Management of Crush Victims in Mass Disasters

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CONTENTS

RENAL DISASTER / CRUSH SYNDROME

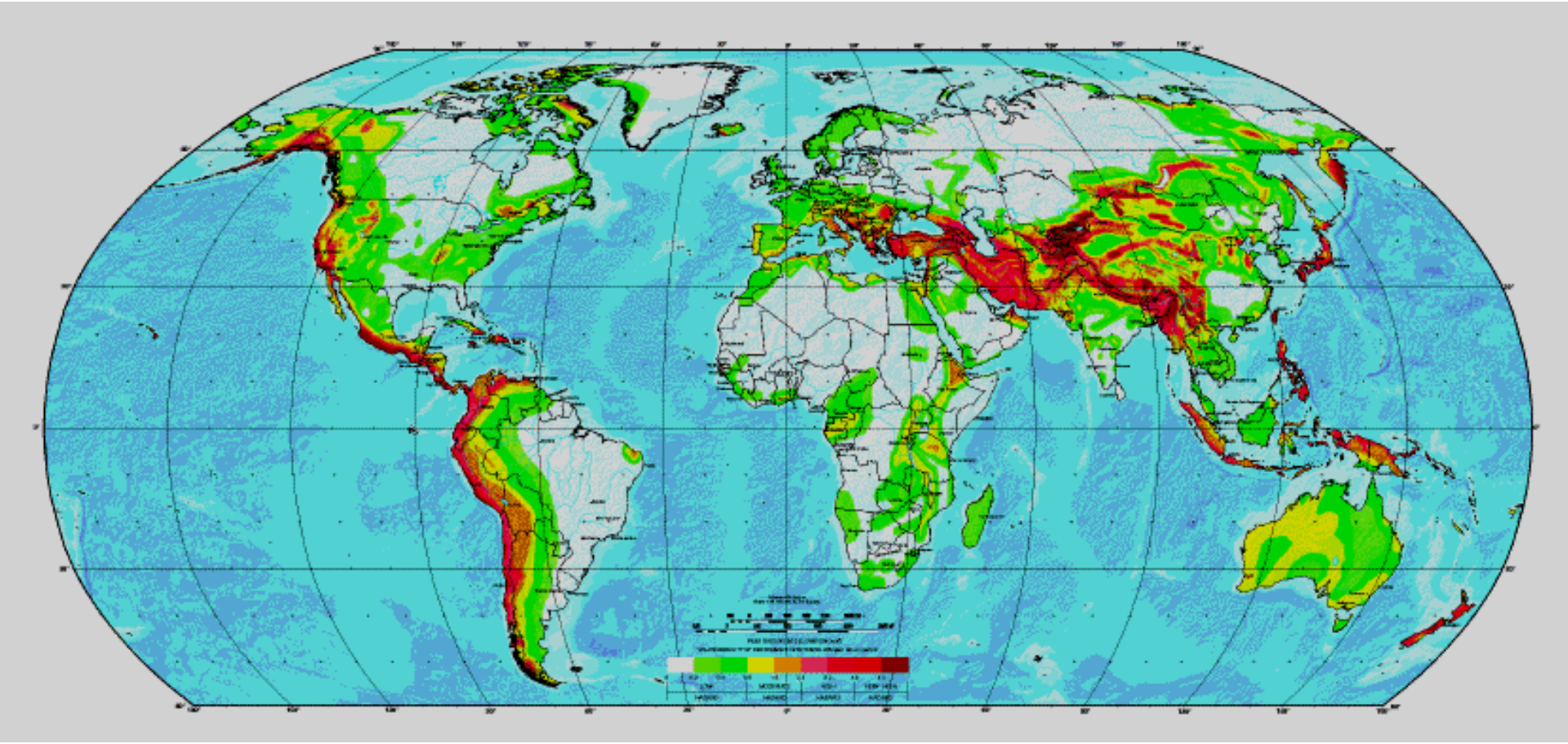
- Introduction
- Etiology / pathogenesis
- Clinical / lab. findings
- Prophylactic / therapeutic interventions

