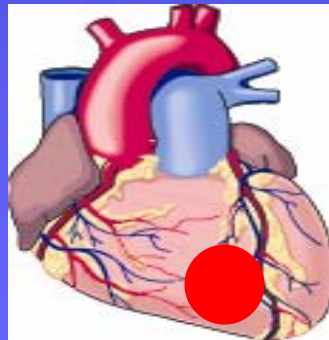
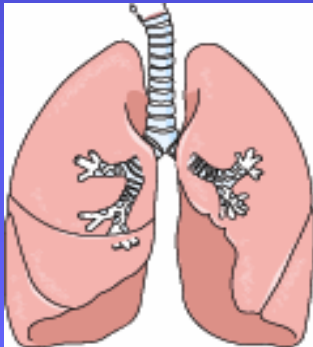
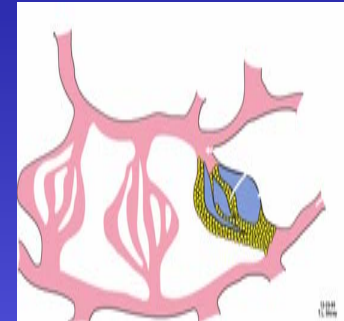
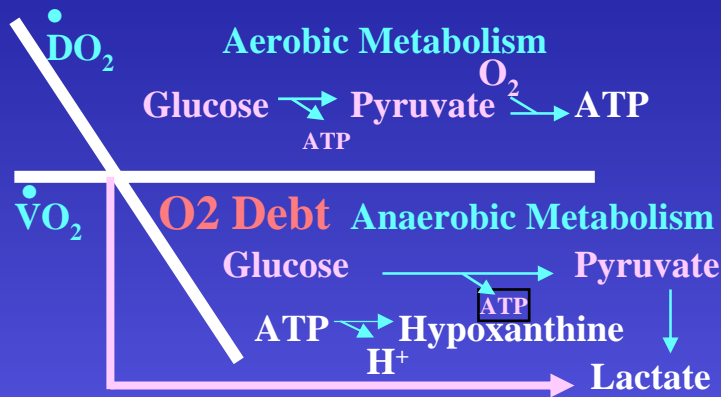


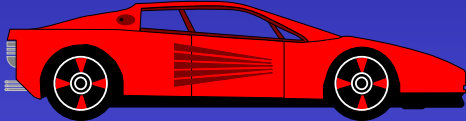
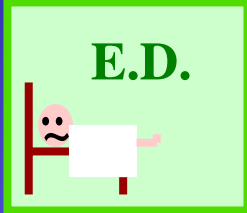

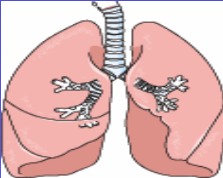
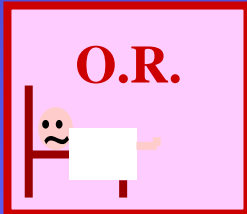
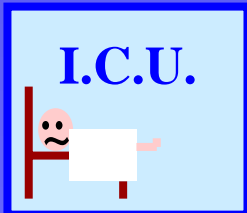
# POC Lactate: The Marker for Perfusion Deficit, Therapy, and Prognosis in the Critically Ill



**Urgent question: “Are the patient’s tissues getting enough oxygen?”**

**Terry Shirey, Ph.D.**  
Director, Medical Affairs  
[tshirey@novabiomed.com](mailto:tshirey@novabiomed.com)

# Rapid Testing for Lactate Can Affect Outcomes

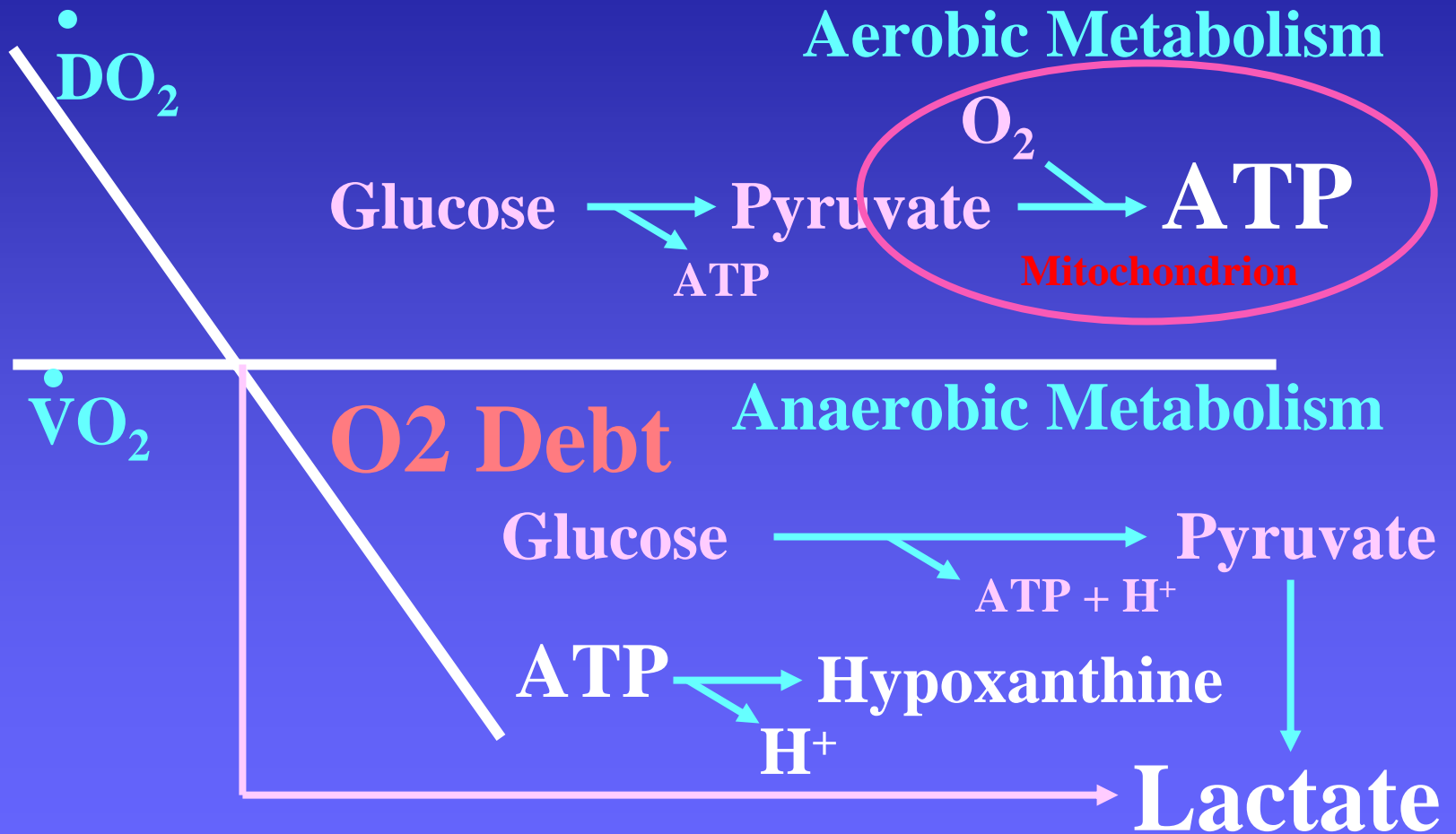
<u>Patient Hx</u>	<u>Site of Testing</u>	<u>Lactate (mM)</u>	<u>Outcome</u>
 Blunt trauma	 E.D.	12	 RIP
 Lung transplant	 O.R.	3 ↑	Reopen Chest
Circulatory Shock	 I.C.U.	< 10% Change @ 1 hr	Change Rx

# Outline

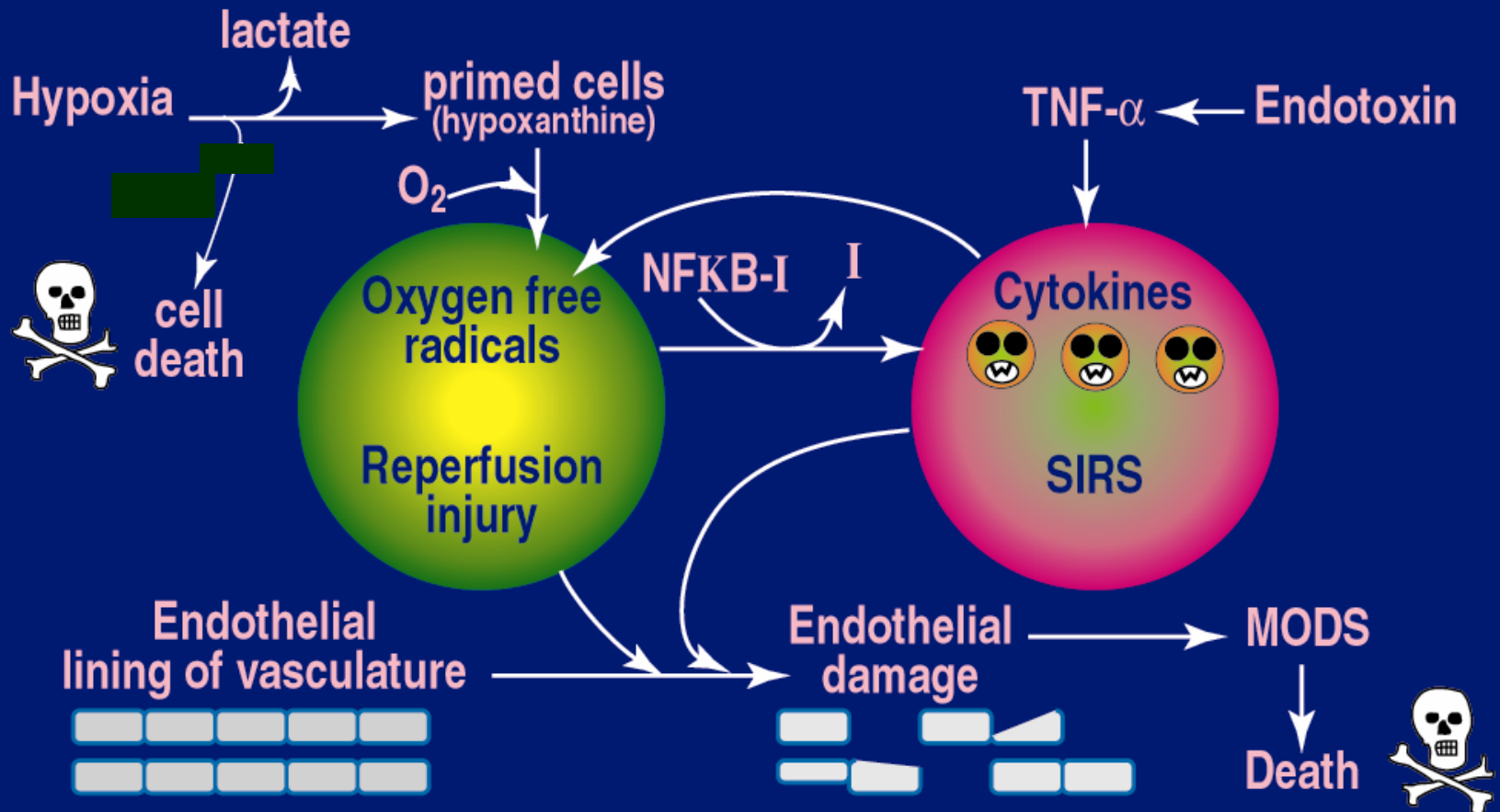
---

- **Causes of elevated lactate**
  - Hypoxia
  - Other
- **Interpreting lactate values**
- **Clinical settings requiring lactate testing**

# Hypoxia Causes Elevated Lactate



# Lactate, Reperfusion Injury and SIRS



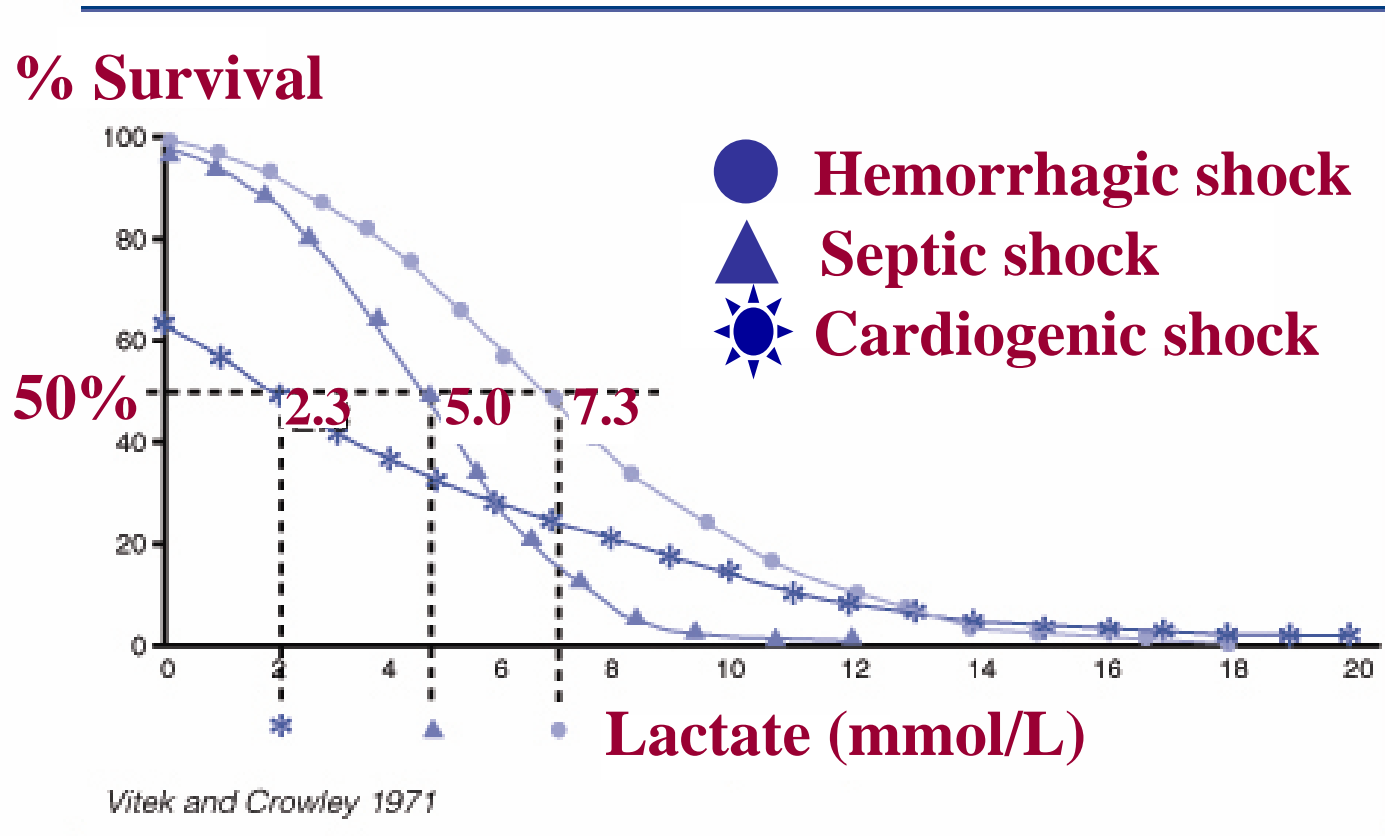
# Which Subject Has the Poorer Prognosis?

