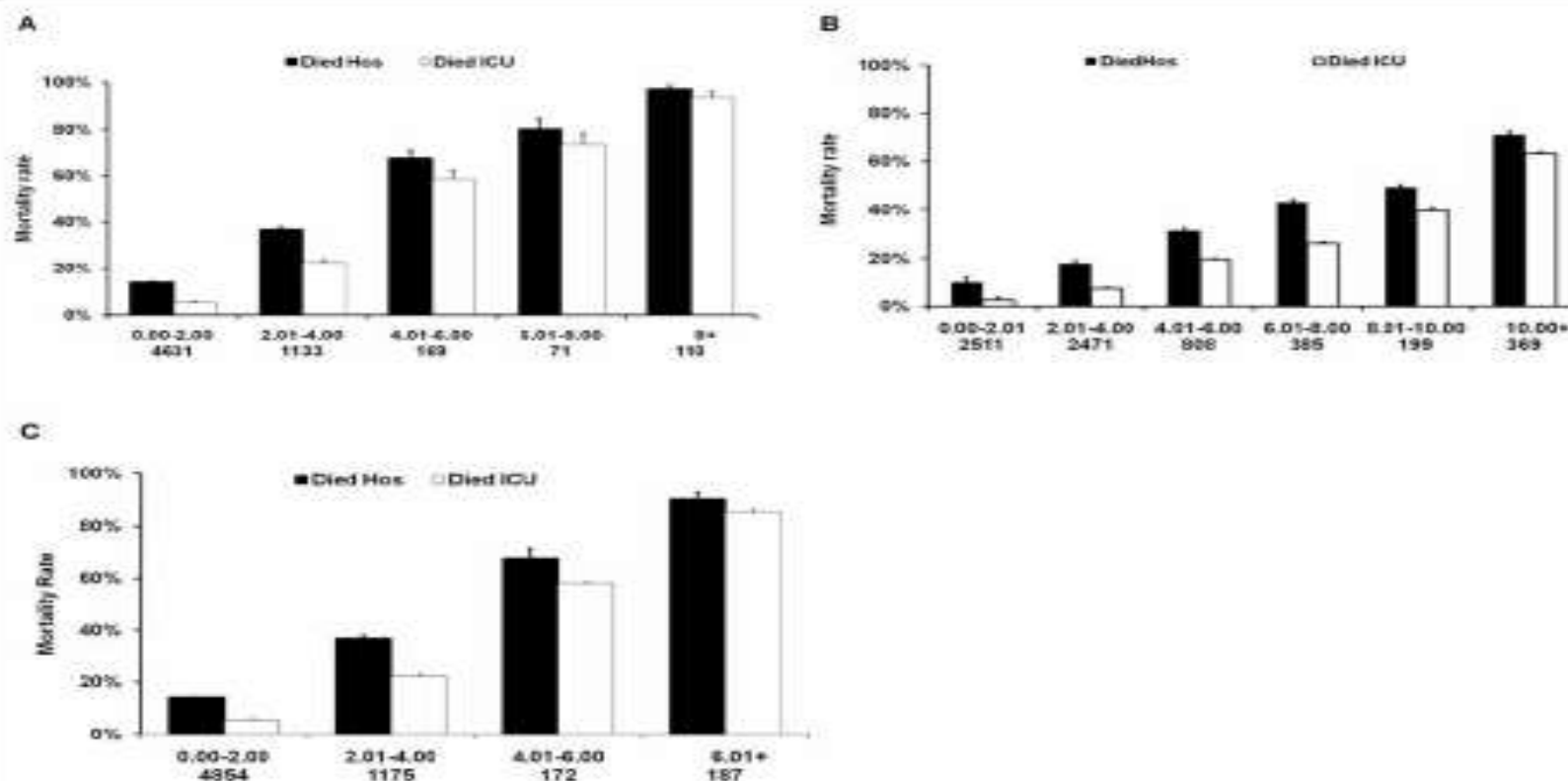


Figure 1 Relationship among the admission, maximal and time weighted blood lactate concentration and mortality. Relationship among the admission blood lactate concentration (Lac_{ADM}) Panel (a); maximal blood lactate concentration (Lac_{MAX}) Panel (b); and time weighted blood lactate concentration (Lac_{TW}) Panel (c); and hospital and ICU mortality. The number of patients in each group is expressed as (n).