LOGISTIC ISSUES

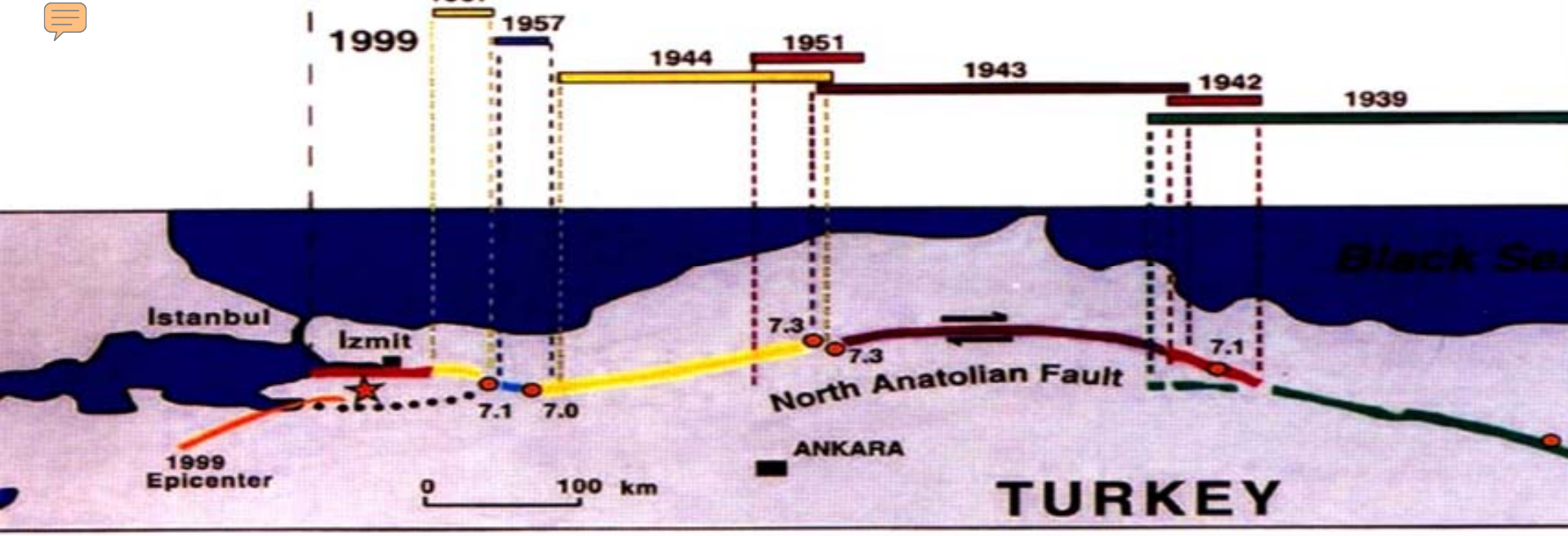
- Severity assesment
- Providing health care
- Medical support
- Other logistic issues

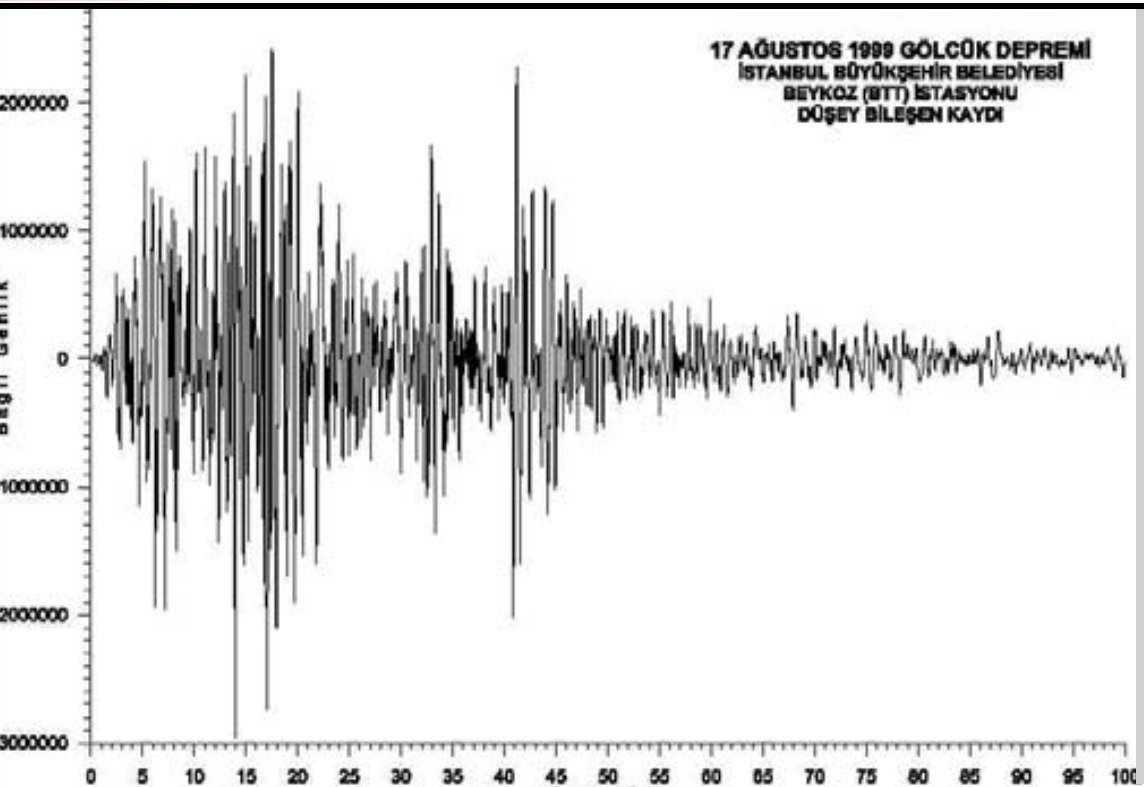
CONCLUSIONS

GLOBAL SEISMIC HAZARD MAP



EARTHQUAKES: A WORLWIDE PROBLEM





- 17 August, 1999
- 7.4 (Richter scale)
- 45 sec
- Deaths: 17,480
- Injured: 43,953

