

Management of Crush Related Injuries After a Disaster

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RENAL DISASTER / CRUSH SYNDROME

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

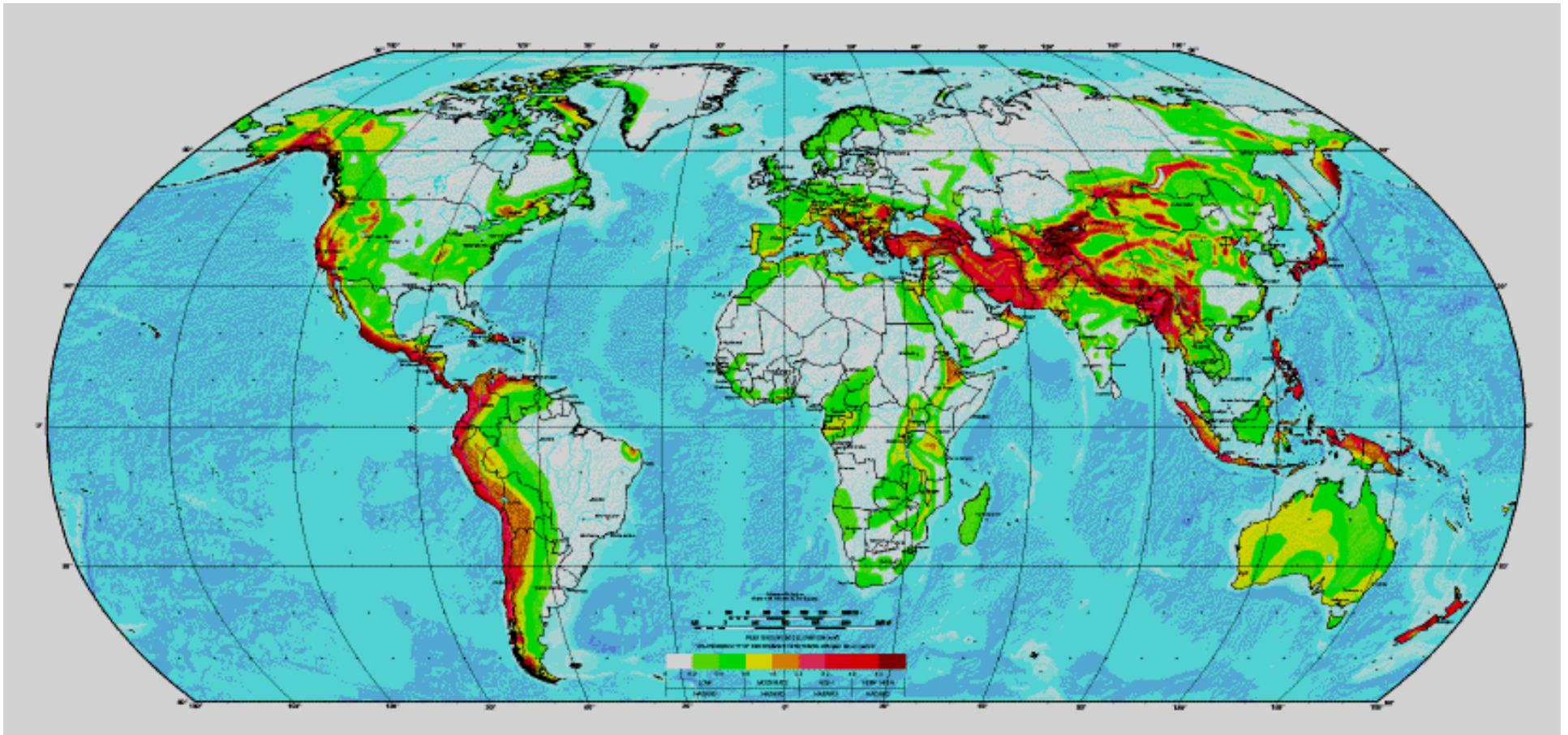
LOGISTIC ISSUES

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

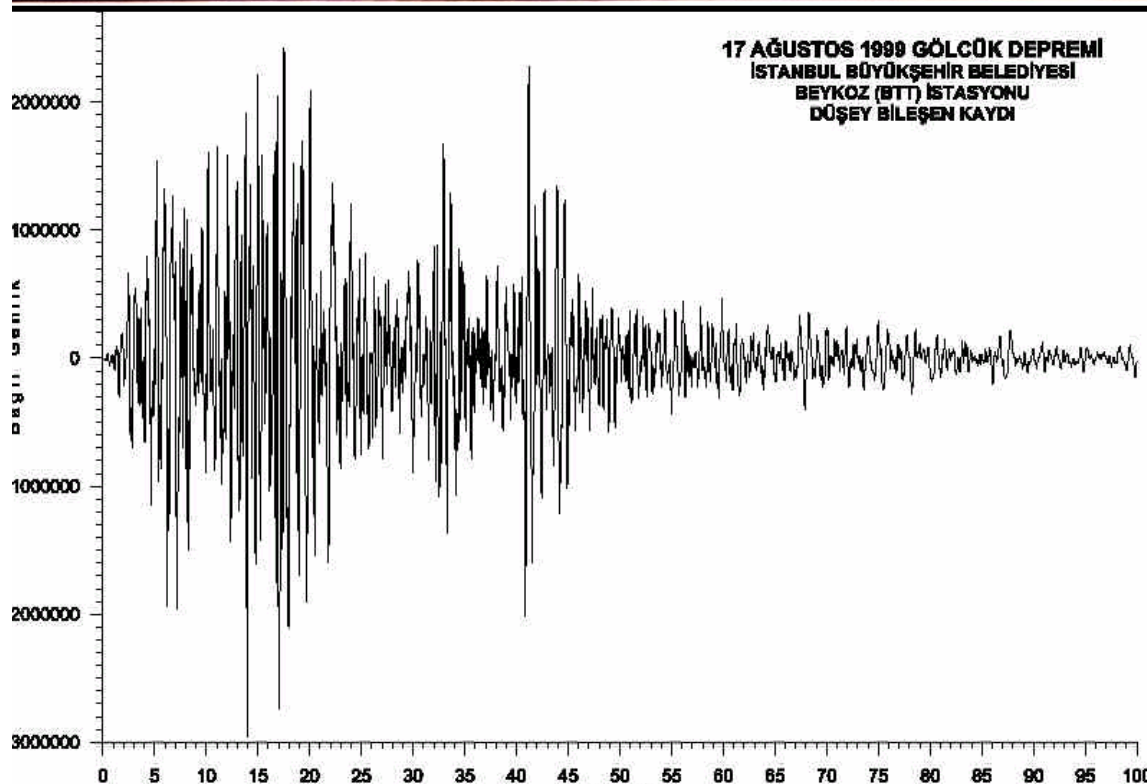
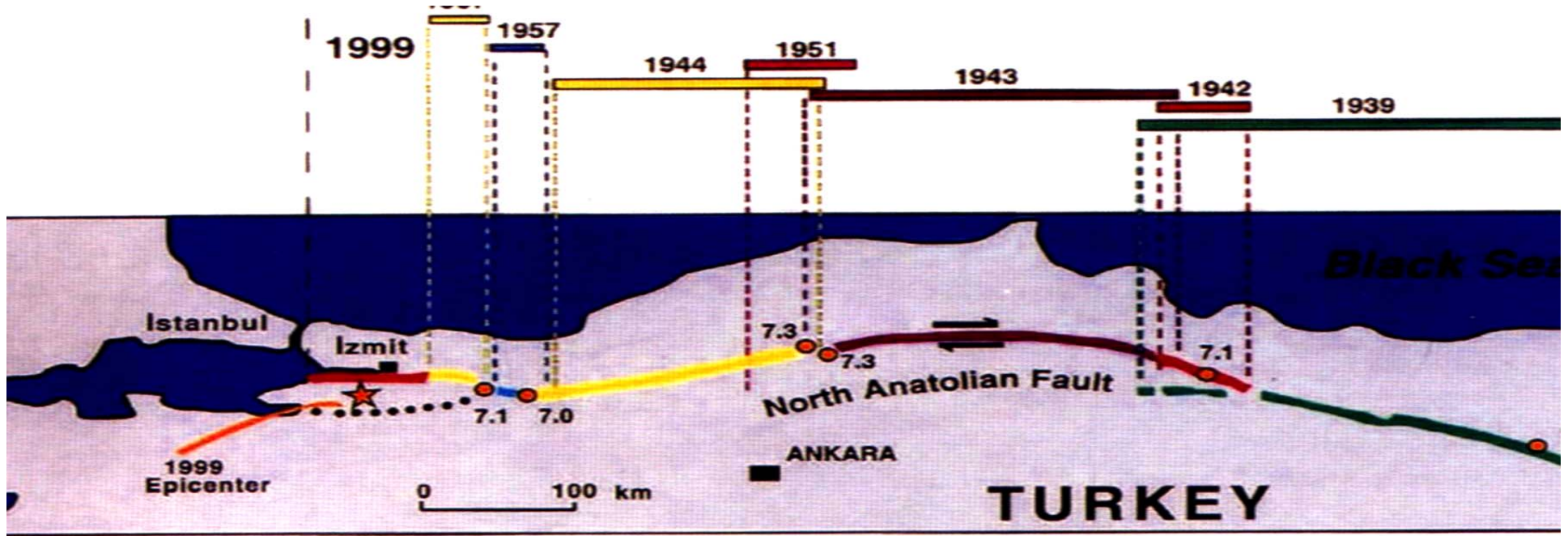
CONCLUSIONS



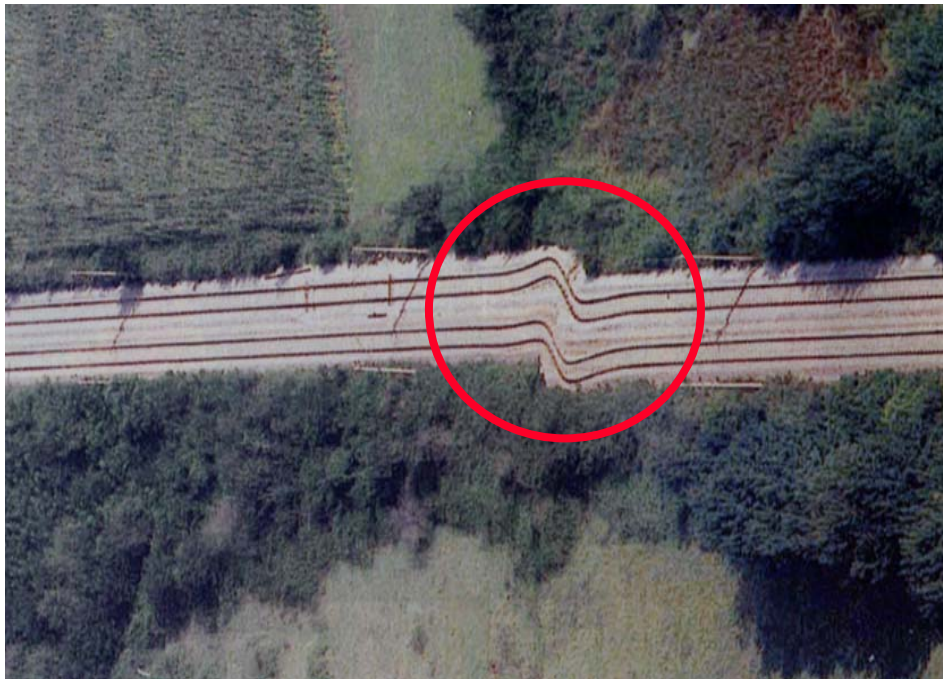
GLOBAL SEISMIC HAZARD MAP



EARTHQUAKES: A WORLDWIDE PROBLEM



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



The Marmara Earthquake

Pts. with renal prob.: 639

Pts. requiring Dx.: 477