	Lactate (mmol/L)	pH
Subject 1	32.1	6.8
Subject 2	8.2	7.3

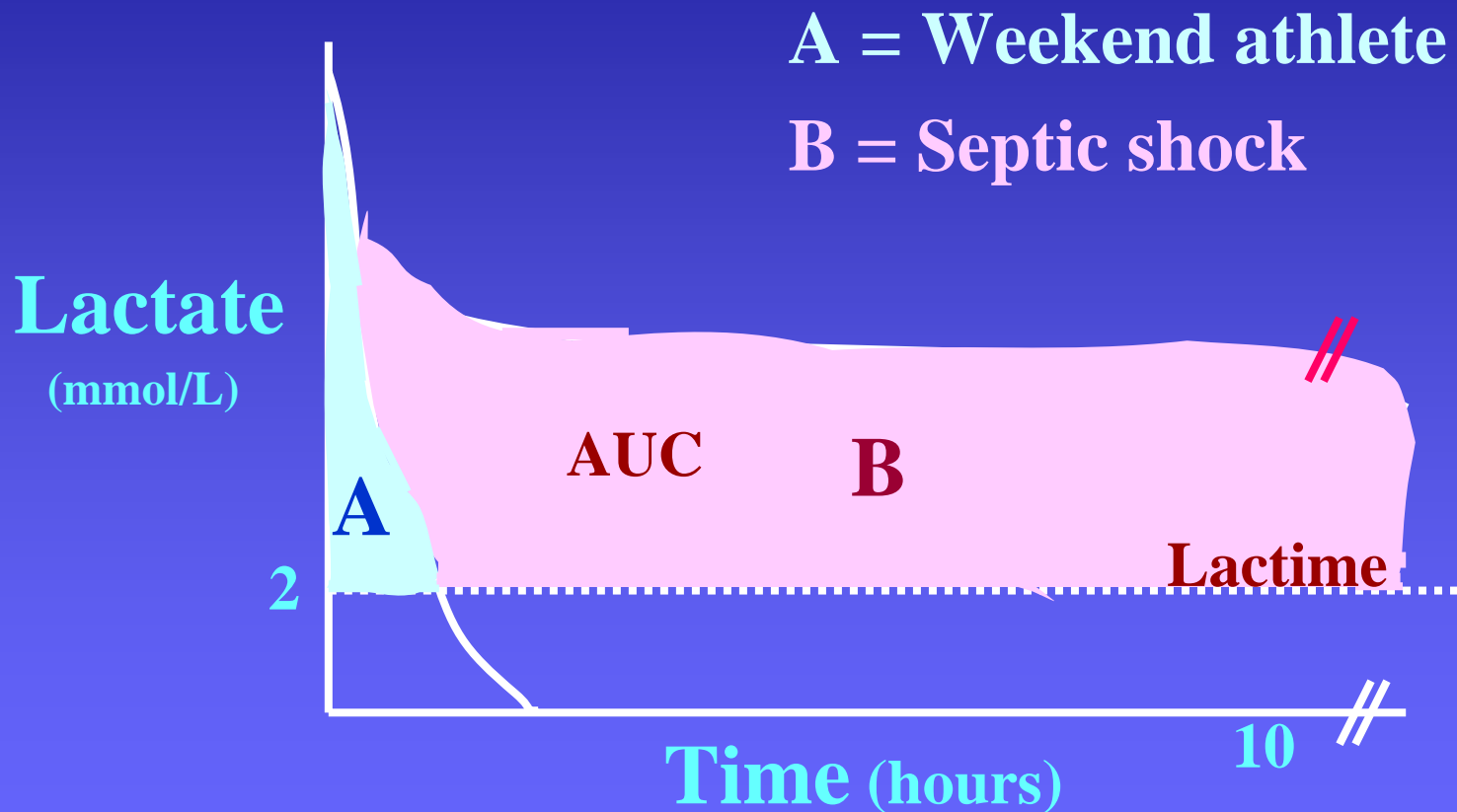
# Clinical setting helps interpretation of lactate (1)

	Lactate (mmol/L)	pH	Clinical Setting
Subject 1	32.1	6.8	Weekend athlete
Subject 2	8.2	7.3	Septic shock

# Clinical Setting Helps Interpretation of Lactate (2)



# Progression of Lactate Values Helps Interpretation of Lactate



*Bakker 1996*

# Serial Lactates for Better Prognosis

RIP  
CNS

RIP  
Liver

RIP  
Kidney

RIP  
Lungs

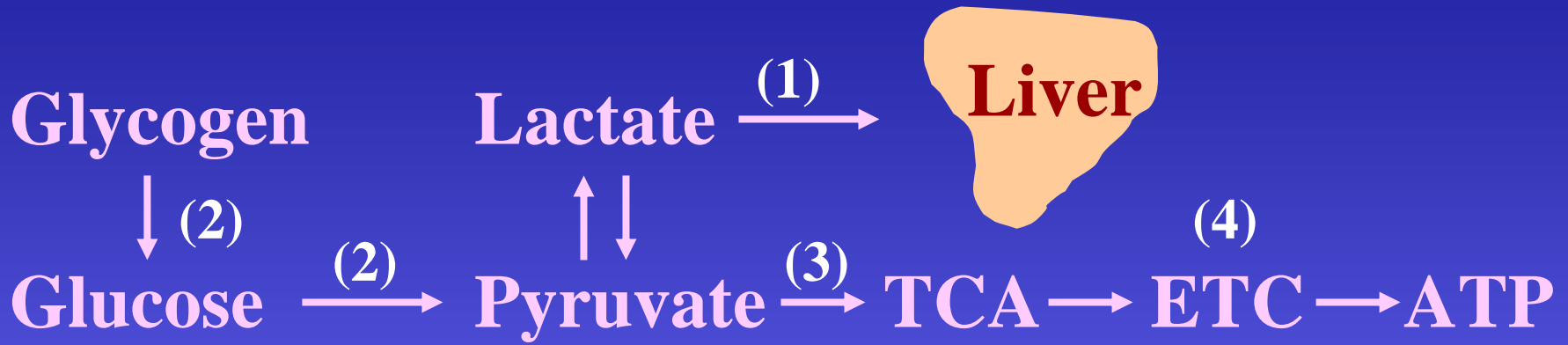
RIP  
Heart

## Multiple Organ Dysfunction Syndrome

Failed Organs	Initial Lactate (mmol/L)	Lactime (hours)	AUC
1-2	3.4	~18	~25
3-4	4.8	~27	~100
5-6	5.3	~57	~160
7-8	7.0	~58	~215

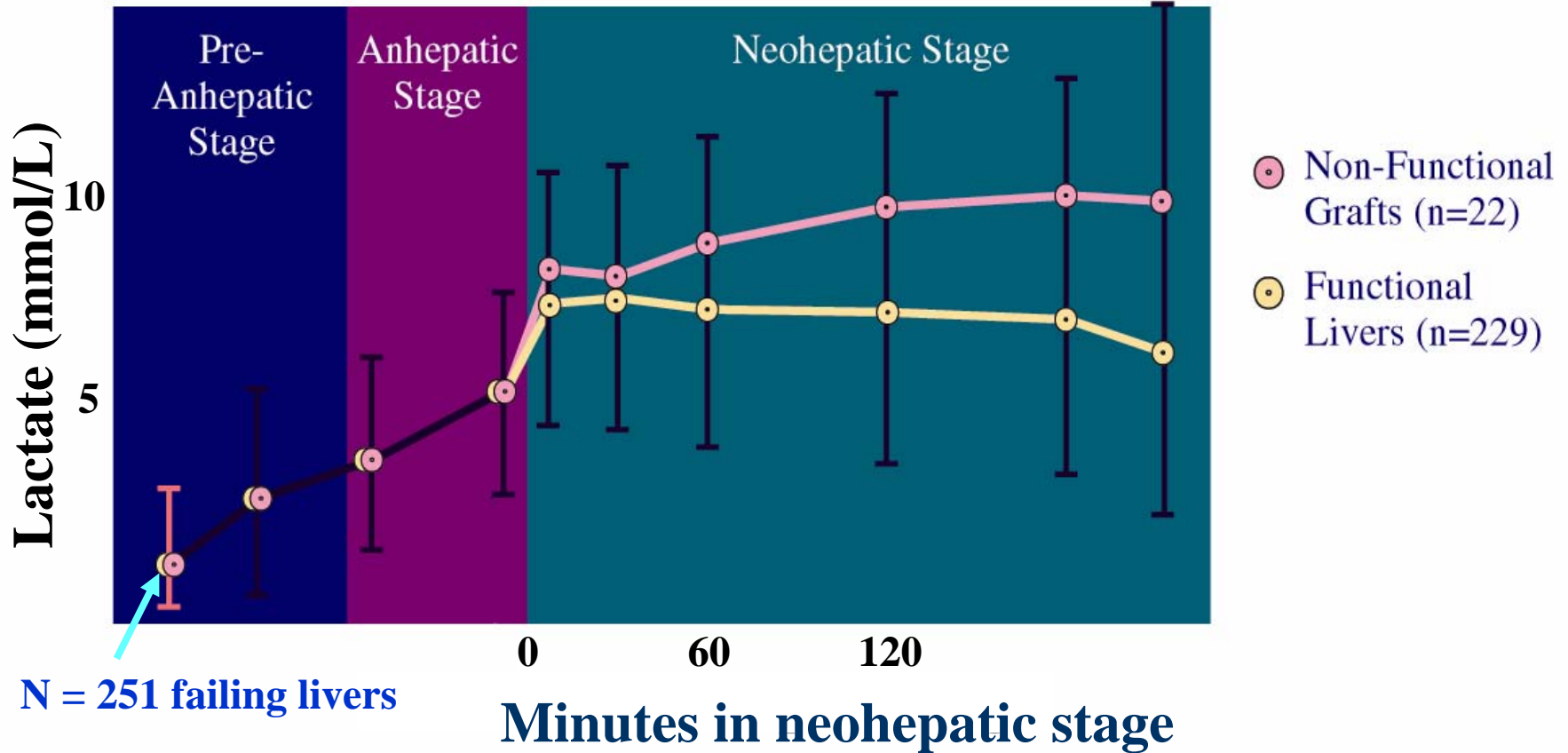
*Bakker 1996*

# Contributors to high lactate values other than hypoxia



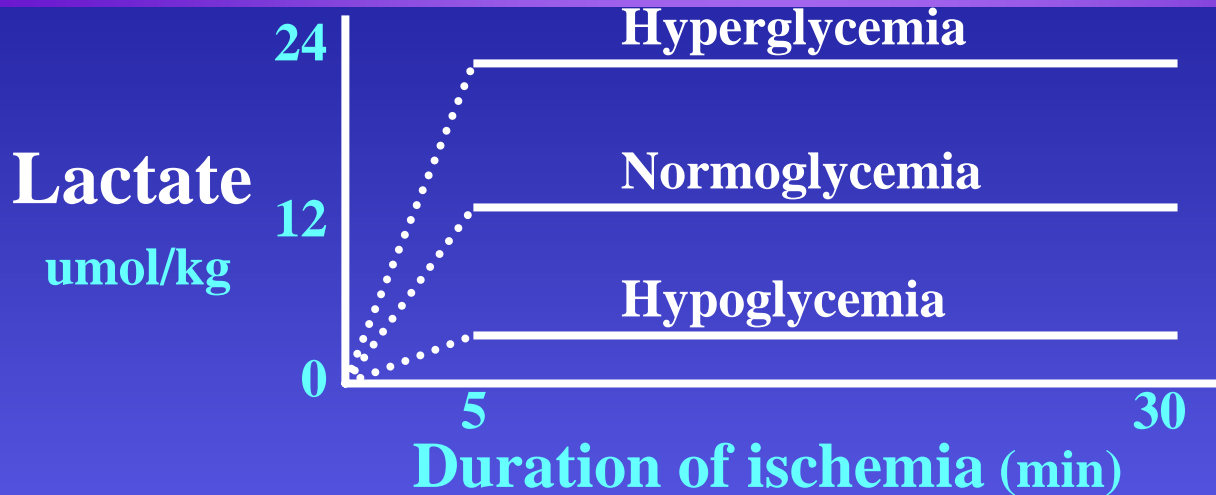
- Inadequate liver metabolism of lactate (1)
- Increased glycolysis (stress) (2)
- Inhibition of pyruvate dehydrogenase (3)
- Electron transport chain poisons (4)
- Washout (reperfusion)