The Marmara Earthquake

Patients. with renal problems: 639

Patients requiring dialysis: 477

The Hanshin-Awaji (Kobe) Earthquake

Patients with AKI: 202

Patients requiring Dialysis:123

The largest “renal disaster” documented so far !

Sever et al. Kidney Int 2001

Oda et al. J Trauma 1997

Dialysis for acute renal failure due to crush injuries after the Armenian earthquake

Br Med J 1989; 298: 443-5

N T Richards, J Tattersall, M McCann, A Samson, T Mathias, A Johnson

On 7 December 1988 an earthquake measuring ... all patients develop acute renal failure at the same time,

"RENAL DISASTER"

Kidney International, Vol. 44 (1993), pp. 479–483

Kidney Int 1993; 44: 479-83

INVITED CONTRIBUTION

International dialysis aid in earthquakes and other disasters[1]

KIM SOLEZ, DAVID BIHARI, ALLAN J. COLLINS, GARABED EKNOYAN, HASKEL ELIAHOU, V.D. FEDOROV, CARL KJELLSTRAND, NORBERT LAMEIRE, JOSEPH LETTERI, ALLEN R. NISSENSON, ERIC K. NOJI,[2] J.P. WAUTERS, and YASUHIRO YAMAMOTO

University of Alberta Hospitals, 5B4.02 W.C. Mackenzie Health Sciences Centre, Edmonton, Alberta, Canada; Guy's Hospital, London,

- 80% die instantly
- 10% minor injuries
- 10% major injuries

Crush syndrome

2nd most frequent cause of deaths
(following direct effect of trauma)

"RENAL DISASTER"

Ron et al. Arch Intern Med 1984

Ukai. Ren Fail 1997

Crush syndrome is a life-threatening disorder !

SYMPOSIUM PAPER

The Great Hanshin-Awaji Earthquake and the Problems with Emergency Medical Care

Takashi Ukai, MD

Cause of Deaths of the Victims of the Great Hanshin-Awaji Earthquake (Analysis of Inquest Records by Dr. A. Nishimura)

Cause of Death	Number (%)
Asphyxia	1967 (53.9%)
Crush injury (chest, whole body)	456 (12.5%)
Burn and CO poisoning	444 (12.2%)

Mortality in crush s.:

- Overall: 24.8% (50/202)

Mortality rates in dialyzed crush victims:

Marmara: 17%, Taiwan: 17%; Pakistan: 19%; Iran: 13%

Hwang et al. 2001; Sever et al 2004; Van der Tol et al. 2008; Hatamizadeh et al AJKD 2006

TERMINOLOGY - I

Crush: injury due to pressure between opposing elements

Crush syndrome: systemic manifestations of crush injury-induced rhabdomyolysis

SURGICAL

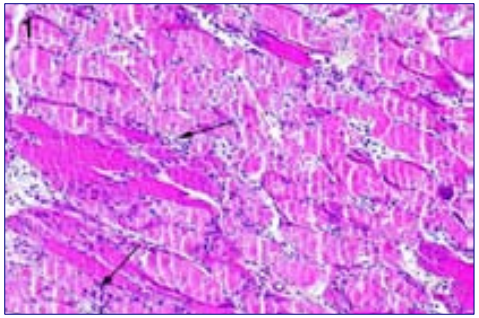
- Local findings of trauma
- Compartment syndrome