The Hanshin-Awaji (Kobe) Earthquake

Pts. with ARF: 202

Pts. requiring Dx.: 123

The largest “renal disaster” documented so far !

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 disasters¹

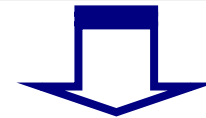
KIM SOLEZ, DAVID BIHARI, ALLAN J. COLLINS, GARABED EKNOYAN, HASKEL ELIAHOU,
V.D. FEDOROV, CARL KJELLSTRAND, NORBERT LAMEIRE, JOSEPH LETTERI,
ALLEN R. NISSENSON, ERIC K. NOJI,² J.P. WAUTERS,
and YASUHIRO YAMAMOTO

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



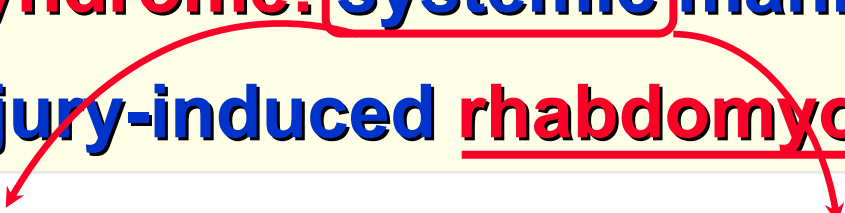
2nd most frequent cause of deaths
(following direct effect of trauma)

"RENAL DISASTER"