Central venous oxygen saturation and blood lactate levels during cardiopulmonary bypass are associated with outcome after pediatric cardiac surgery

Marco Ranucci^{1*}, Giuseppe Isgro¹, Concetta Carlucci¹, Teresa De La Torre¹, Stefania Enginoli¹, Alessandro Frigiola², Surgical and Clinical Outcome REsearch (SCORE) Group¹

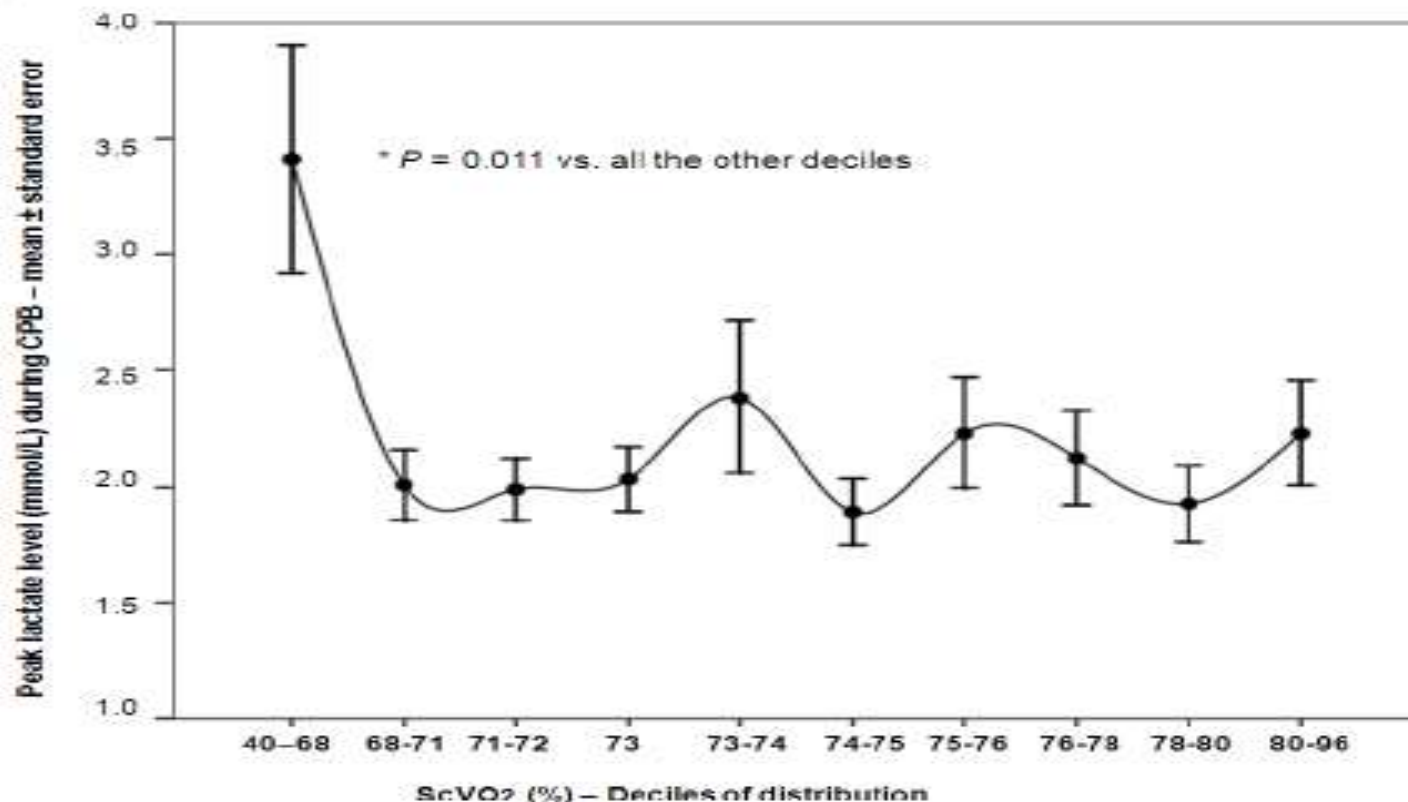
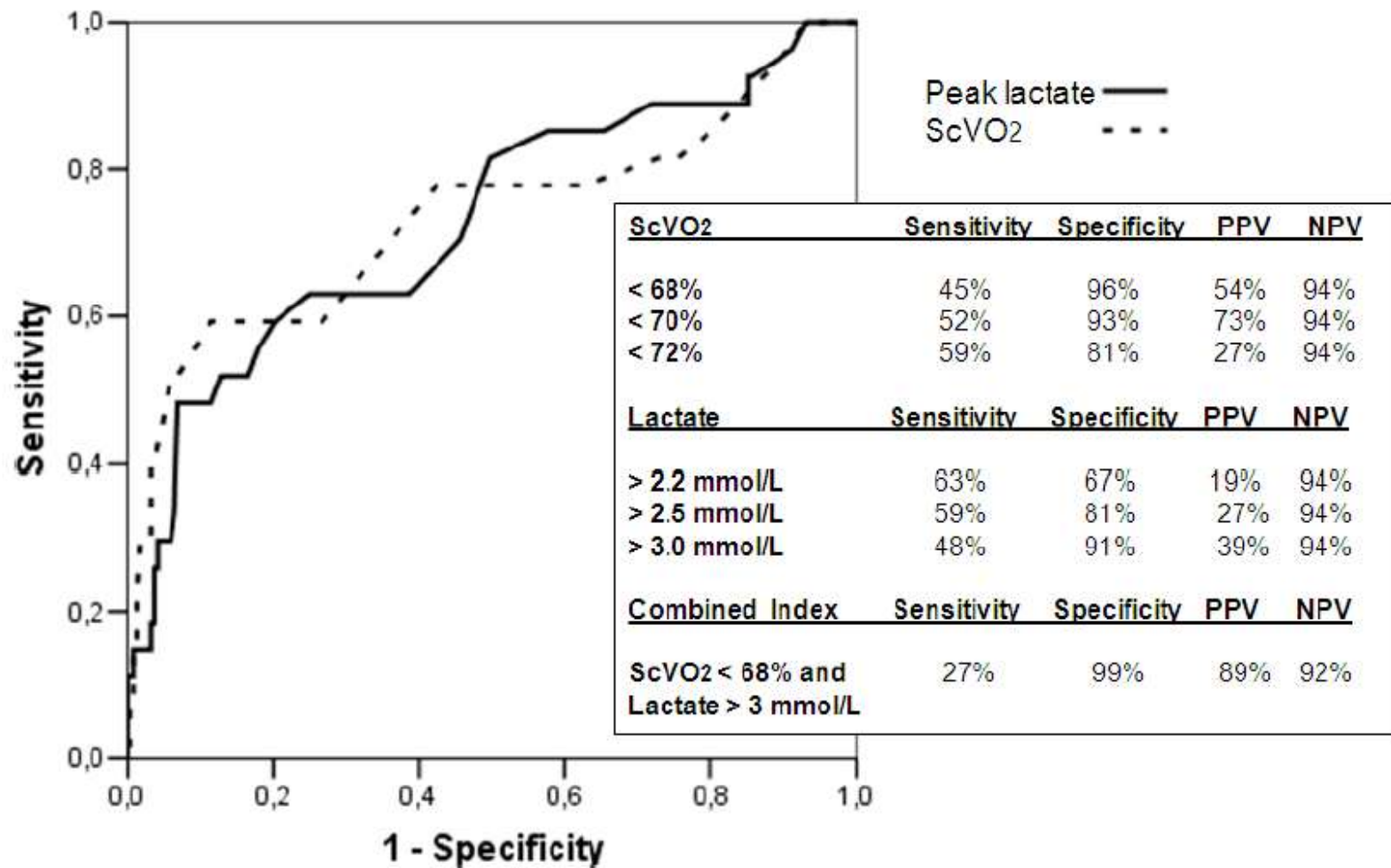