# Liver Transplant: Lactate



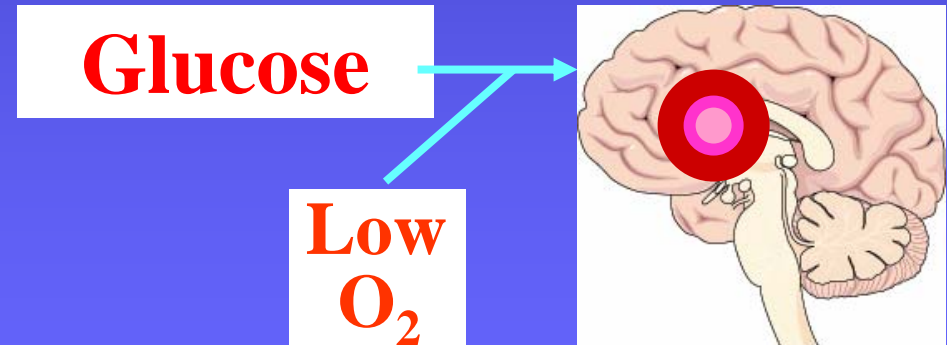
*Begliomini 1989*

# Lactate Increases with Glucose During Complete Ischemia

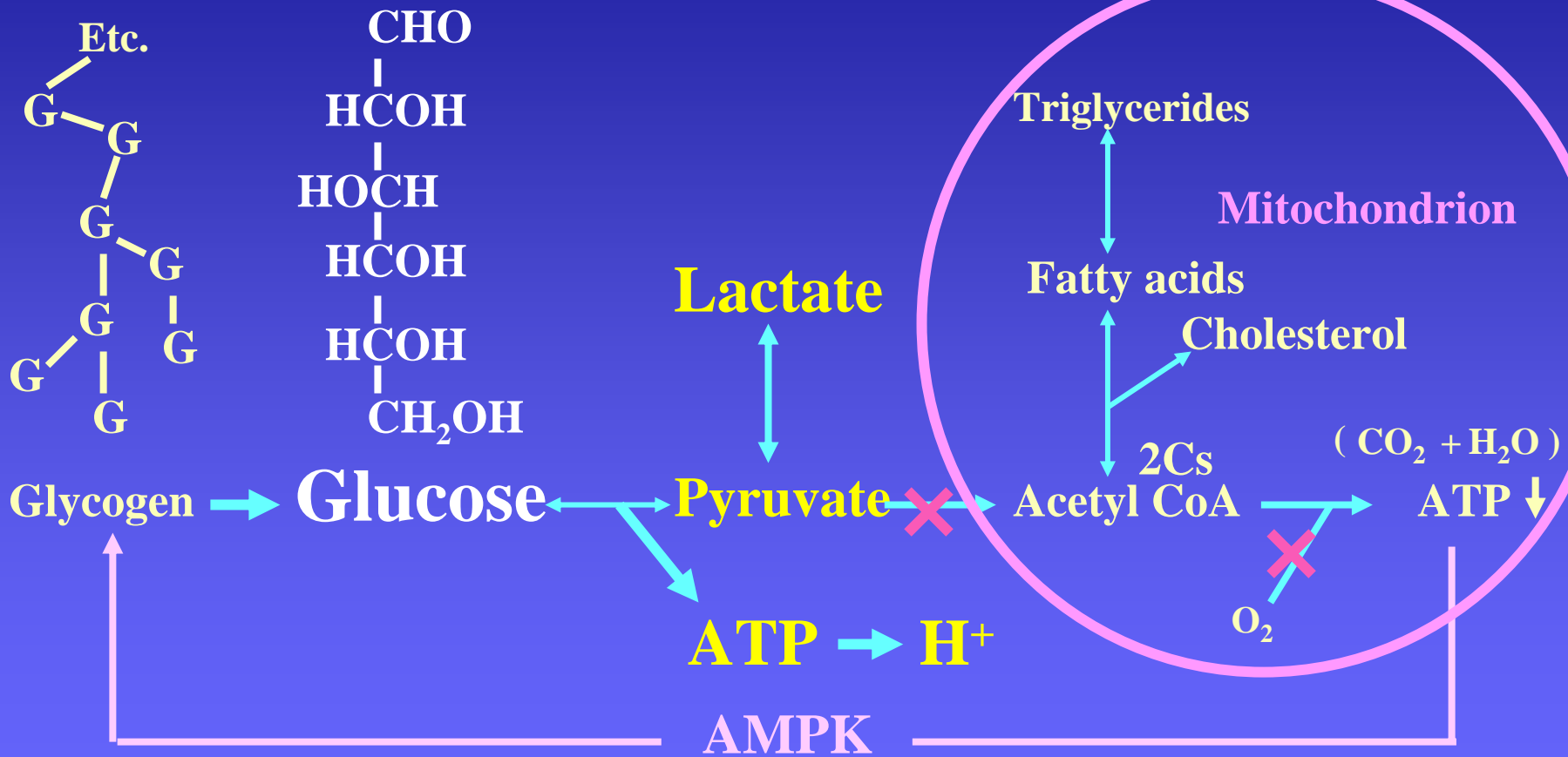


*Siesjo 1981*

High glucose (from stress or infusions) amplifies tissue damage during hypoxia (larger infarcts)



# Hypoxia as a Cause of Acute Hyperglycemia



Robergs 2004

TLShirey 4-27-06

# Lactate has value in the Emergency Department for:

**Trauma**

**Burns/Smoke**

**Heart Failure**

**Cardiac Arrest**

**Chest Pain**

**DKA**

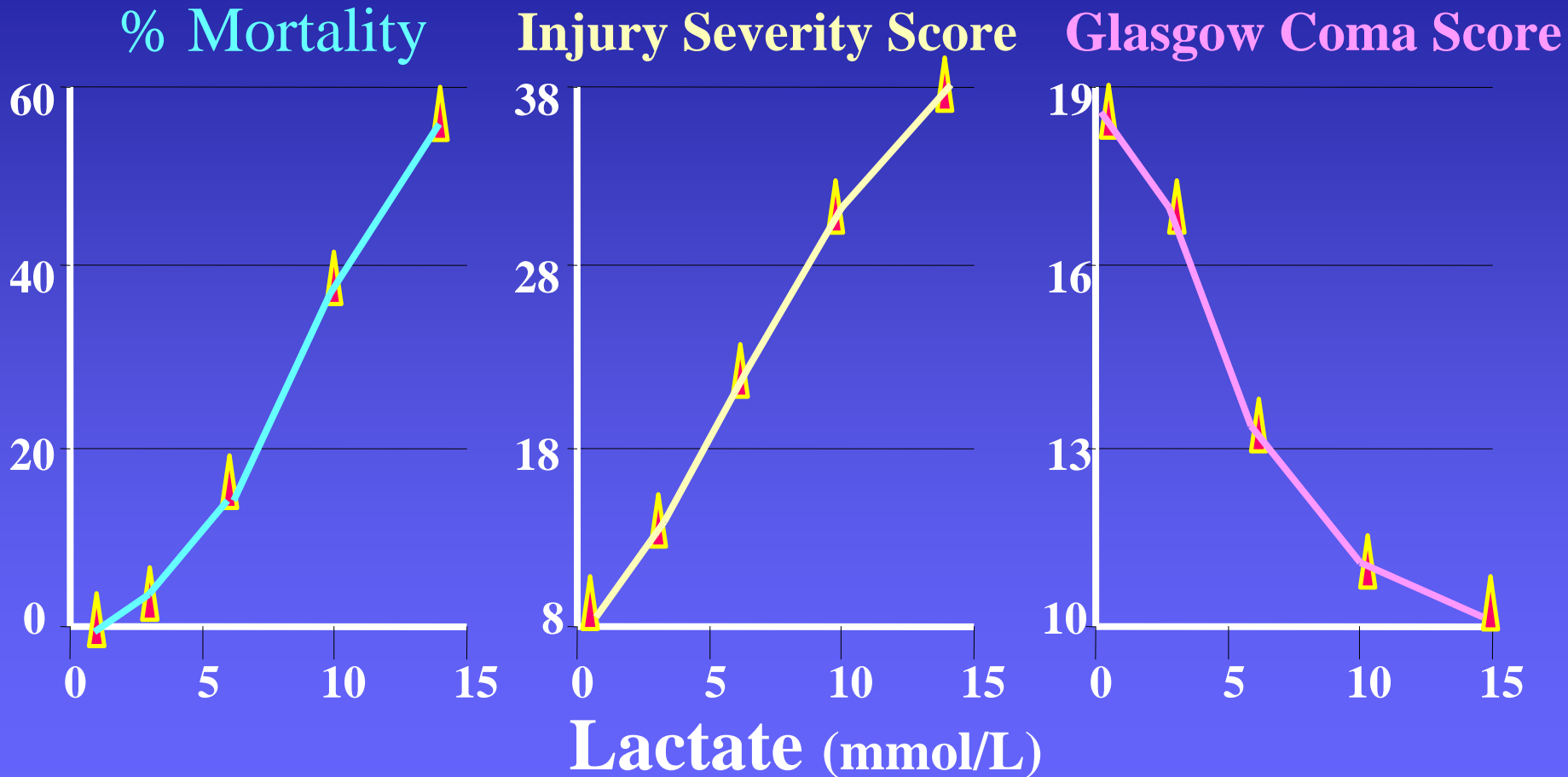
**Sepsis**

**Shock**

**Acute Abdomen**

**Occult Disease**

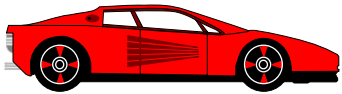
# Trauma Prognosis: Lactate



*Milzman 1992*

# Trauma Case History: Lactate

*Bakker*



**Automobile  
accident**

**E.D.**

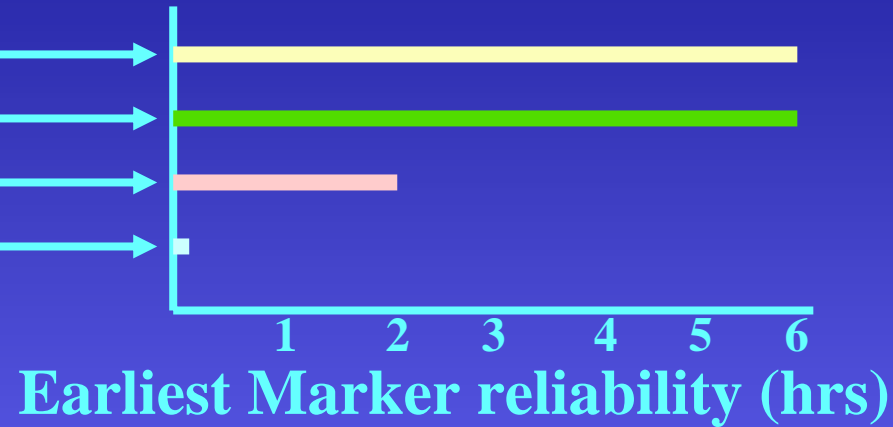
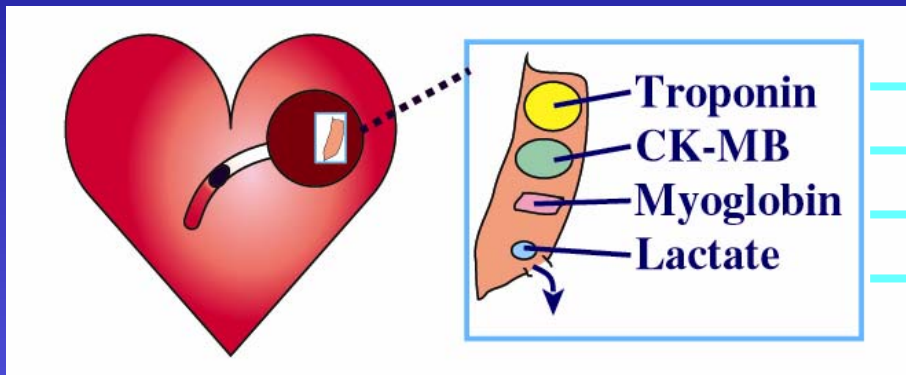
**Young alert male**

**Lactate = 12 mmol/L**

**30 minutes**

**R.I.P.**

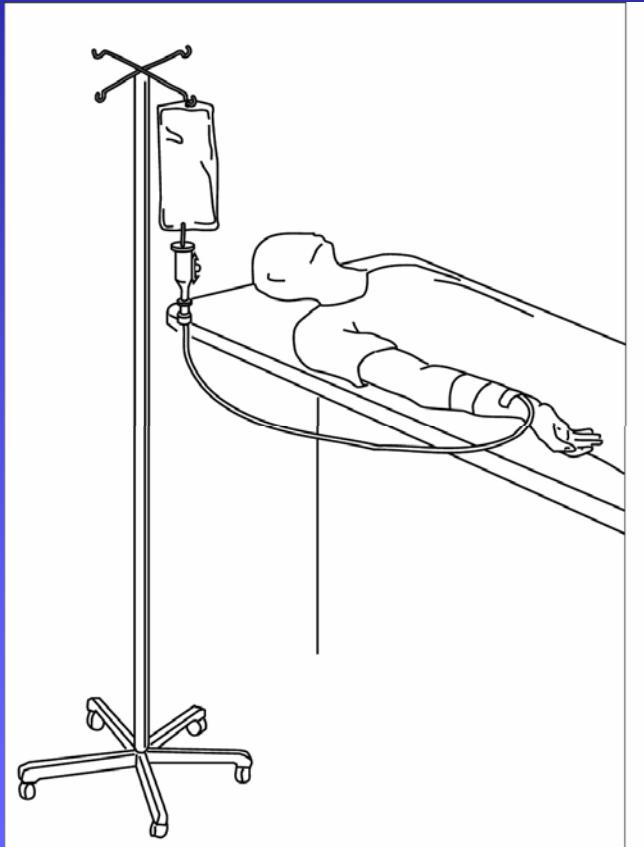
# Chest Pain: Lactate



	Lactate (mmol/L)	% AMI	Action
Rule out AMI	< 1.5	< 4	Early release?
Possible AMI	≥ 1.5	37	Anticlotting Rx?