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

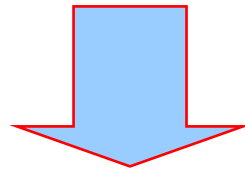
TERMINOLOGY - II



Rhabdomyolysis: Disintegration of striated muscles that results in release of muscular cell contents into the extracellular fluid

Muscles: largest organ system in the body (40% of body weight)
The risk to be traumatized is very high

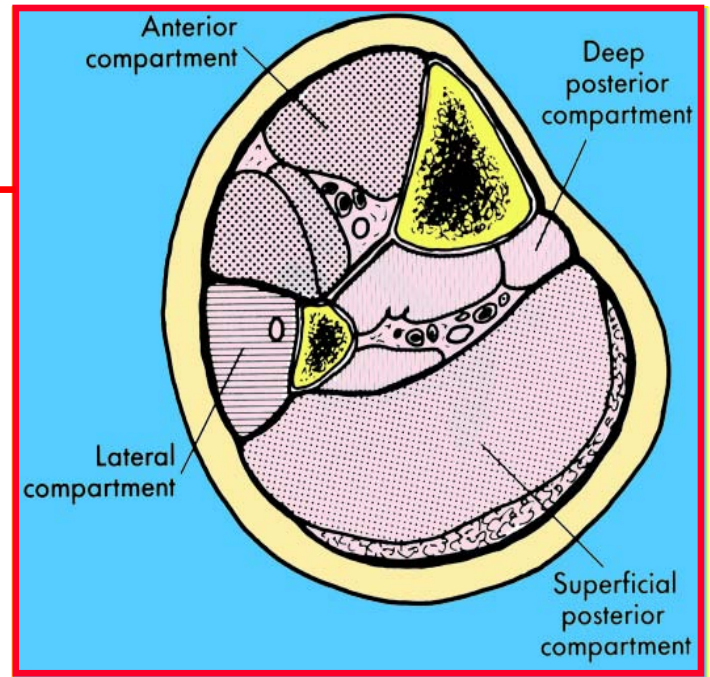
- | | | |
|------------------|-----------------|--------------------|
| • lactic acid | • nucleic acids | • Myoglobin |
| • thromboplastin | • phosphate | • Potassium |
| • creatin kinase | • creatine | |



CRUSH SYNDROME

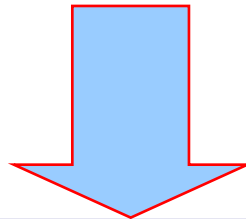
TERMINOLOGY - III

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



Compartment syndrome

- increased pressure in the compartments due to traumatic tissue swelling



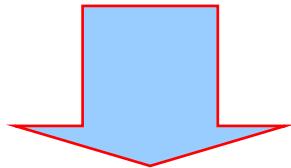
Disrupts perfusion / hinders muscle function



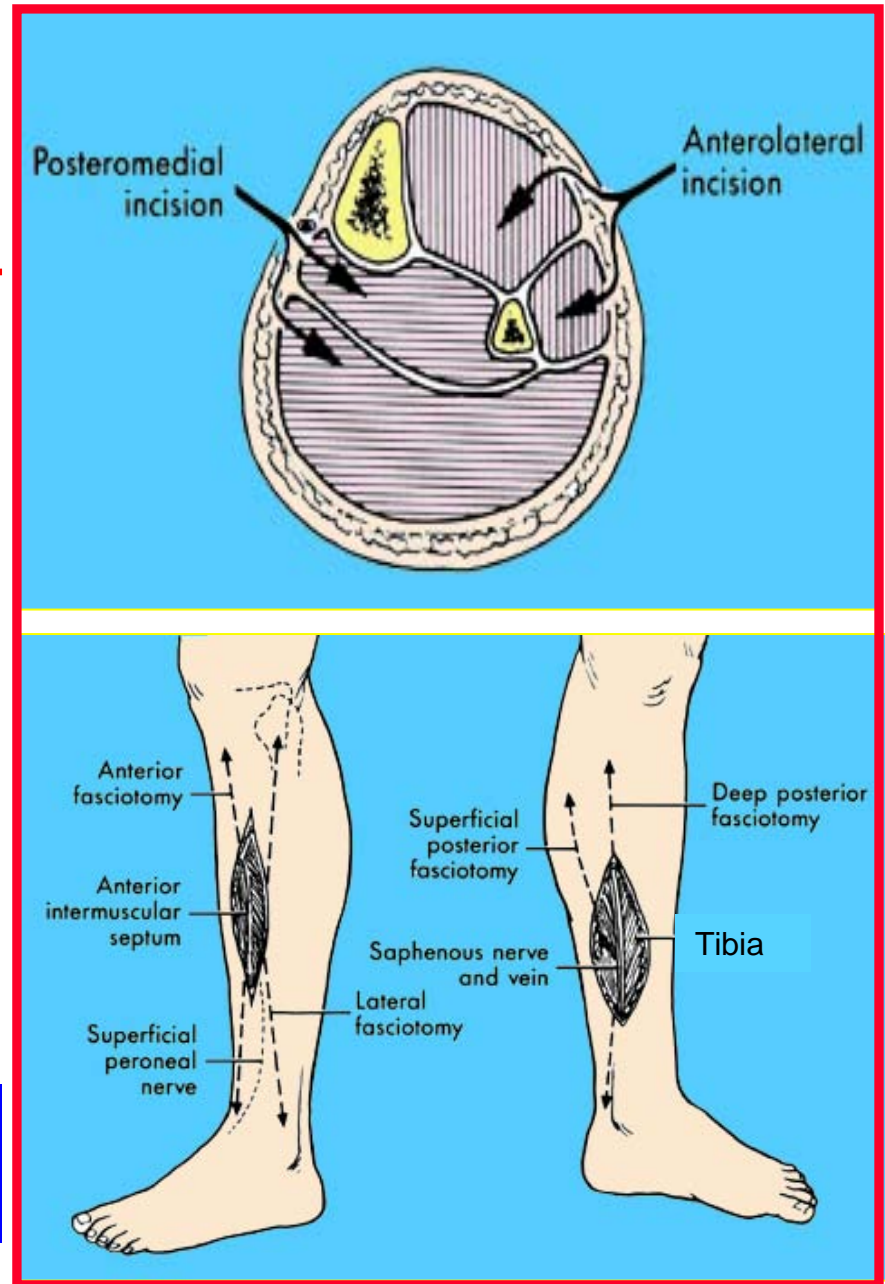
TERMINOLOGY - IV

Fasciotomy

- surgical incision through the fasciae to reduce intracompartmental pressure



Decompressive intervention

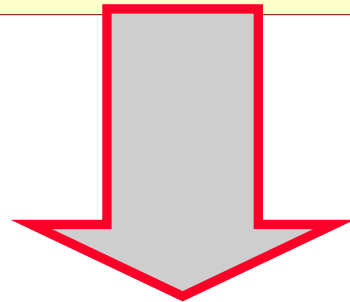




CRUSH SYNDROME:

2nd most frequent cause of deaths

Underlying pathology in crush syndrome



RHABDOMYOLYSIS

RENAL DISASTER / CRUSH SYNDROME

- Introduction
- **Etiology / pathogenesis**
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LOGISTIC ISSUES

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CONCLUSIONS

ETIOLOGY of RHABDOMYOLYSIS

Non-traumatic

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

Traumatic

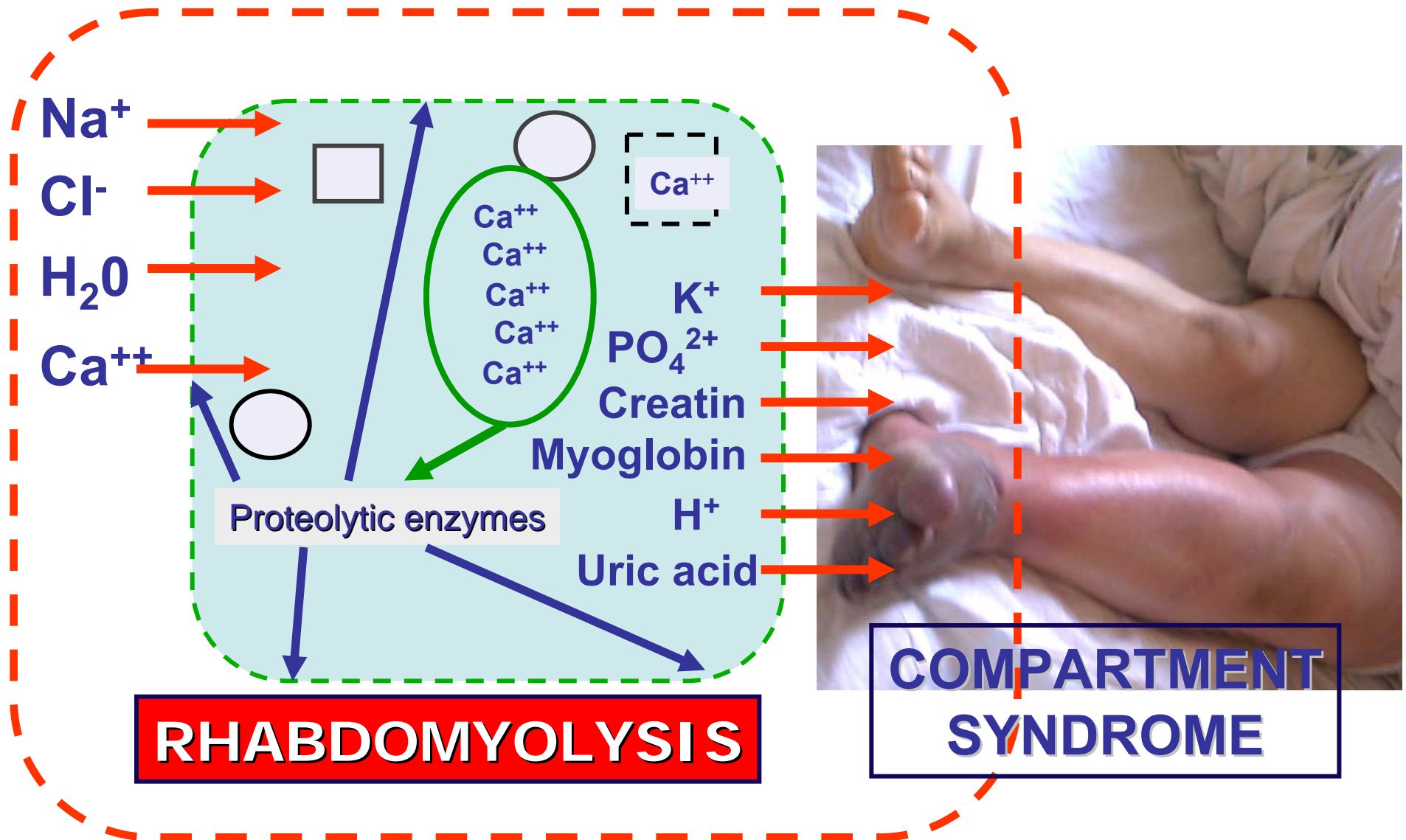
- Traffic or working accidents
- Prolonged immobilization
- Vessel clamping
- Strainful exercise of muscles
- Electrical current
- Hyperthermia
- **Disasters**

PATHOGENESIS of CRUSH SYNDROME

I. Traumatic rhabdomyolysis

II. Rhabdomyolysis-induced ARF

PATHOGENESIS of TRAUMATIC RHABDOMYOLYSIS



PATHOGENESIS of RHABDOMYOLYSIS-INDUCED ARF

A. Intravascular volume depletion

- **Compartment syndrome**
- **Vasoconstrictor substances**

B. Direct toxicity of myoglobin

C. Intratubular obstruction (myoglobin, uric acid)

D. Other factors

- **Free iron**
- **Hyperphosphatemia**
- **Hyperuricemia**
- **Disseminated intravascular coagulation**
- **Free radicals**
- **Infection**
- **Drug induced nephrotoxicity**

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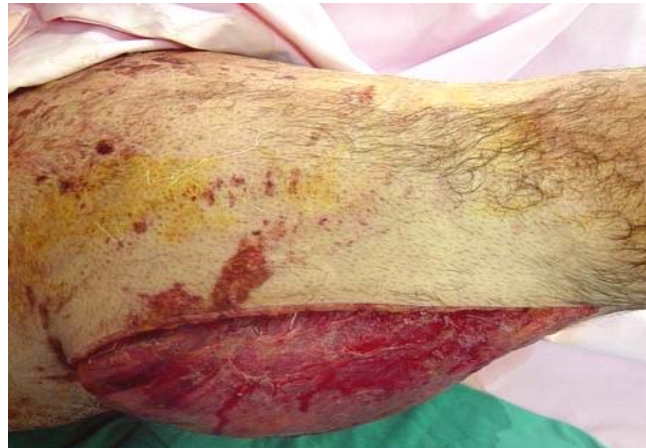
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CONCLUSIONS