MEDICAL

- Hypovolemic shock
- Hyperkalemia
- Infections
- Acute renal failure

Rhabdomyolysis

Disintegration of striated muscles



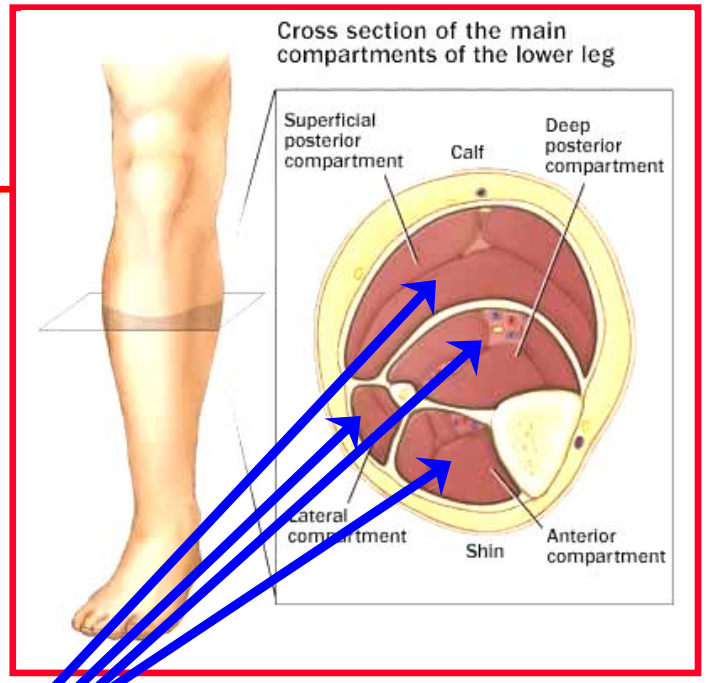
resulting in release of muscular cell contents

- lactic acid
- thromboplastin
- creatin kinase
- nucleic acids
- phosphate
- creatine
- **Myoglobin**
- **Potassium**

into the extracellular fluid

TERMINOLOGY - II

- **Compartment**: space restricted by the rigid fasciae surrounding the muscles



Compartment syndrome

- increased pressure in the compartments due to traumatic tissue swelling

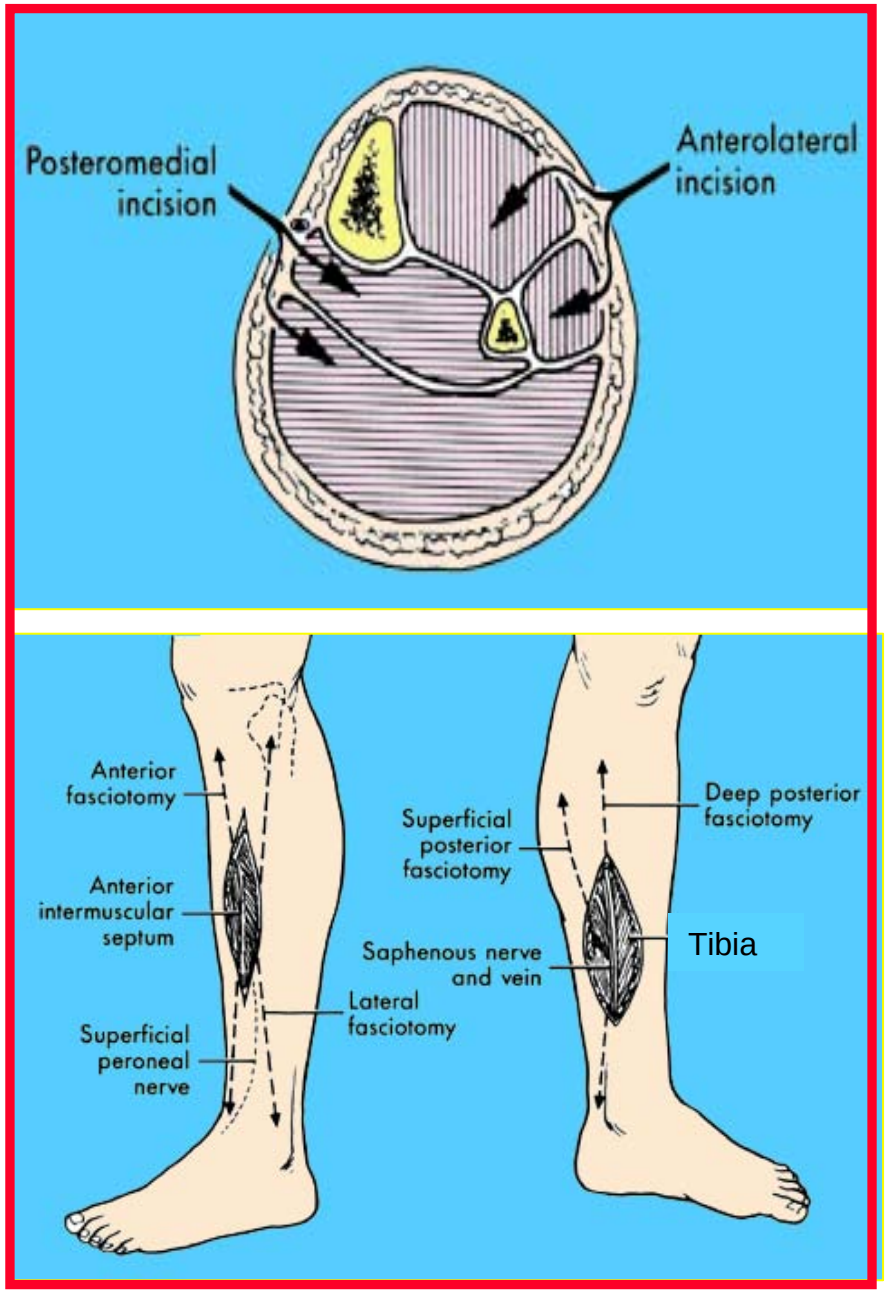
Disrupts perfusion / hinders muscle function