Schmeichen 1997

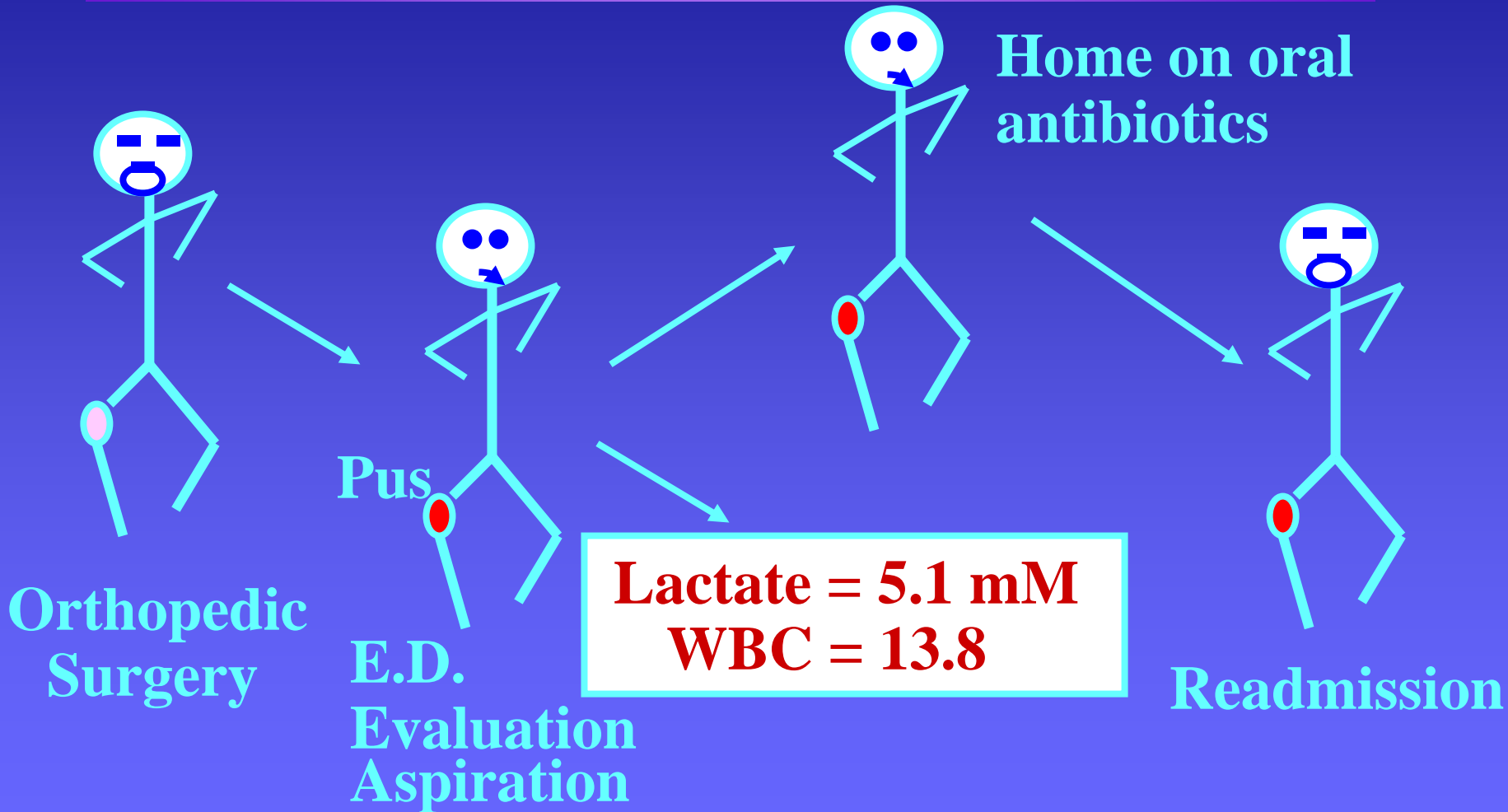
# Burns: Lactate



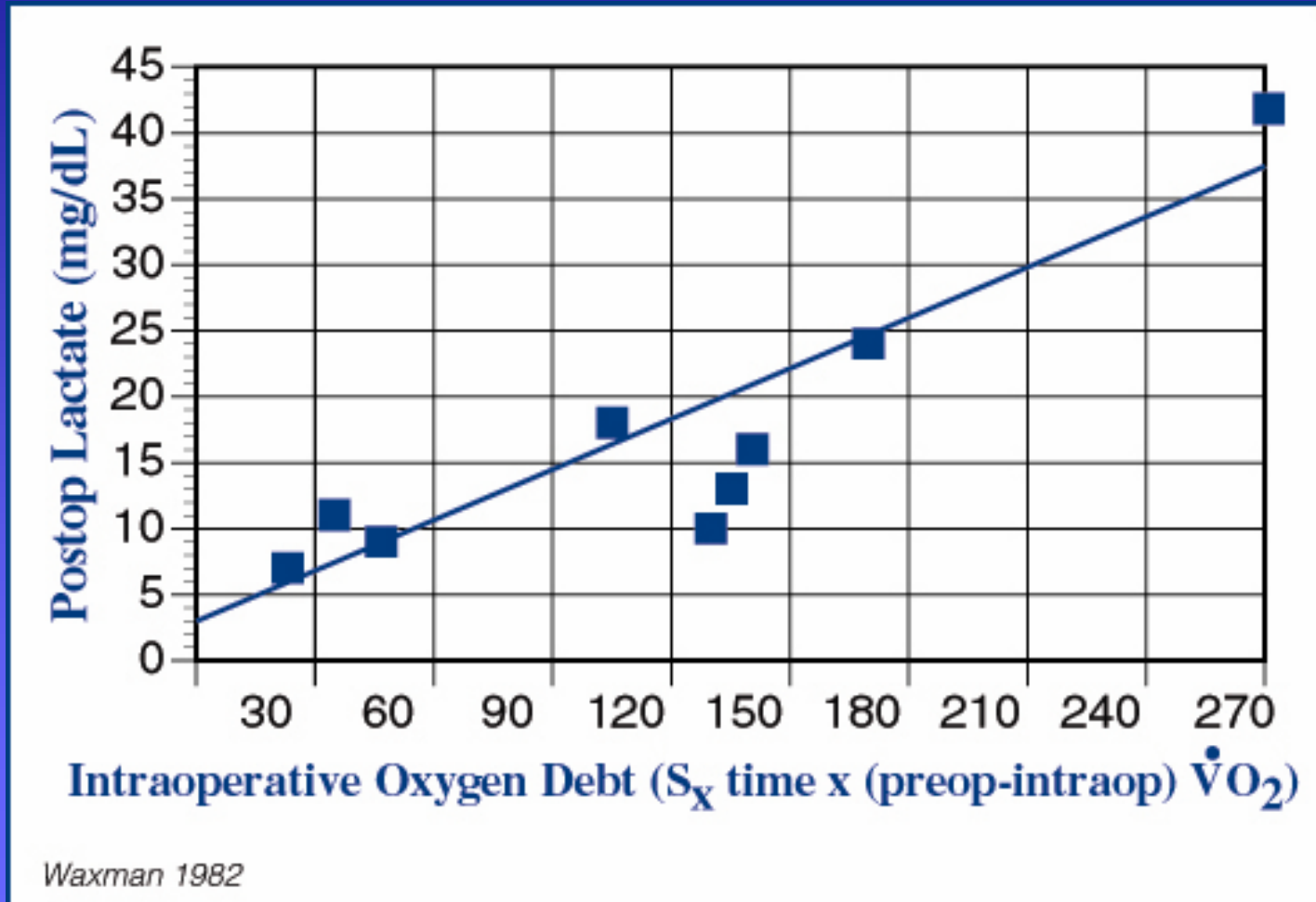
	Lactate (mmol/L)
Survivors (n = 47)	$3.4 \pm 1.5$
Nonsurvivors (n = 10)	$7.8 \pm 3.5$

*Jeng 1997*

# Occult Disease



# Lactate quantifies O<sub>2</sub>-debt in the Operating Theater



# High-Risk Surgeries: Lactate

- Patients 62
  - Vascular surgery 41
  - Abdominal surgery 18
  - Other high-risk surgery 3
- Fatal Outcomes 11

## % Mortality

---

- Lactate > 3 mmol/L 57
- Lactate ≤ 3 mmol/L 13

*Bakker 2001*

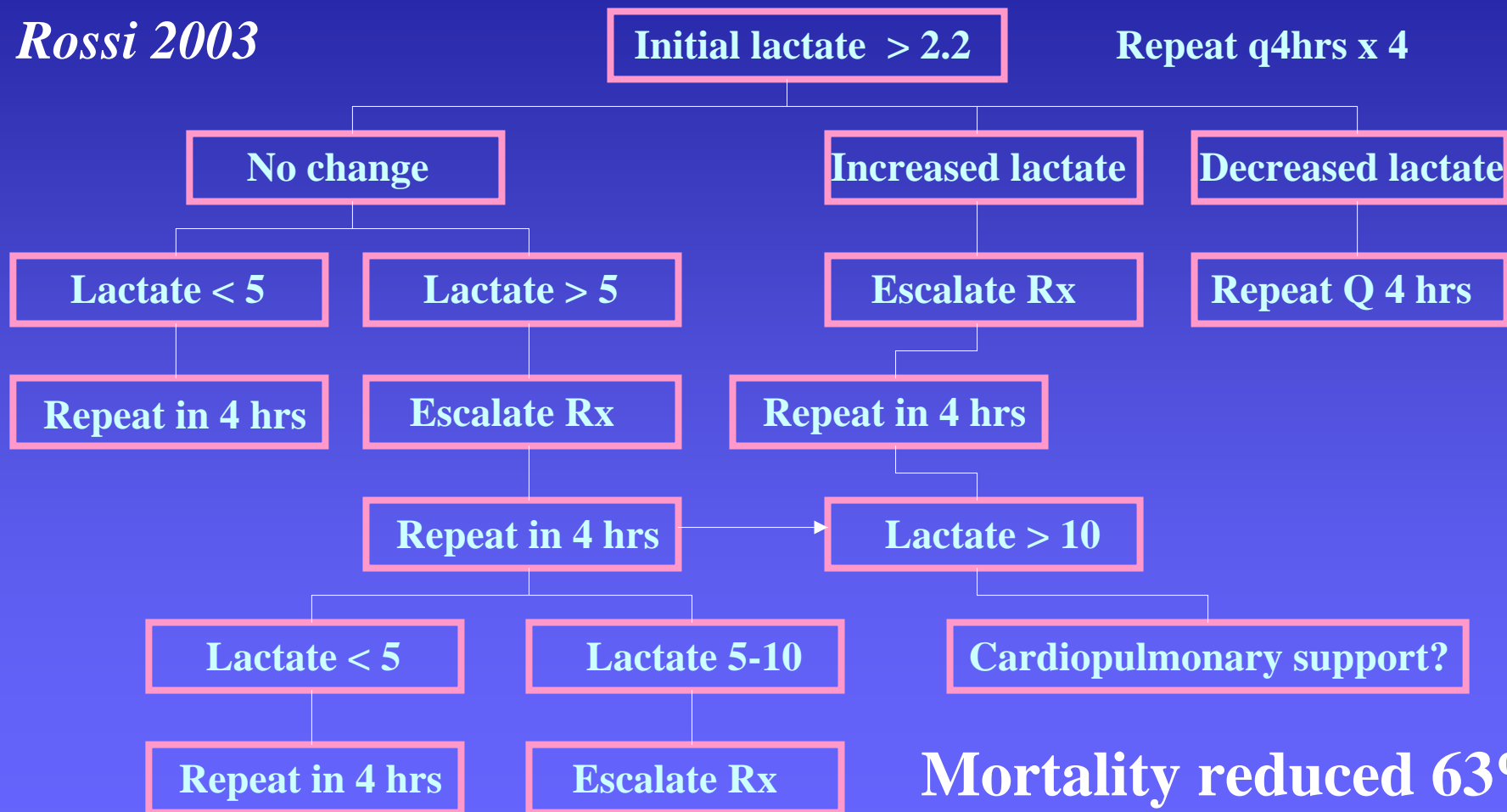
# Post-Surgical Shock: Lactate

## Lactate Levels (mmol/L)

Study	n	Uncomplicated Outcome	Complicated Outcome or Death
Shemie 1996	109	3.2 ± 1.9	8.6 ± 6.1
Siegel 1996	34	2.4 ± 1.5	6.9 ± 3.2

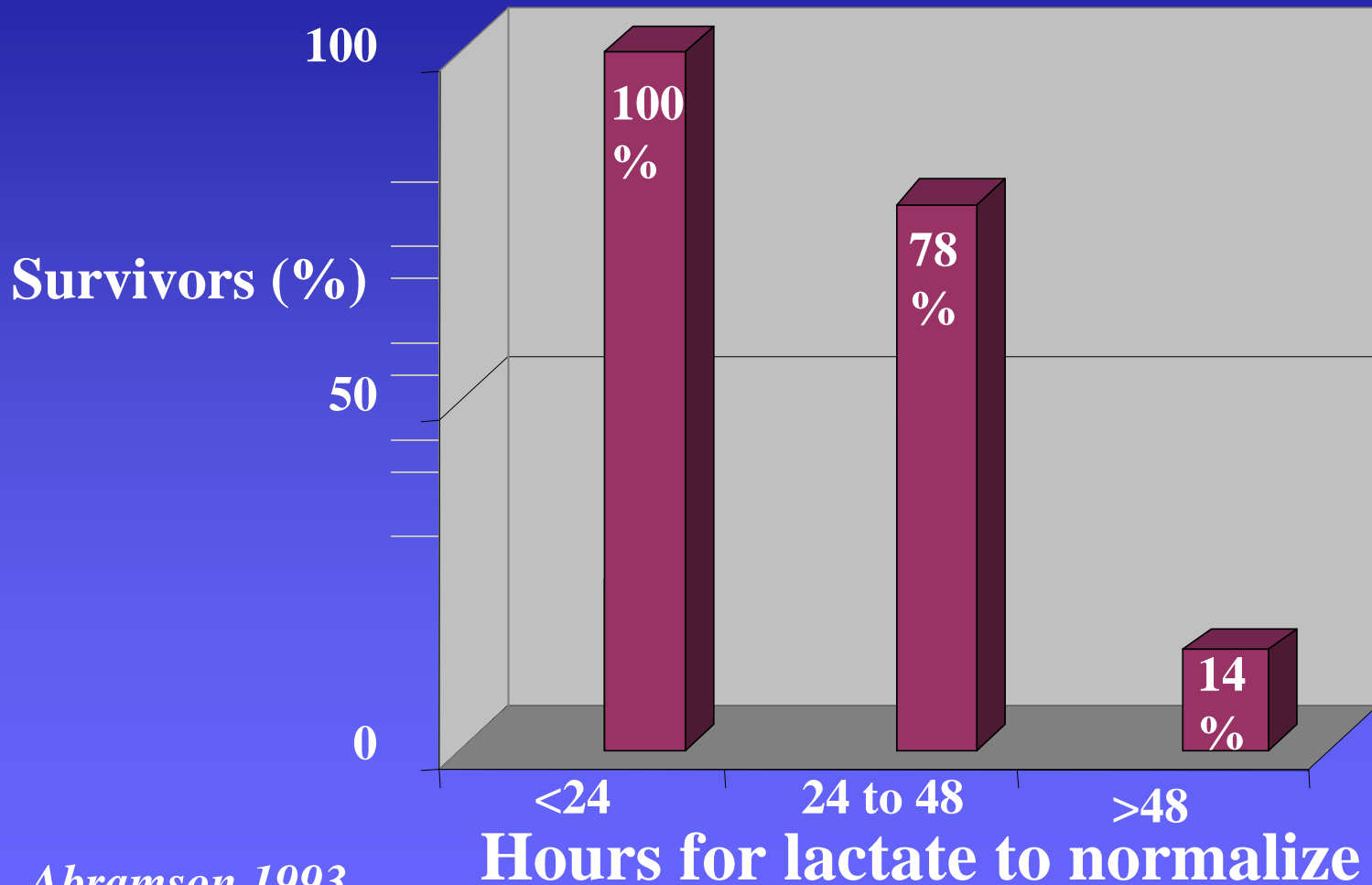
# Therapy for Post-Surgical Shock Directed by Lactate