CLINICAL FINDINGS

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

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



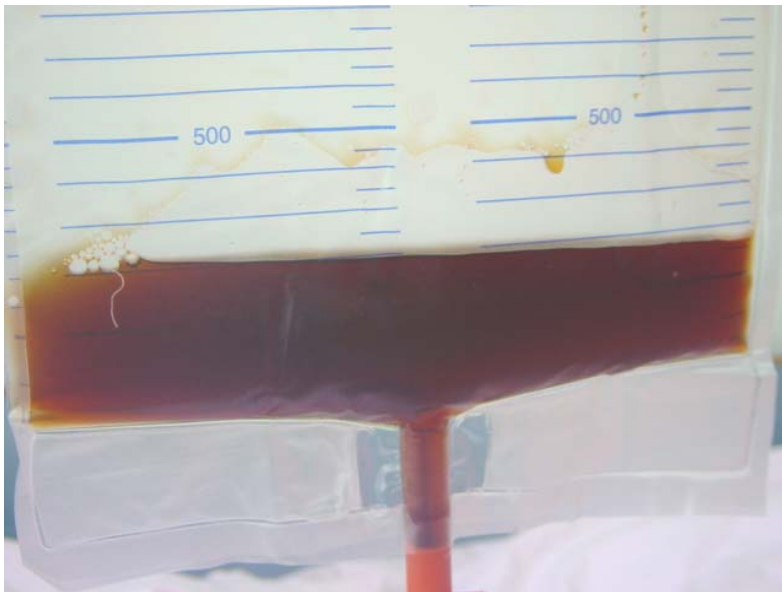
Systemic manifestations of rhabdomyolysis (C.S.)

- Hypovolemic shock
- ARF
- Hyperkalemia
- Heart failure
-

LABORATORY FINDINGS

Urinary findings

- Myoglobinuria
- Other findings



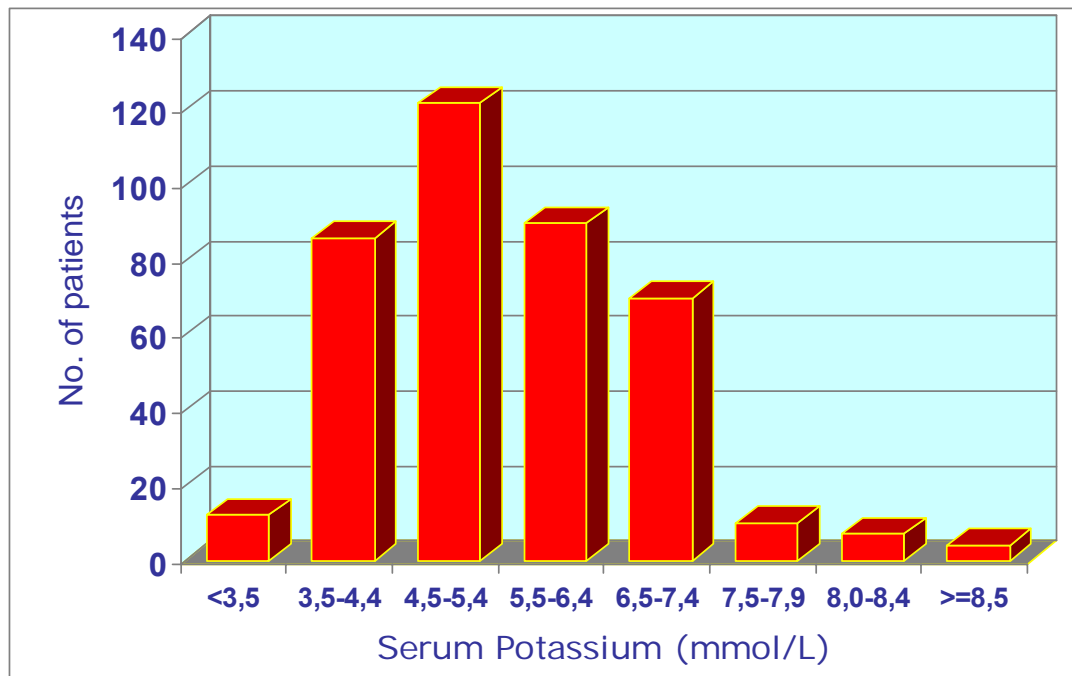
Biochemistry

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

SERUM POTASSIUM ON ADMISSION

(The Marmara Earthquake Experience)

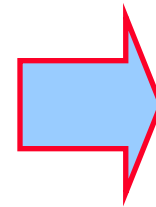
5.3 ± 1.3 (2.4 – 13.3) mmol/L



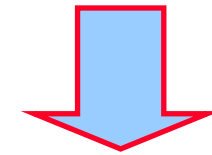
Cum. No. of the pts.	Potassium (mmol/L)
22	< 3.5
116	>=6.5
70	>=7.0
6	>=8.5

Many patients died at the disaster field or within the first hours of admission to hospitals due to fatal hyperkalemia!

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



**RESCUE
DEATH**



- Severe metabolic acidosis
- Fatal hyperkalemia

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PROPHYLAXIS of CRUSH SYNDROME - I

**EARLY FLUID ADMINISTRATION
IS OF VITAL IMPORTANCE !**

(1 L/hr saline)



- After the rescue → alkaline solution
- Adequate urine response ⇒ + mannitol → 8 - 12 L/day
- Less aggressively (4 - 6 L/day) in disasters
- **CVP measurements**

THERAPEUTIC INTERVENTIONS

MEDICAL

- Blood and blood product transfusions
- Renal replacement therapy
- Treatment of infections and other complications

SURGICAL

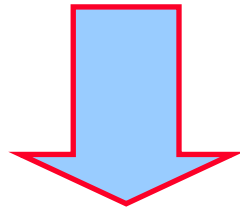
- Management of traumatic wounds, amputations
- Fasciotomy

BLOOD and BLOOD PRODUCT TRANSFUSIONS

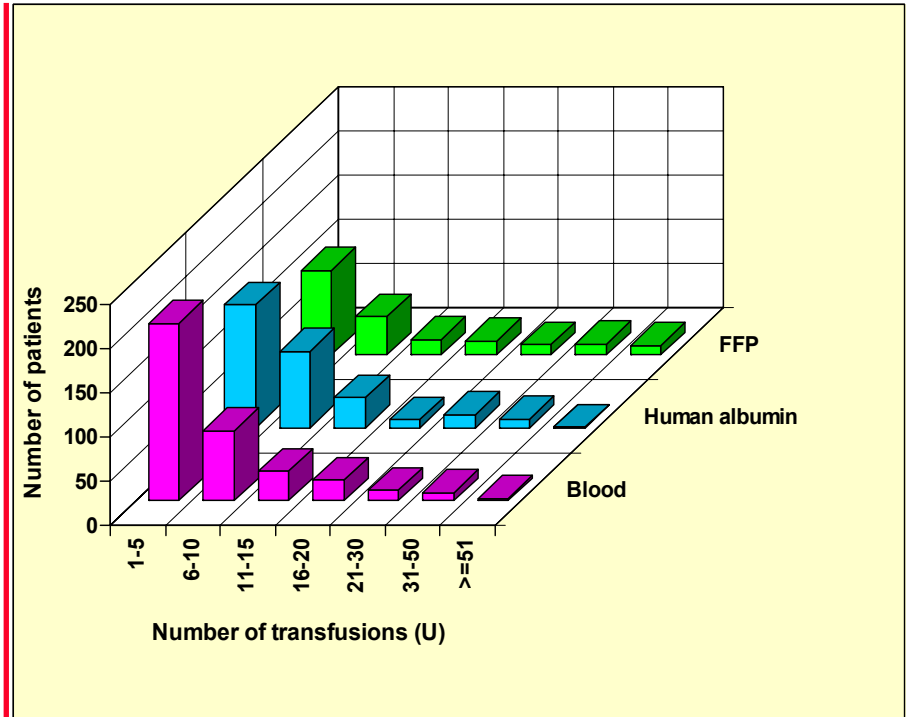
(The Marmara earthquake experience)