Figure 1 Peak whole blood lactate according to the nadir ScVO₂ value. Significance assessed with the Kruskal-Wallis test.

Major morbidity



Multisite Near-Infrared Spectroscopy Predicts Elevated Blood Lactate Level in Children After Cardiac Surgery

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Table 3. Correlation Coefficients of Ln (Regional Oxyhemoglobin Saturation) with Respect to Lactate at Each Postoperative Time Point

Time Point	Cerebral rSO ₂ (r)	Splanchnic rSO ₂ (r)	Muscle rSO ₂ (r)	Renal rSO ₂ (r)	Average Cerebral and Renal rSO ₂ (r)
0	-0.67†	-0.48*	-0.51*	-0.48*	-0.77‡
2	-0.62†	-0.42*	-0.41	-0.52*	-0.68†
4	-0.78‡	-0.62†	-0.48*	-0.69†	-0.86‡
6	-0.68†	-0.70†	-0.46*	-0.63†	-0.89‡
8	-0.81‡	-0.59*	-0.32	-0.58*	-0.90‡
10	-0.78†	-0.58*	-0.81†	-0.77†	-0.94‡
12	-0.82†	-0.56	-0.42	-0.48	-0.94†
14	-0.92†	-0.86*	0.01	0.07	-0.93†
24	-0.62†	-0.31	-0.68†	-0.65†	-0.71†

NOTE. Bold indicates significant values.

* $p < 0.05$.

† $p < 0.01$.

‡ $p < 0.0001$.

Özetle

- **Hiperlaktatemi açık kalp cerrahisi sonrası mortalite ve morbidite göstergesi**
- **Cerrahinin başından itibaren riskli hastalarda sunu/tüketim dengesine önem verilmeli**
- **Pompa esnasında O2 sunumu pompa flow, ısı ve Hb ile optimize edilir**
- **Özellikle sebat eden laktat yüksekliklerinde alert olunmalı ve oksijen sunumunu arttırmaya yönelik manevralar yapılmalıdır**
- **Laktat ile birlikte NIRS veya ScVO2 takibi komplikasyon oranlarını azaltır.**

Teşekkürler