Rossi 2003



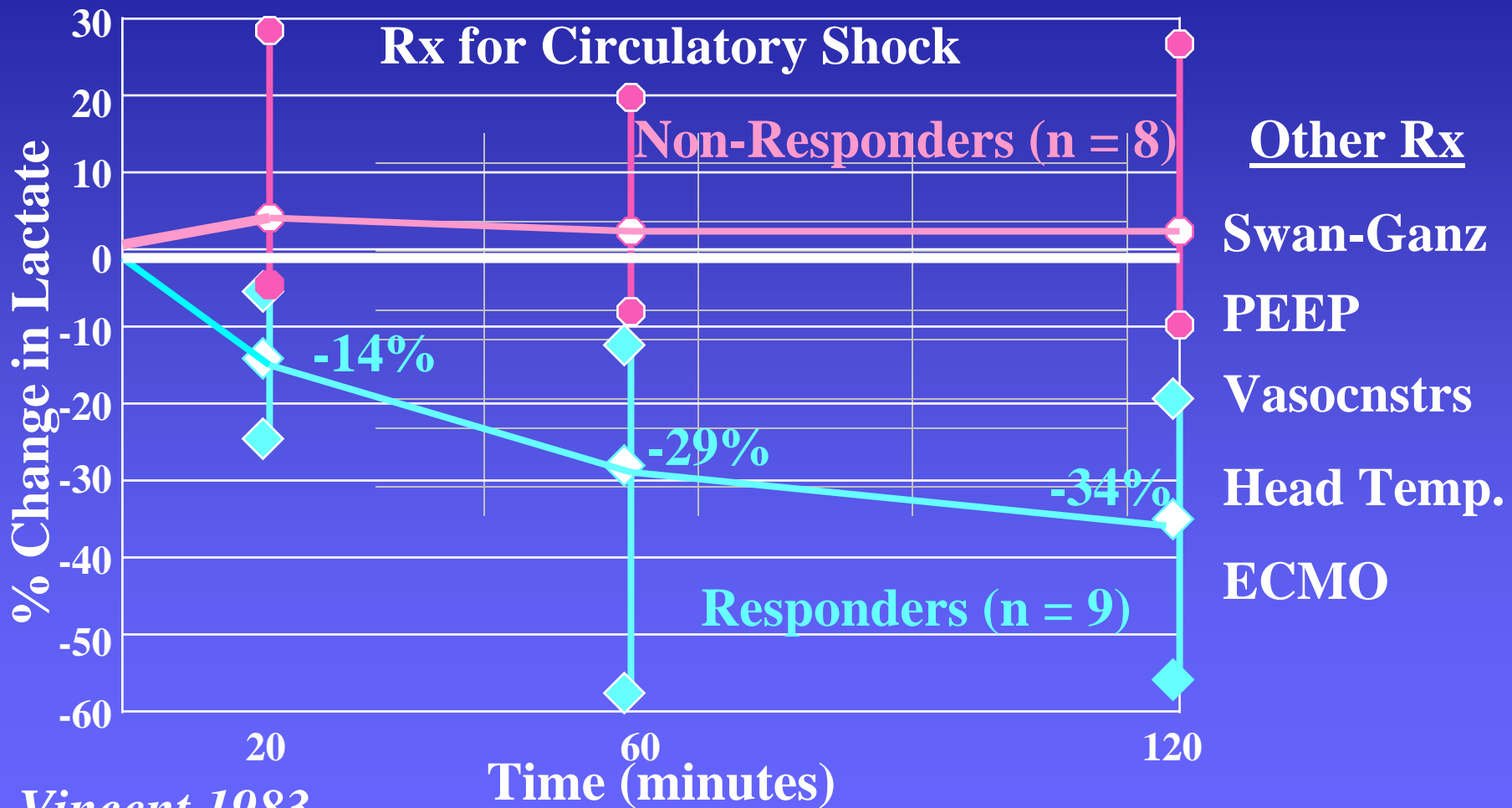
Mortality reduced 63%

# Post-Traumatic Shock: Lactate

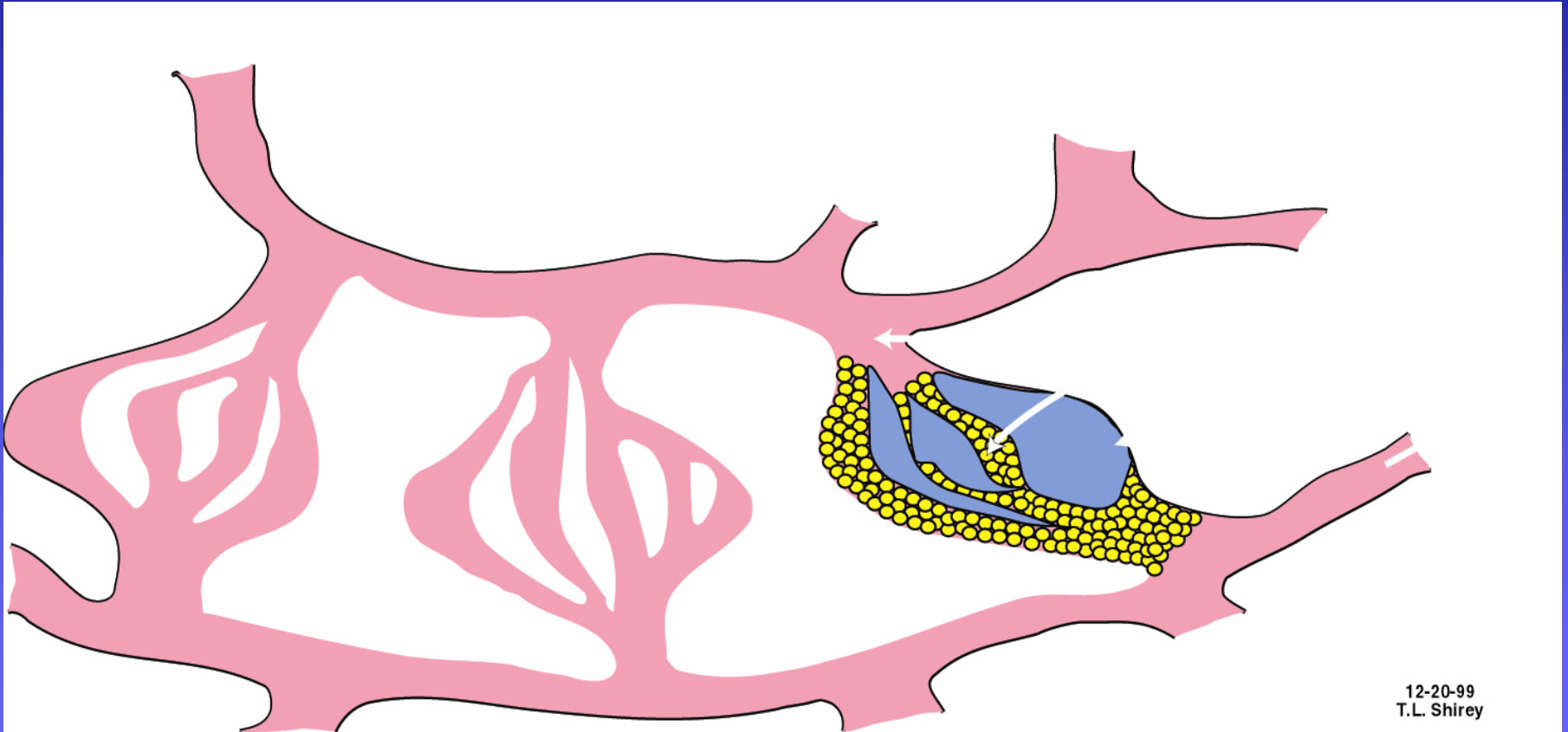


*Abramson 1993*

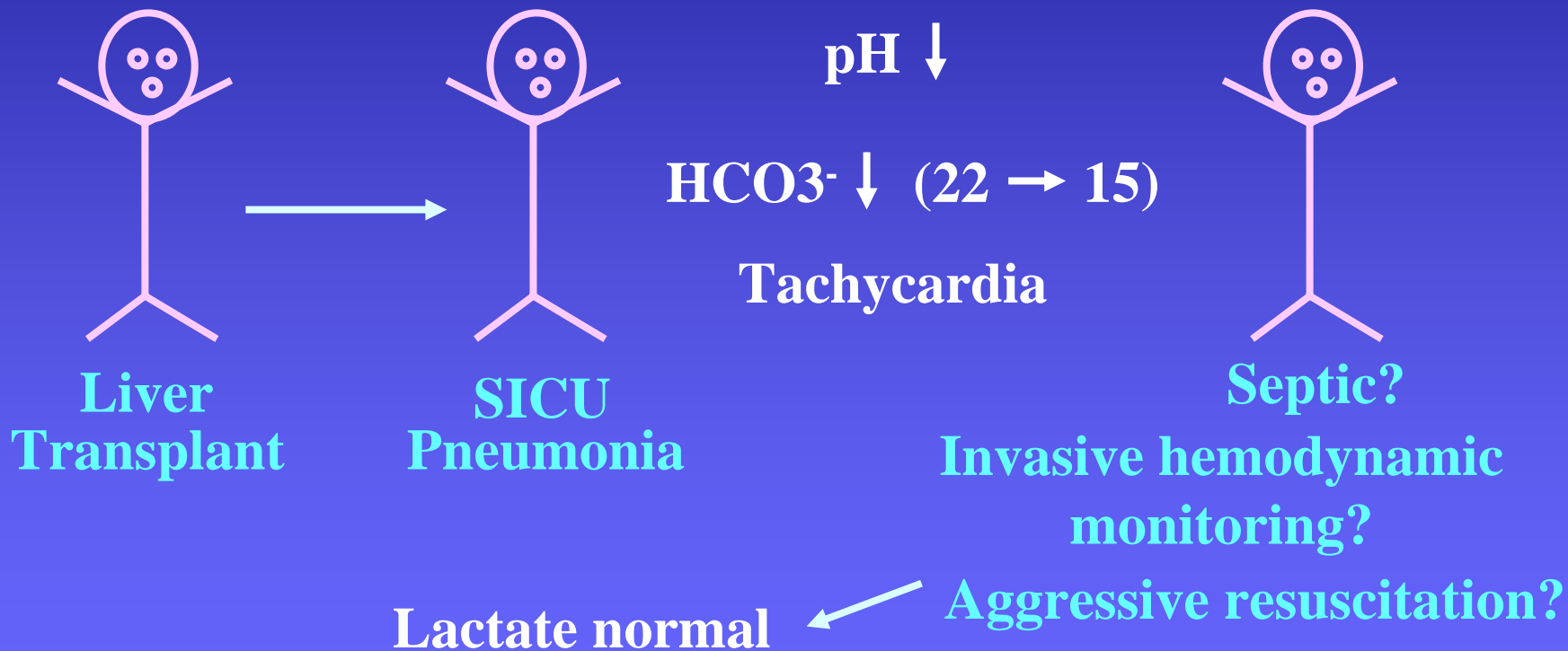
# Lactate to Monitor Therapy



# Model for Septic Shock



# Septic Shock?



Nasraway 1992

# Summary-1

Lactate answers the question:  
“Are tissues getting enough oxygen?”