TERMINOLOGY - III

Fasciotomy

- surgical incision through the fasciae to reduce intracompartmental pressure

Decompressive intervention



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ETIOLOGY of RHABDOMYOLYSIS

Non-traumatic

- Metabolic myopathies
- Drugs and toxins
- Infections
- Electrolyte abnormalities
- Endocrine disorders
- Polymyositis, dermatomyositis

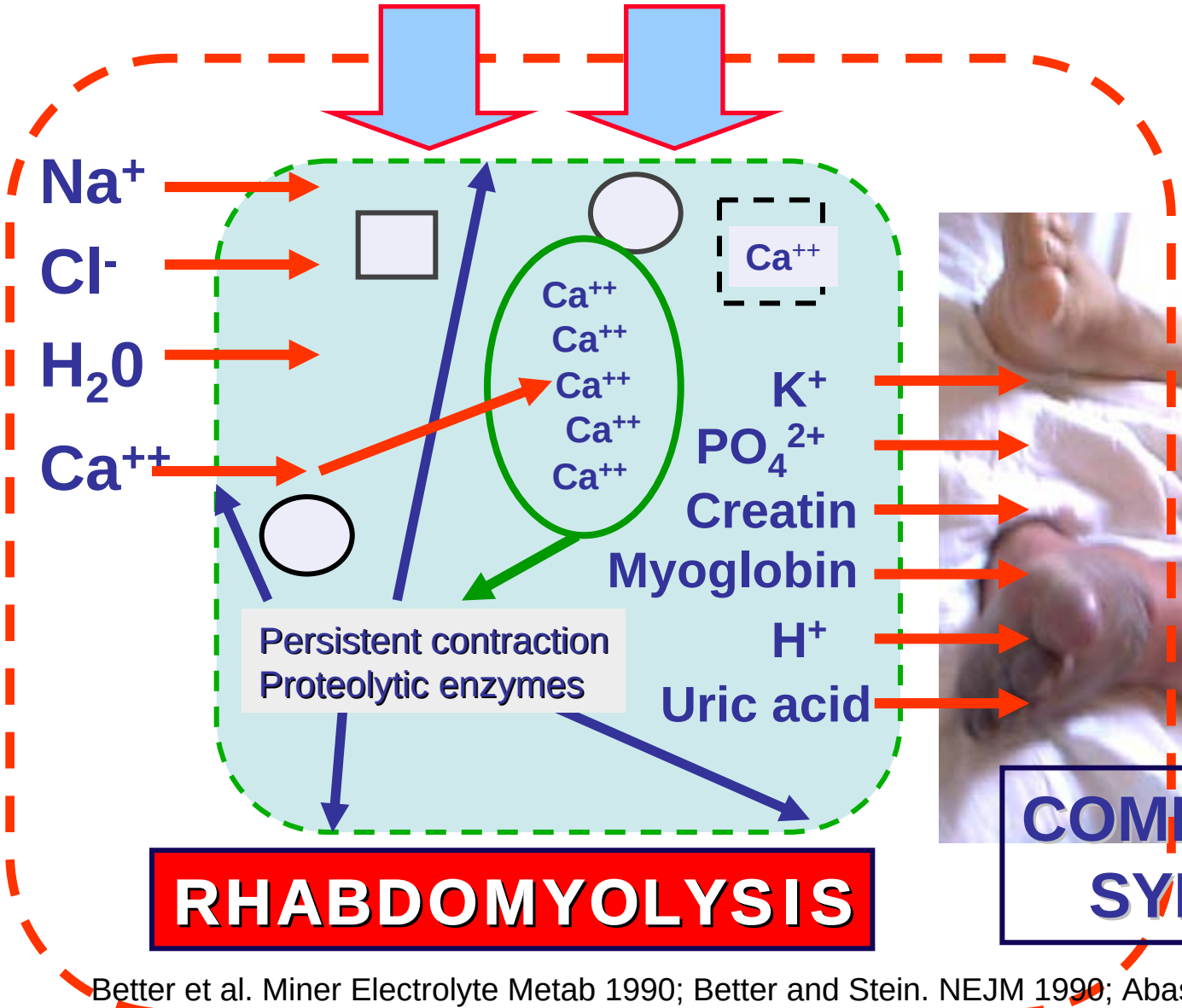
Traumatic

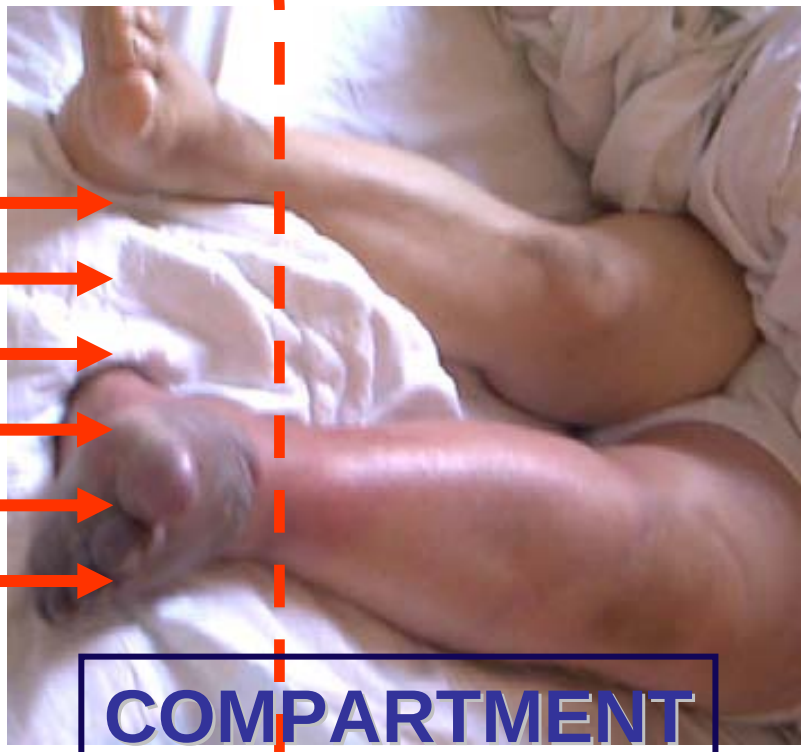
- Traffic or working accidents
- Prolonged immobilization
- Vessel clamping
- Strainful exercise of muscles
- Electrical current
- Hyperthermia
- **Disasters**

Brumback et al. Pediatr Clin N Am 1992

Vanholder et al. JASN 2000

PATHOGENESIS of TRAUMATIC RHABDOMYOLYSIS





COMPARTMENT SYNDROME

Better et al. Miner Electrolyte Metab 1990; Better and Stein. NEJM 1990; Abassi et al. AJKD 1998

PATHOGENESIS of RHABDOMYOLYSIS-INDUCED AKI