Blood: 2981 u.
FFP: 2837 u.
H. alb.: 2594 u.

4u.



8500 units



- Medical concerns
- Logistic concerns

RENAL REPLACEMENT THERAPY -I

Dialysis indications:

- Clinical symptoms of uremia
(hypertension, volume overload, nausea...)
- Biochemical abnormalities
(severe uremia, hyperkalemia, acidemia..)

Prophylactic dialysis

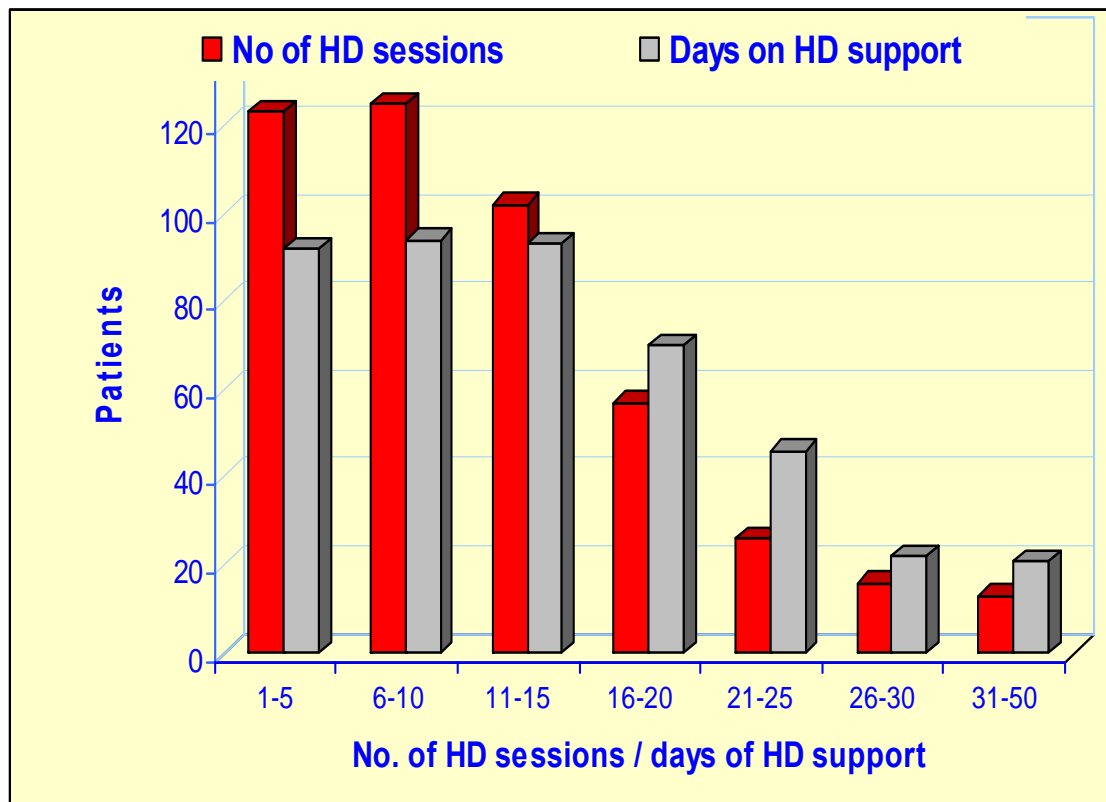
-High risk for hyperkalemia

RENAL REPLACEMENT THERAPY -II

(The Marmara Earthquake experience)

RRT support in 477 (74.6%) patients

IHD: 462, SCT: 34, PD: 8



HD sessions: 11.1 ± 8.0
Days on HD: 13.4 ± 9.0

**5137 sessions
of IHD**

Sever et al. Kidney Int 2002

FASCIOTOMIES in the Marmara E.