# Summary-2

## Interpreting lactate requires additional information

- \*Clinical setting
- \*Serial lactate values
  - Monitoring therapy
  - Predicting outcome

# Summary-3: Value of Lactate

---

Early marker for O<sub>2</sub>-debt

Admission/triage decisions

Differential diagnosis

Monitoring therapy

Prognosis

# Summary-4: Where Rapid Lactate Testing Is Needed

E.D.	O.R.	ICU
<p>Chest Pain</p> <p>Heart failure</p> <p>Trauma</p> <p>Head injury</p> <p>Burns/smoke</p> <p>Cardiac arrest</p> <p>DKA</p> <p>Shock</p> <p>Sepsis</p>	<p>High-risk surgery</p> <p>Cardiovascular</p> <p>Neural Sx</p> <p>Transplant Sx</p>	<p>Post Surgery</p> <p>Trauma</p> <p>Cardiovascular distress</p> <p>Burns/smoke</p> <p>Respiratory distress</p> <p>Hemostasis</p> <p>Shock</p> <p>    Hemorrhagic</p> <p>    Cardiogenic</p> <p>Sepsis Syndrome</p>

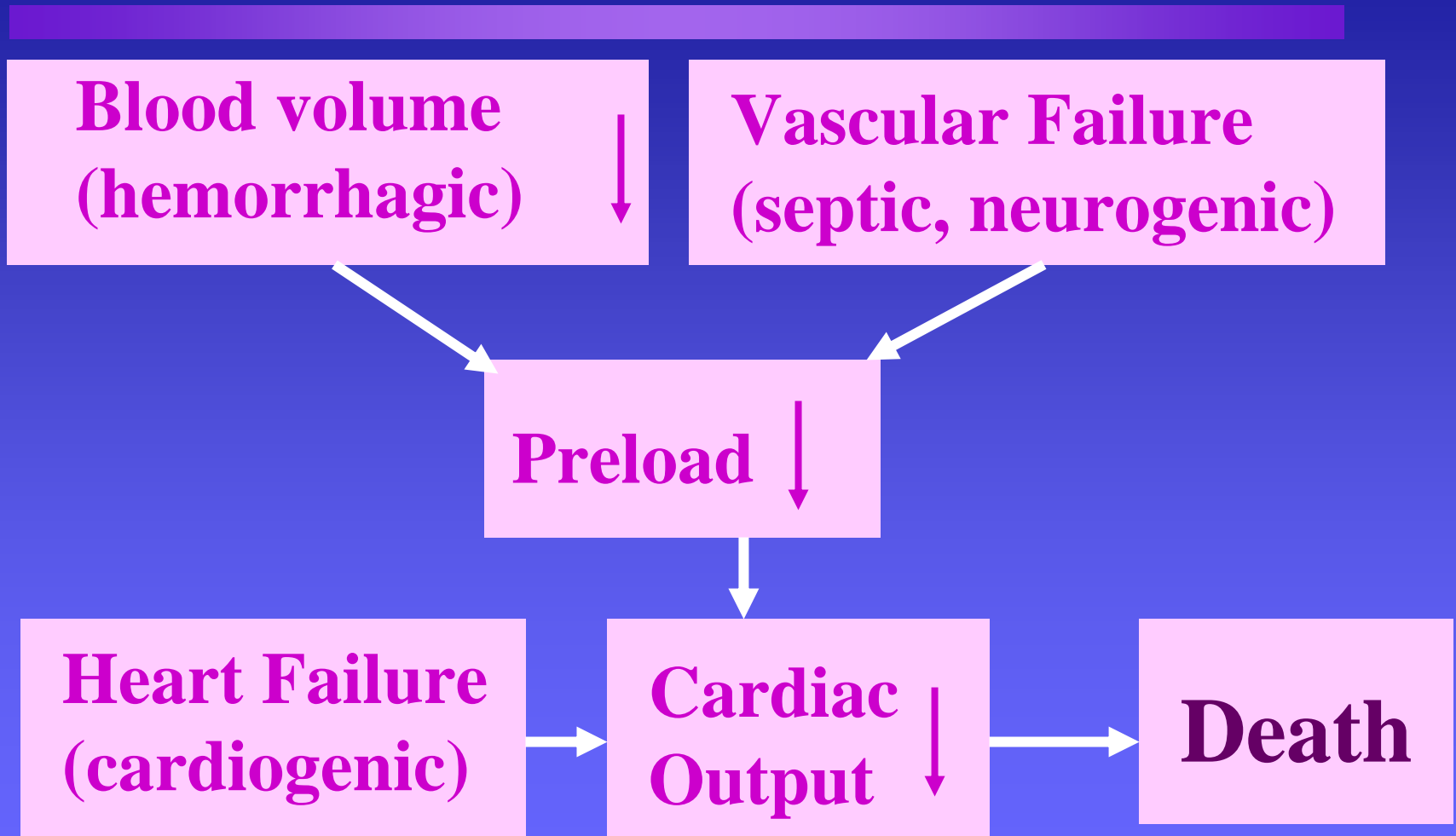


# Lactate in Septic Shock is Prognostic for Survival

	<b>Initial lactate</b> (mmol/L)	<b>Lactime</b> (hours)	<b>AUC</b> (hrs x mmol/L)
<b>Survivors</b> (n = 33)	<b>4.7 ± 2.5</b>	<b>24 ± 17</b>	<b>59 ± 64</b>
<b>Non survivors</b> (n = 54)	<b>5.6 ± 3.7</b>	<b>47 ± 30</b>	<b>191 ± 183</b>

*Bakker 1994*

# Shock



# Sepsis Syndrome: Lactate and iMg

## Progression of Sepsis Syndrome

Infectious agent → Sepsis → Septic shock → MODS → Death

### Current

**Dx:** Wound, white cells, fever, HR, breathing, lactate, etc.

**Rx:** Antibiotics

Fluids, inotropes, vasoconstrictors

### Future inclusions?

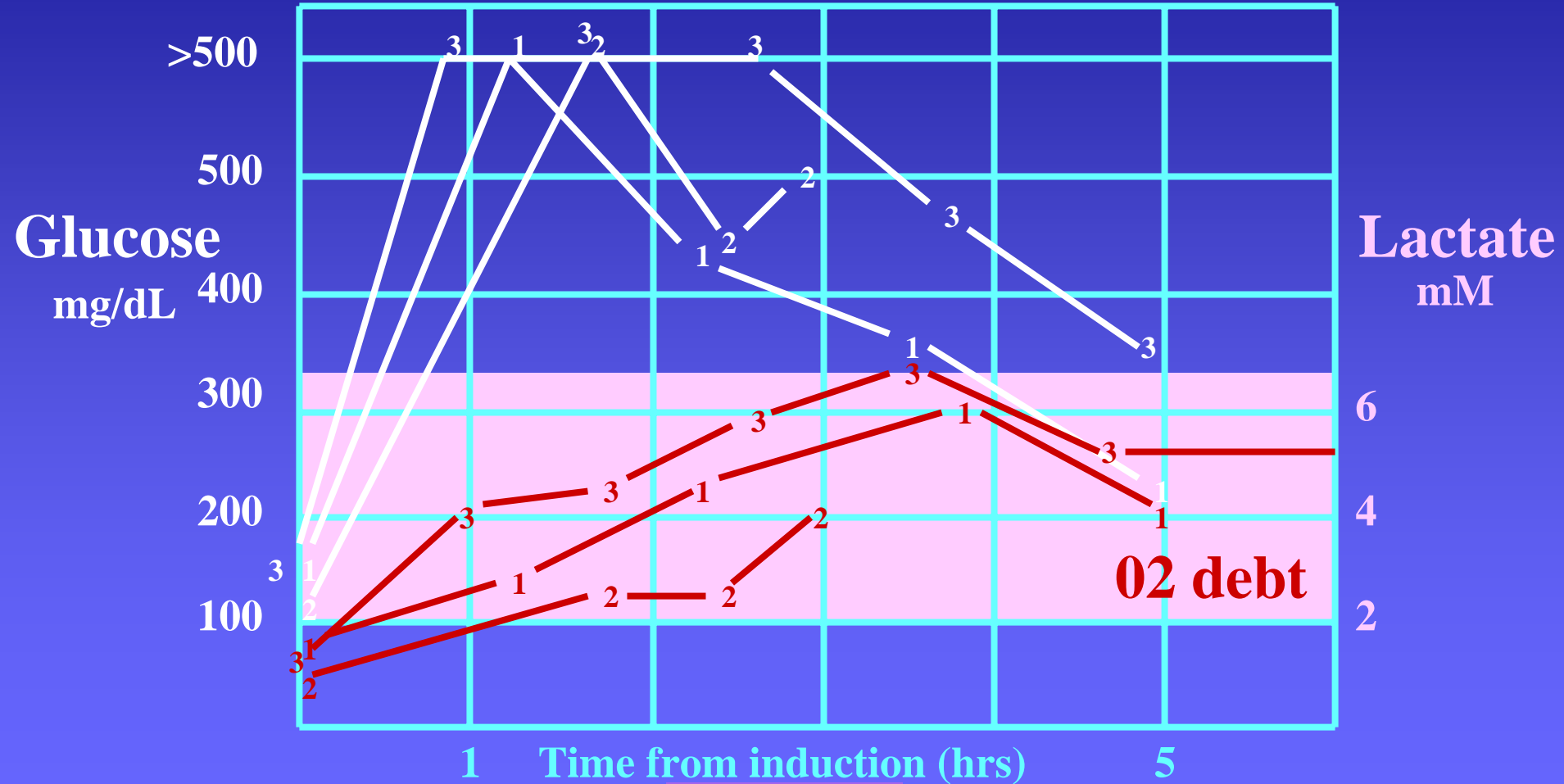
**Dx:** Inflammatory markers?

Lactate?

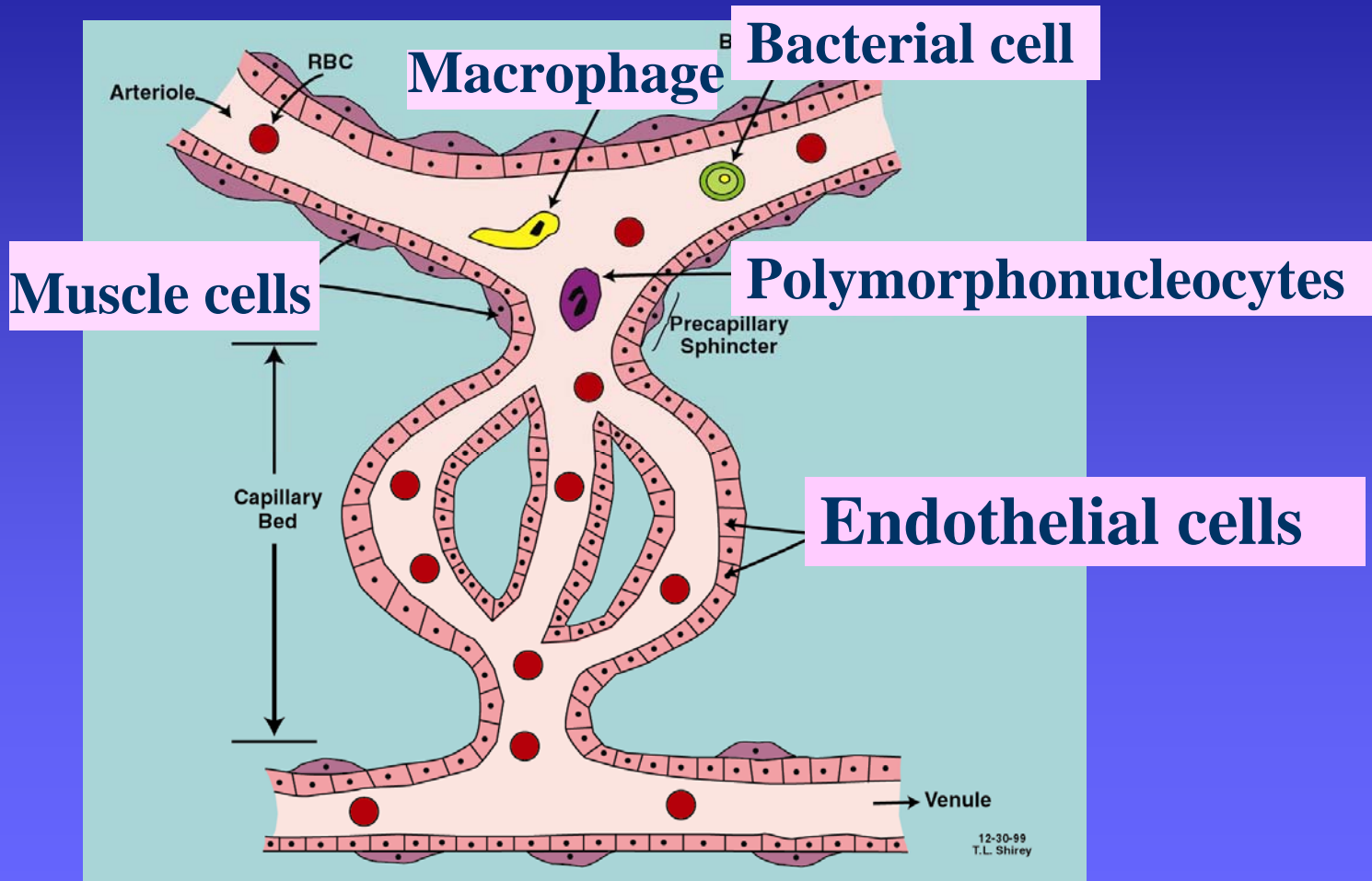
**Rx:** Anti-inflammatory, anti-coagulation drugs?  
Mg?

Mg?