~ 30–50% of rhabdomyolysis ⇒ AKI

Rhabdomyolysis ⇒ a frequent cause of AKI (5 - 20%)

Better and Stein. NEJM 1990 Zager. Kidney Int 1996 Vanholder et al. JASN 2000

Primary importance Secondary importance Tertiary importance

Pathogenesis of rhabdomyolysis-induced AKI

Thromboplastin

Potassium

Hyperphosphatemia

Hypocalcemia

Endotoxin/ cytokines

↘IVV

Uric ac.

Lactic ac.

NO scavenging

Myoglobinemia

Myoglobinuria

Renal hypoperfusion/ischemia

Cast formation

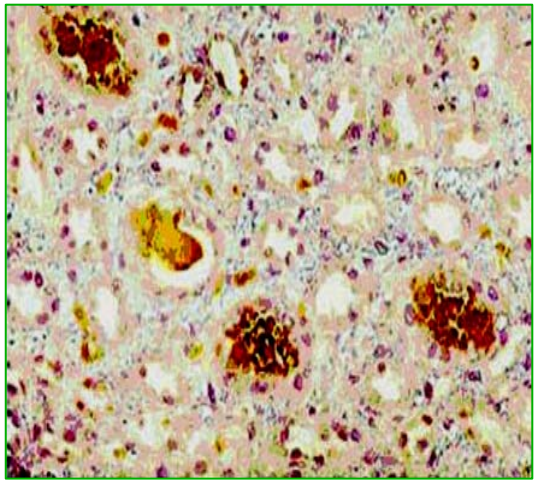
Luminal stasis

Tubular damage

ATN

Fe loading

Free radicals



DIC

AKI

$CaPO_4$ salts

Better and Stein, NEJM 1990,
Zager, KI 1996,
Vanholder et al. JASN 2000

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CLINICAL FINDINGS in CRUSH SYNDROME

Local findings in the traumatized muscles (6 "P"s)

1. **Pain**
2. **Pressure**
3. **Paresthesia**
4. **Paresis or paralysis**
5. **Pallor**
6. **Pulselesness**

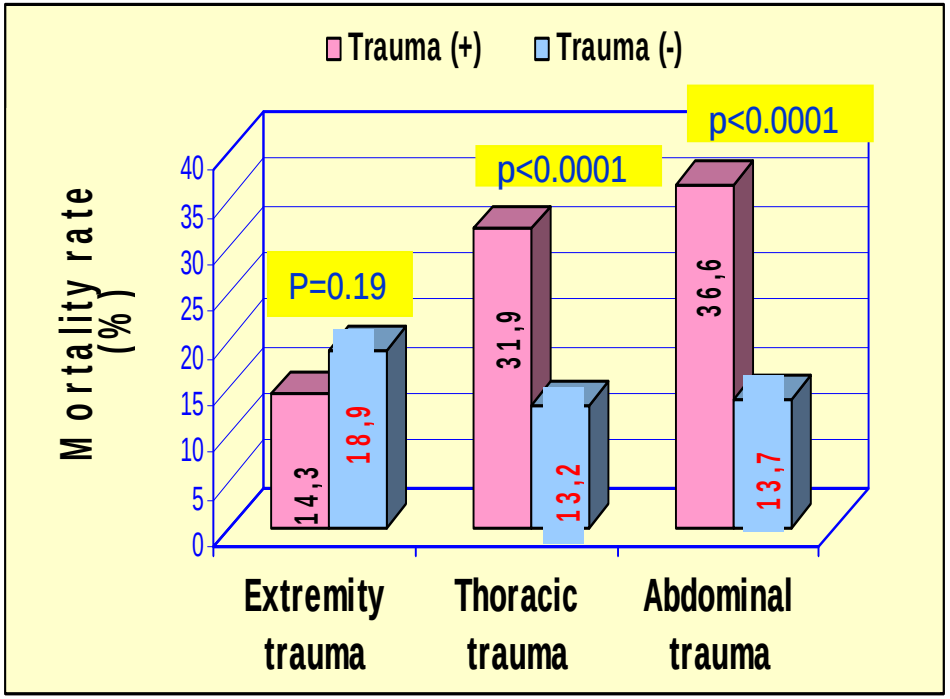
Systemic manifestations of rhabdomyolysis (C.S.)

- **Hypovolemic shock**
- **AKI**
- **Hyperkalemia**
- **Heart failure**
- **.....**

TRAUMA PATTERN in the MARMARA EARTHQUAKE CRUSH VICTIMS

No. of traum. Extremities	
1	274
2	205
3	26
4	7
Global	790

Thoracic	69
Abdominal	41
Skull	32
Multiple	54
Others	51



Multivariate analysis:

- **Thoracic (p=0.001, o.r.=2.8)**
- **Abdominal (p<0.0014, o.r.=3.8)**

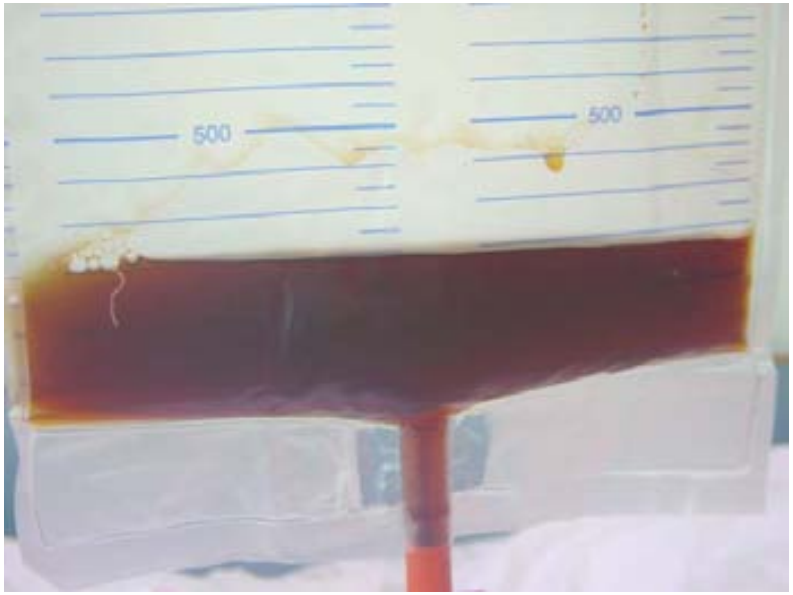
Victims with thoracic / abdominal traumas should be referred from the field as soon as possible