# Heart Surgery: Glucose and Lactate



# Capillary Unit



# Low Cardiac Output Syndrome

## Low Cardiac Output Syndrome



Pre Surgery

During Surgery

Recovery

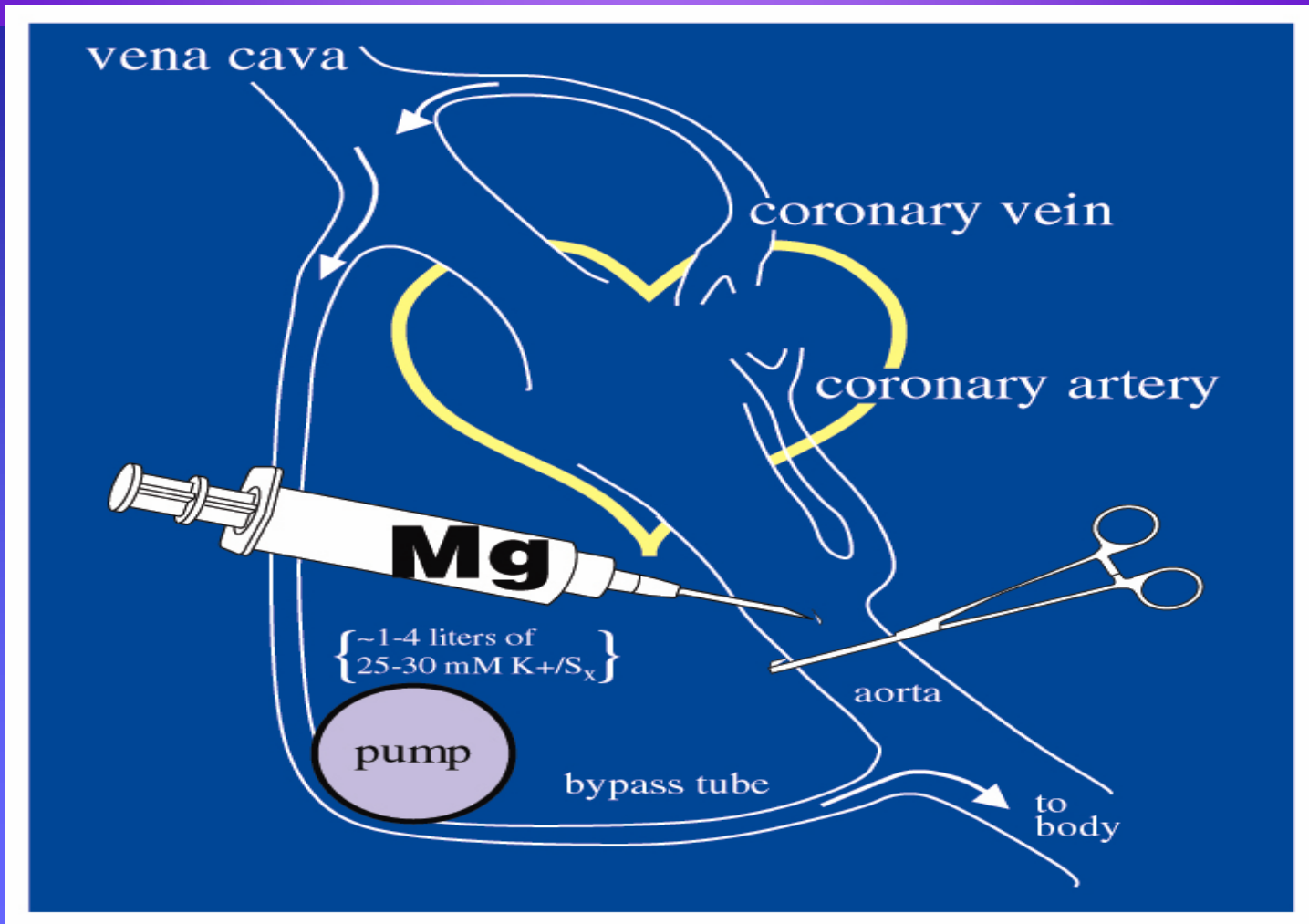
Dx: Lactate ↑

Rx: During Sx, keep lactate down

Low cardiac output syndrome

*Rao 2001*

# Heart Surgery



# Diabetic ketoacidosis

**Low insulin**

**Glucose ↑**

**H<sup>+</sup> ↑ pCO<sub>2</sub>**

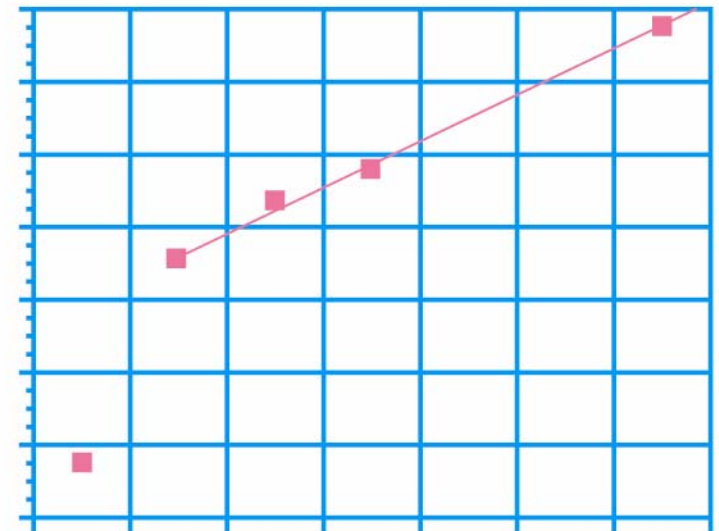
**Ketone bodies ↑**

**Lactate**

# Cardiac Arrest: Lactate



Lactate (mmol/L)

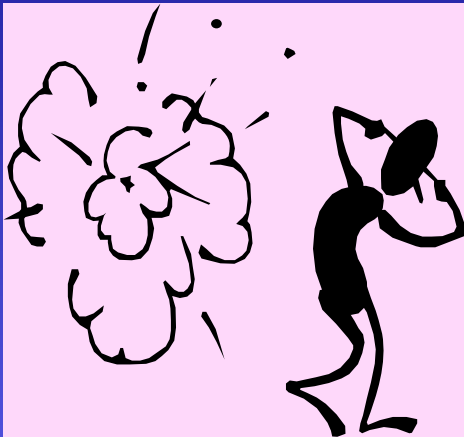


0 5 10 15 20 25 30

Downtime (minutes)

*Cardin 1985*

# Trauma Compensation: Lactate

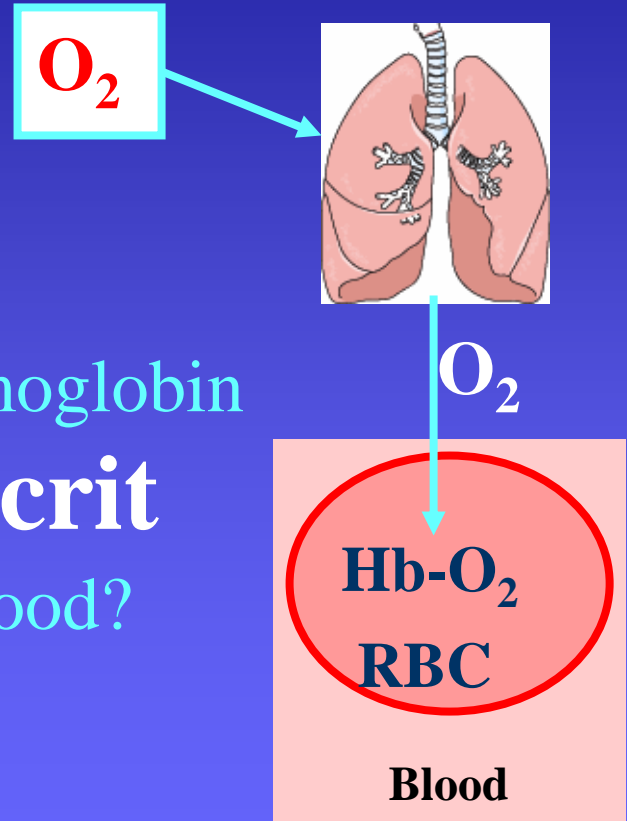


*Abou-Khalil 1994*

	<u>Survivor</u>	<u>Nonsurvivor</u>
MAP (mmHg)	106	105
HR (beats/min)	104	105
CI (liters/min/m <sup>2</sup> )	3.2	3.0
Lactate (mmol/L)	4.1	7.7

# Adequate Oxygen?

- $pO_2$  ( $sO_2$ ,  $pCO_2$ )
  - Enough oxygen across lung?
- $pH$  and  $pCO_2$ 
  - Oxygen dissociation from hemoglobin
- **Hemoglobin or Hematocrit**
  - Enough oxygen carrier in the blood?
- **Lactate**
  - Tissues getting enough oxygen?

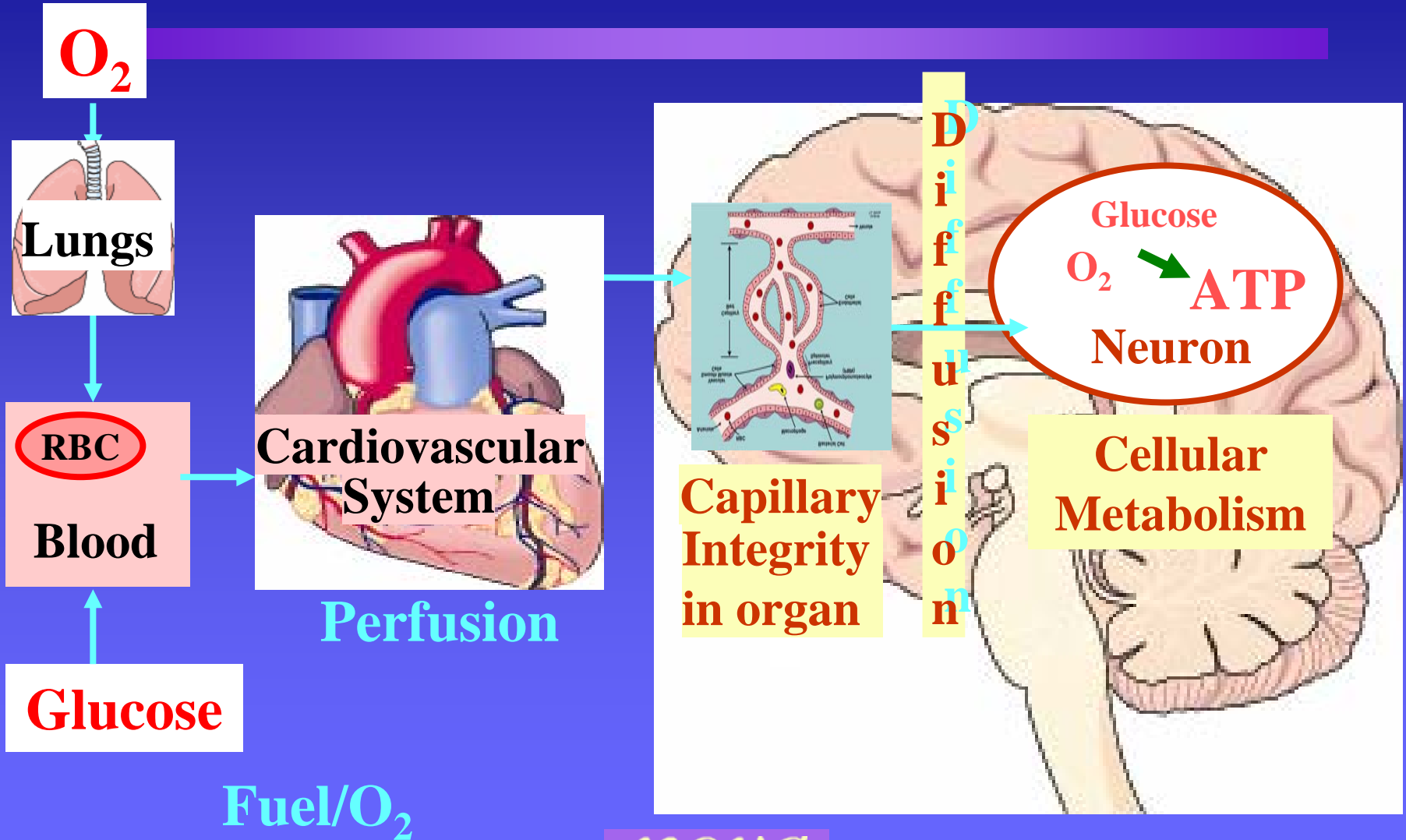


# Information needed

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- **Clinical setting**
- **Progression of lactate values**

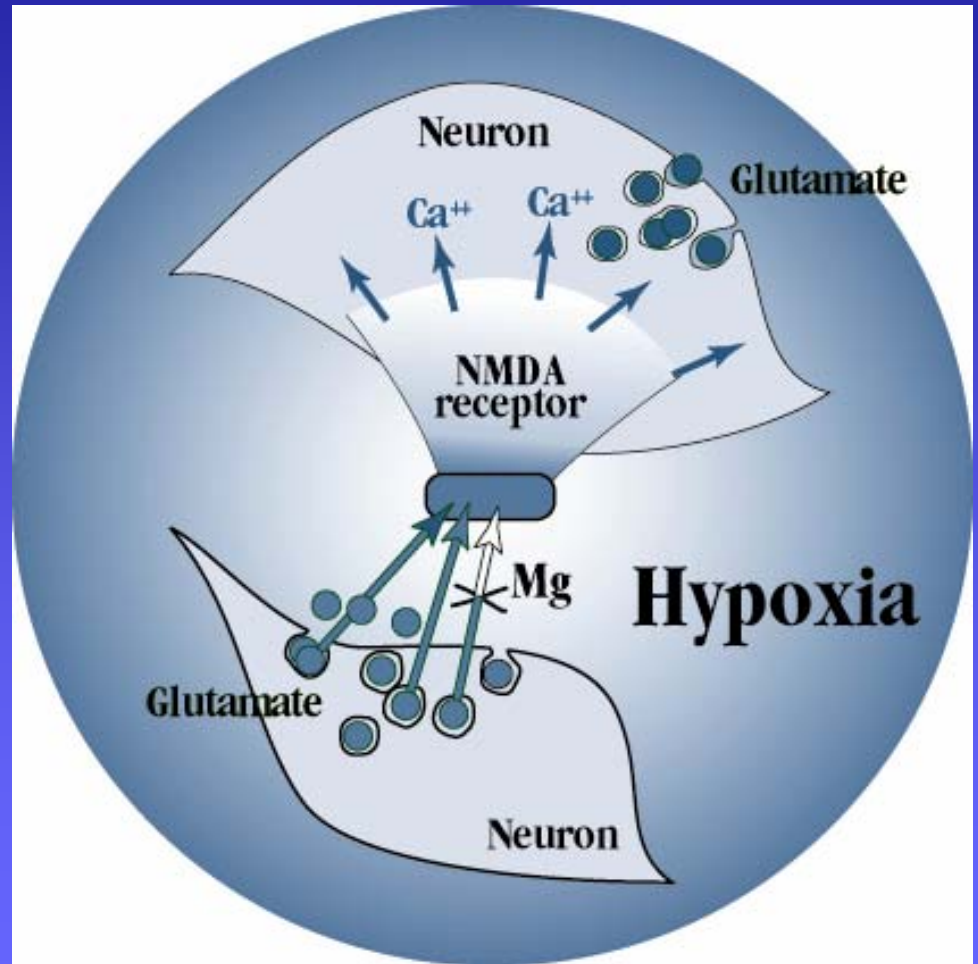
# A core Critical Care Profile Protects the “Energy Pathway”



# Head and Spinal Injury

Intracranial perfusion ↓

Carotid lactate ↑



*Hoffman 1994*

*Costello 1997*

# Chest Pain in the E.D.

**Early release** ← **Rapid Diagnosis** → **Immediate therapy (Rx)**  
(save \$2-5k/patient) (save muscle)

**6M chest pain into E.D.**

**2M released early**

(\$4 to 10B saved)

**24,000 missed ACD**

(\$Billions in malpractice)