Sever et al, NDT, 2002

LABORATORY FINDINGS in CRUSH SYNDROME

Urinary findings

- Myoglobinuria
- Other findings

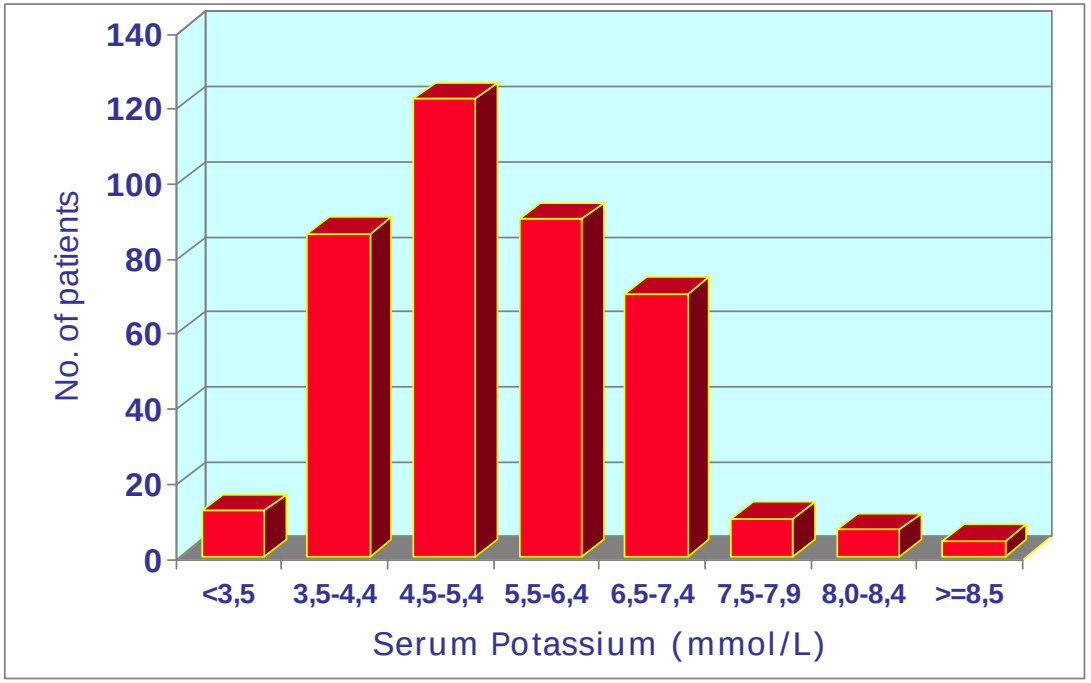


Biochemistry

- ↗ Muscle enzymes
- ↗ Creatinine / BUN
- Acidosis
- Hyperphosphatemia
- Hyperuricemia
- Hypocalcemia
- Hypoalbuminemia
- Abnormal blood count
- **Hyperkalemia**

SERUM POTASSIUM
(The Marmara Earthquake Experience)

Serum potassium: 5.3±1.3 (2.4 - 13.3) mmol/L



Cum. No. of the pts.	Potassium (mmol/L)
176	>=6.0
116	>=6.5
70	>=7.0
6	>=8.5

Many patients died at the field, during transportation or on admission to hospitals due to fatal hyperkalemia!

Sever et al, Clin Nephrol 2003

SERUM POTASSIUM - II
(The Marmara Earthquake Experience)

Marmara E.: 10 % of the patients were receiving K^+ containing solutions on admission

This was certainly can be called nothing less than malpractice

Resulted in many patient deaths ?

K+ containing solutions should NEVER be administered empirically !

- Rescued victims who were seemingly well under the rubble, deteriorated or even died as soon as they were extricatied!

RESCUE

DEATH

- Influx of plasma into the muscles
- Influx of calcium
- Efflux of muscle breakdown products (acidosis, hyperkalemia)

Noji. Crit Care Clin 1992
Ashkenazi et al. Prehosp Disast Med 2005

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HCO3

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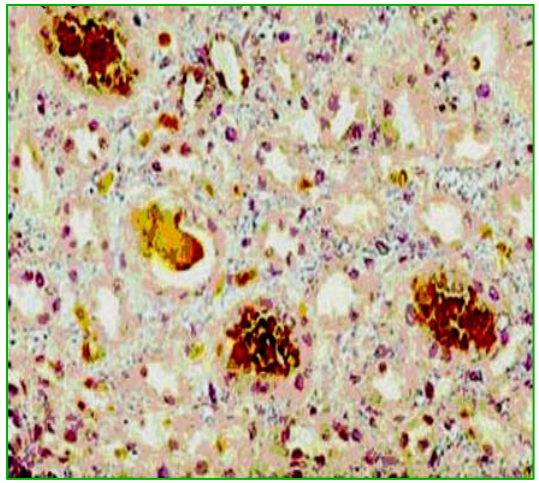
Cast formation

MANN.

FLUIDS

Luminal stasis

Tubular damage



MANN.

ATN

Fe loading

Free radicals

MANN.

AKI

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Section II: Interventions at the disaster field

II.3: Intervention before / during extrication

A victim is detected under the rubble

BEFORE EXTRICATION (A vein is sought in one of the limbs)

- No vein can be found → No fluid is given
- A vein is found → Initiate isotonic saline (1 L/h)

DURING EXTRICATION → (Continue isotonic saline 1 L/h)

Duration of extrication process >2h

Reduce isotonic saline (0.5 L/h or even less)