**No ACD: 34%**

**Early release?**

**Stable angina: 8%**

**Nonischemic ACD: 23%**

**Unstable angina: 15%**

**Appropriate triage & Rx**

**AMI: 20%**

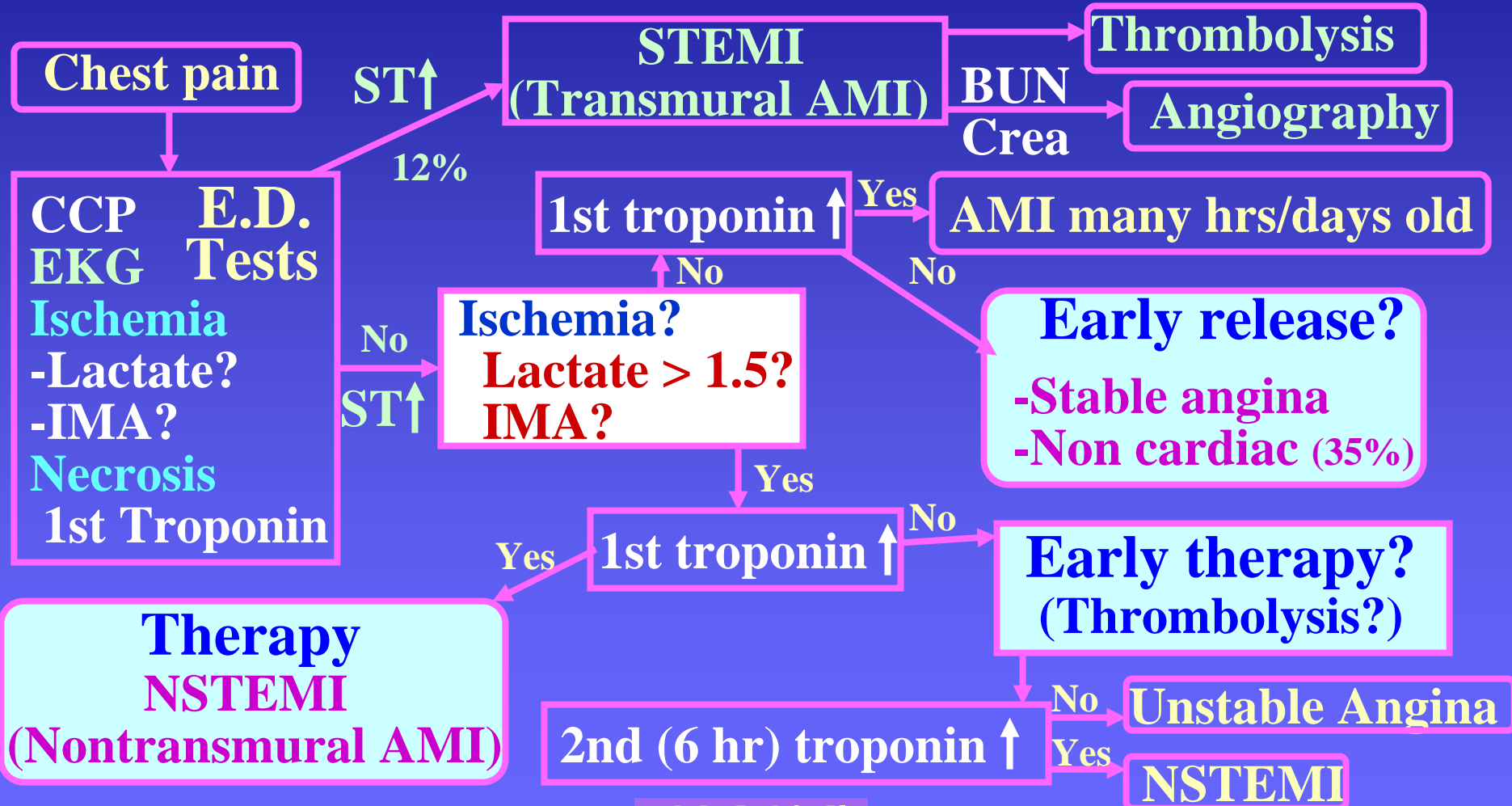
**Immediate Rx**

**4M retained to rule out ACD**

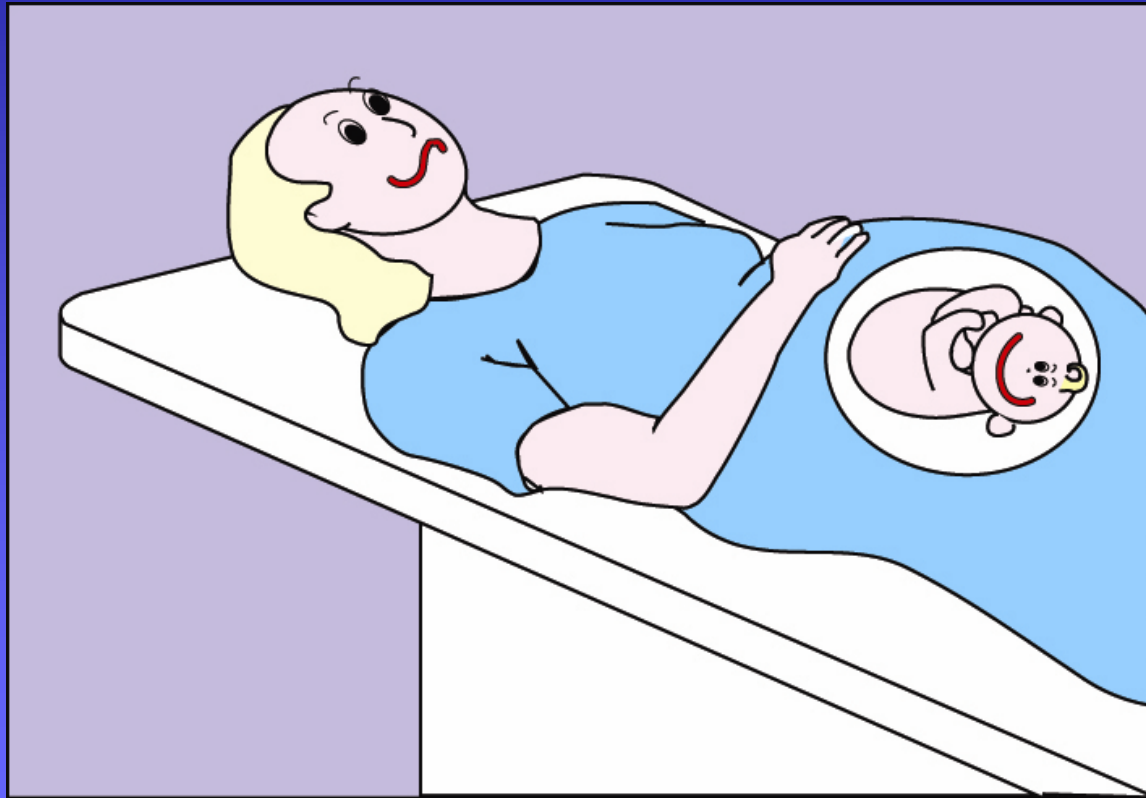
ACD = acute cardiac disease

*Wu 2003*

# Evaluating Chest Pain



# Lactate During Labor and Delivery



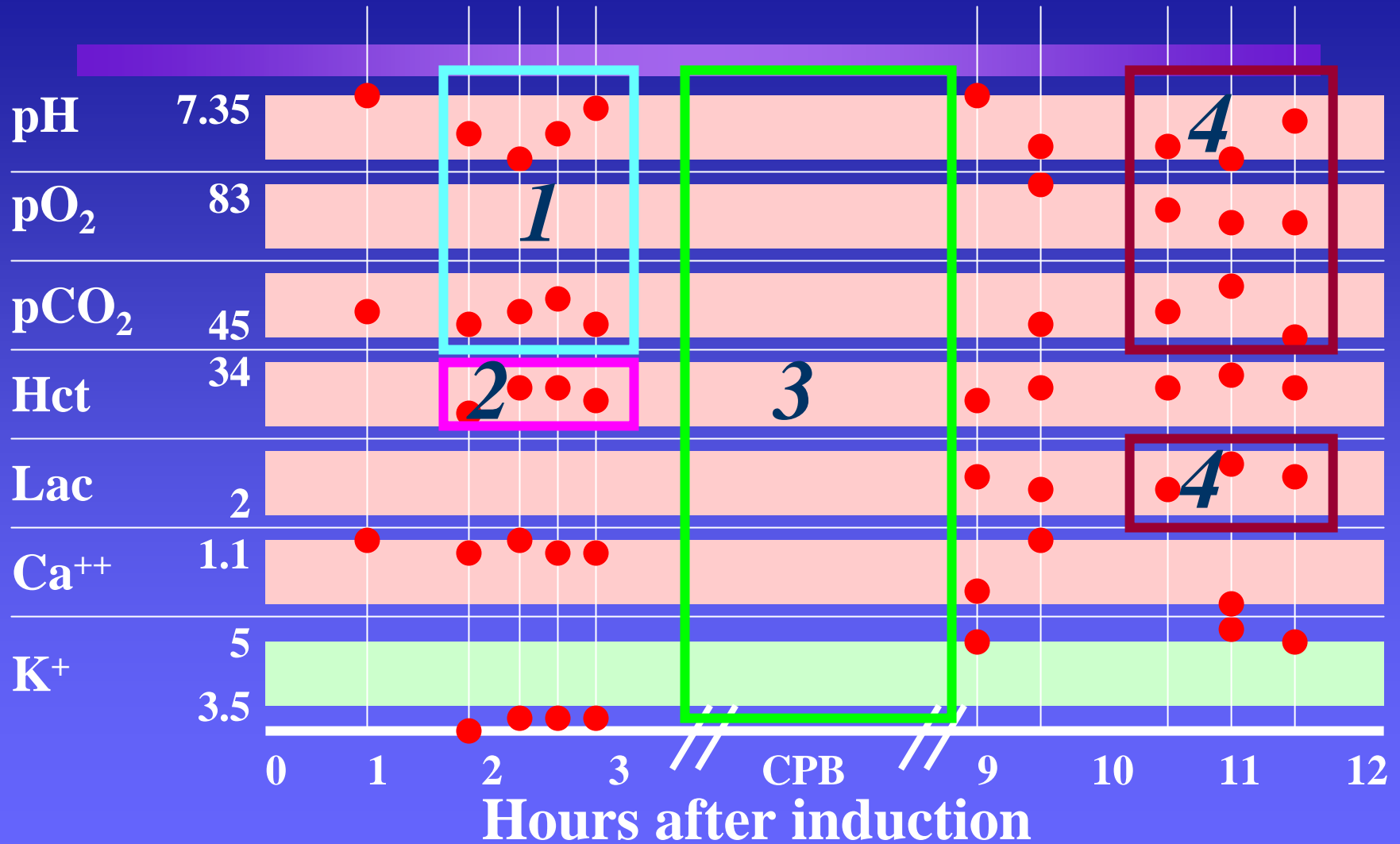
Labor

Cesarean  
section?

Delivery

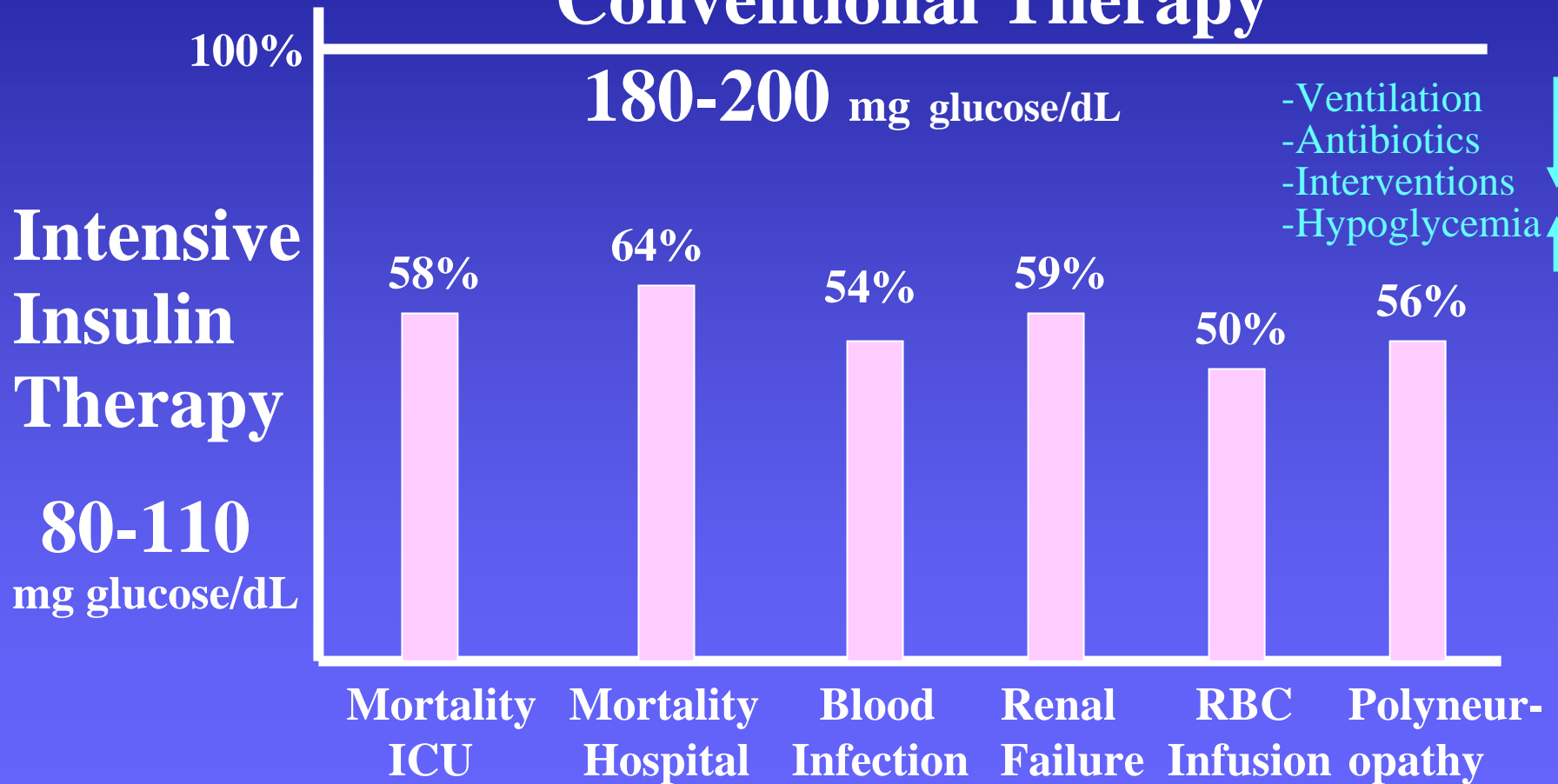
Asphyxia?

# Lung Transplant (Cystic Fibrosis)



# Glucose in the ICU

## Conventional Therapy



Van den Berghe 2001

# Lactate in the ICU

## Diagnosis

## Guiding Rx

## Prognosis

Post Surgery

Shock

Trauma

Hemorrhagic

Cardiovascular Distress

Cardiogenic

Burns

Sepsis Syndrome

Respiratory Distress

Hemostasis