397 fasciotomies
in 323 patients

Sepsis: Fasc. (+): 25%
Fasc. (-): 13%

Mortality: Sepsis (+): 27%
Sepsis (-): 12%

**Fasciotomies ⇒
objective criteria**

Sever et al. NDT 2002



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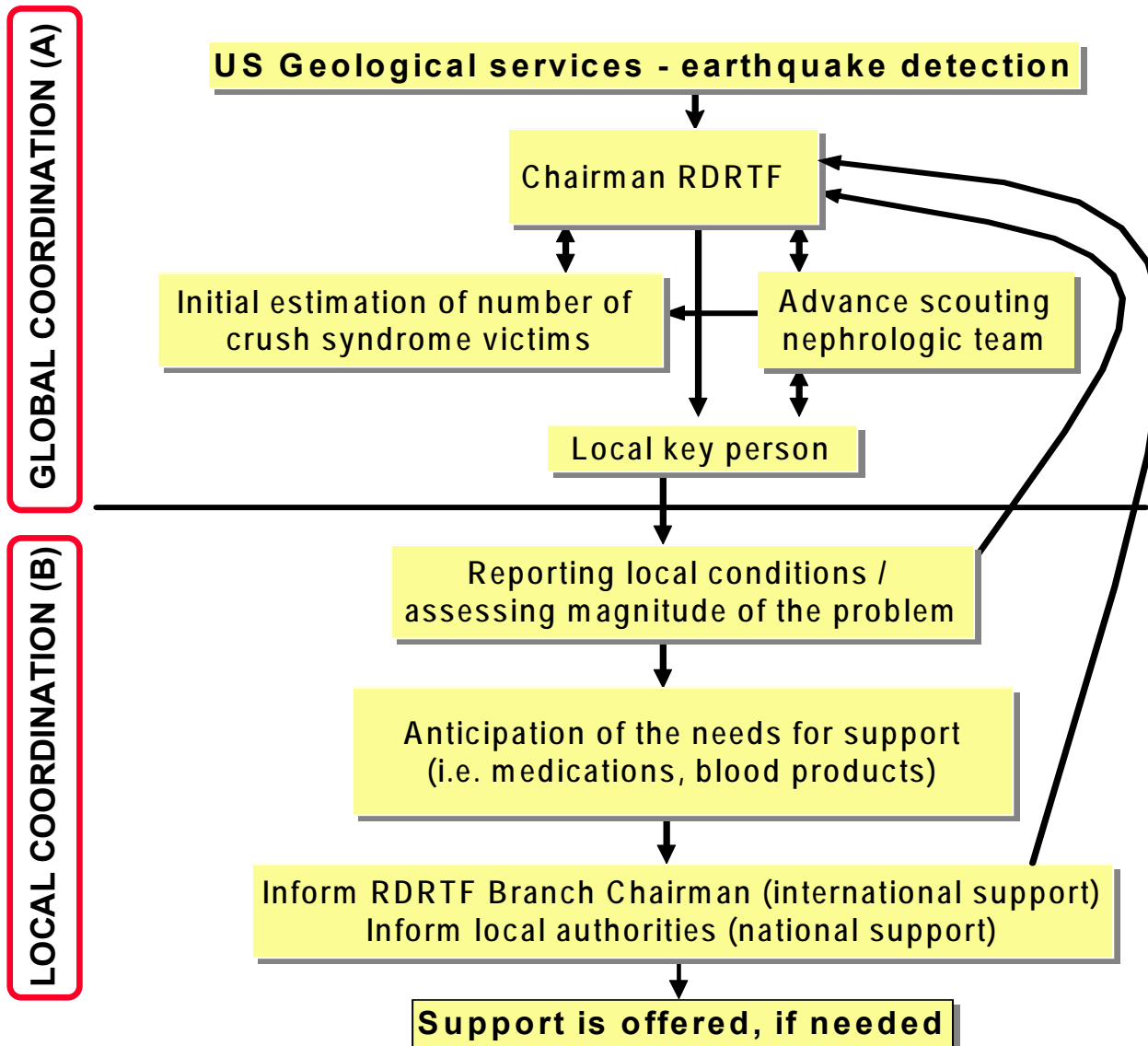
CONCLUSIONS

LOGISTICS

- Procurement
 - Maintenance
 - Distribution
 - Replacement
- Personnel / material**

Vital in disasters due to chaotic conditions

LOGISTIC PLANNING



LOCAL LOGISTIC INTERVENTIONS

I. Severity assesment

III. Medical support

II. Providing health care

- Rescue activities
- Evacuation of the victims
- Logistic planning in hospitals

IV. Other logistic issues

- Global logistic needs
- Managing chr. patients
- Medical records

SEVERITY ASSESSMENT - I

- Following major earthquakes:

Deaths / Injured: $\approx 1 / 3$

- The Marmara Earthquake: **$\approx 1 / 2.5$**
(17,480 / 43,953)

- Crush syndrome in the injured: **2 - 5%**

- The Marmara Earthquake: **$\approx 1.5\%$**
(639 / 43,953)

2 - 3% of all casualties ~ crush syndrome

SEVERITY ASSESSMENT - II

**Many
factors
effective!**

- Intensity of the disaster
- Population density of the region
- Structural characteristics of buildings
- Timing (moment) of disaster
- Efficacy of rescue activities

Noji et al., 1990; Nadjafi et al., 1997



Gujarat Earthquake:
Death: 19,727, Cr.:35

Viroja et al, WCN Abstracts, 2001



Bam Earthquake:
Death: 26,000; Cr.: 124

Argani et al, JASN, 2004



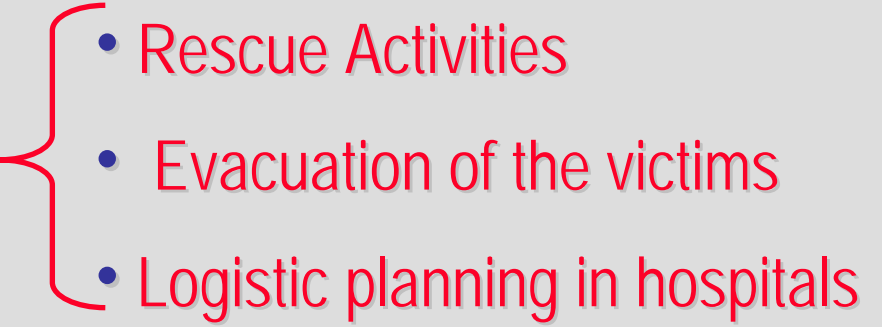
September 11 terrorism
Death: >3,000; Cr.: 1

Goldfarb and Chung, Am J Med, 2002

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- Severity assesment
 - **Providing health care**
 - Medical support
 - Other logistic issues
- 
- Rescue Activities
 - Evacuation of the victims
 - Logistic planning in hospitals

CONCLUSIONS

RESCUE ACTIVITIES

(The Armenian Earthquake Experience)

RESCUER	<i>n</i>	%
Ordinary people (untrained)	125	55.1
Self	21	9.3
Military member	13	5.7
Experienced Soviet rescue teams	6	2.6
Experienced foreign rescue teams	2	0.9
Unidentified	136	60
Total	227	100

SOUTHERN ITALIAN EARTHQUAKE

-Only 18% of the uninjured people took part in the rescue activities

People living in disaster prone regions should consider that they are needed as "rescuers" in the case of a disaster.

RESCUE ACTIVITIES

(Time period under the rubble)

The Marmara Earthquake:

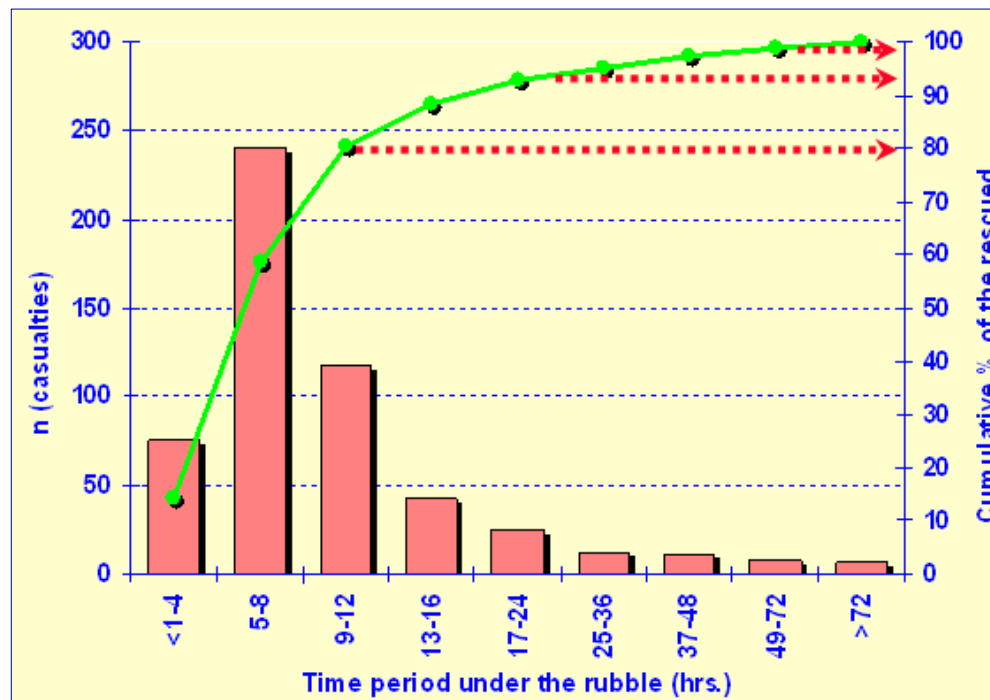
11.7±14.3 (0.5-135) hrs.

Sever et al. KI 2002

Kobe Earthquake:

9 hrs.

(Oda et al, J Trauma 1997)



**Rescue activities within the first 2 days
are of vital importance**

EVACUATION of the VICTIMS

- Aftershocks may further damage hospitals
- Keeping positions open for untransportable cases
- Locally treated patients have a higher risk of mortality

Kuwagata et al, 1997



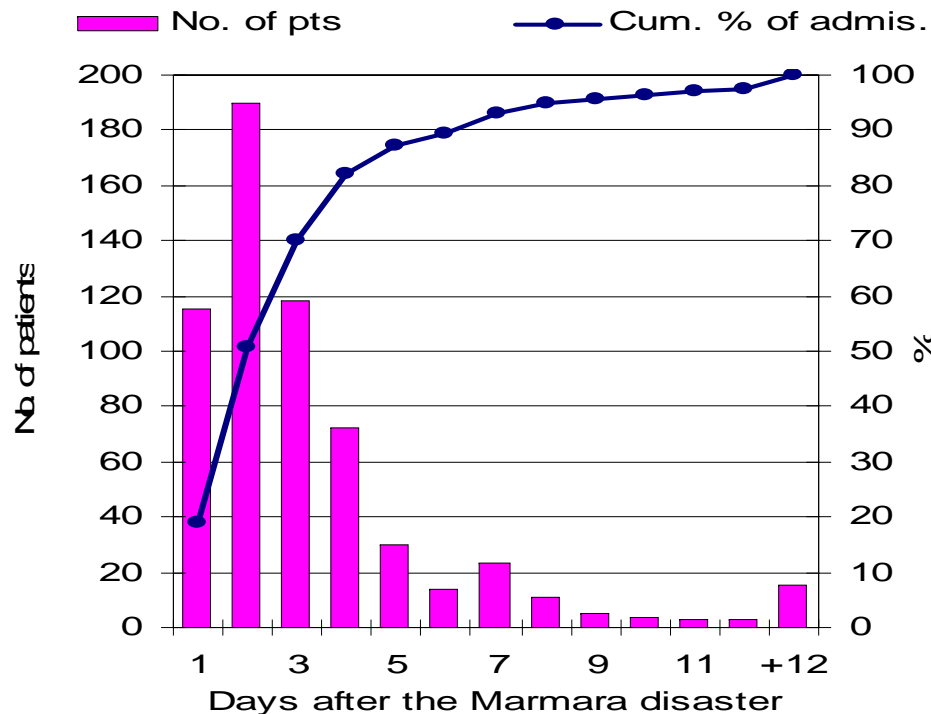
Administer potassium binders before transportation !

LOGISTIC PLANNING in HOSPITALS - I

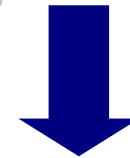
(Timing of hospital admissions)

In disasters most admissions occur within 3 days

Noji, 1990



Mildly injured victims:



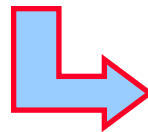
- Arrive shortly after disaster
- Occupy positions of more seriously wounded cases, who often arrive later.
- Can be followed as outpatients

LOGISTIC PLANNING in HOSPITALS - II

(Status of health care personnel)

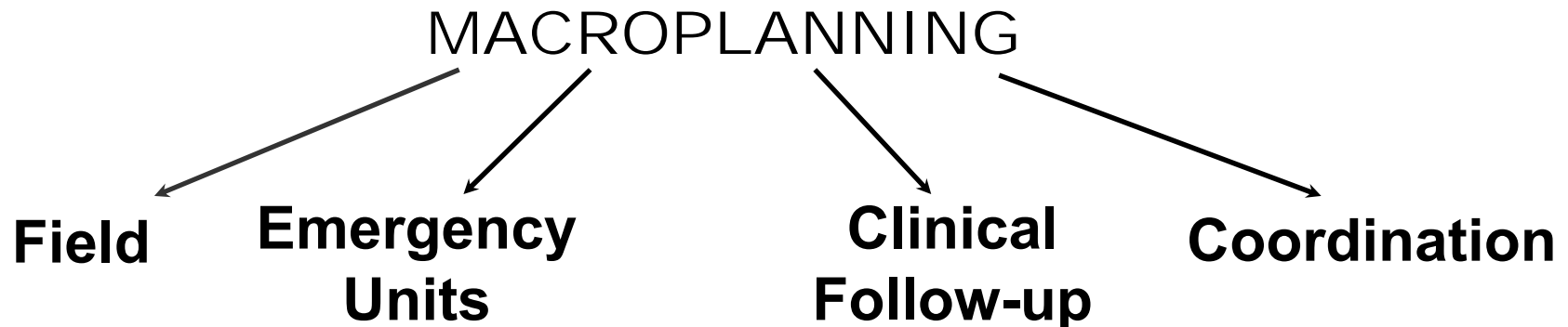
- Personal harm to themselves or family members
- Work overload
- Panic and depression

Ukai, 1997; Waeckerle, 1991



INEFFECTIVE WORK

- Experienced personnel \Rightarrow first days
- Avoid “burn-out” syndrome
- Clear guidelines may minimize risk of malpractice



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CONCLUSIONS

SUPPORT of MEDICAL MATERIAL and PERSONNEL

International relief \neq functional help

- Guatemalan e. \Rightarrow 90% drugs useless (unsorted) Seaman, Injury, 1990
- Armenian e. \Rightarrow 70% useless (expired or damaged) Auiter, Lancet, 1990

International personnel support \Rightarrow useful or harmful

Local / Global integrated responses are mandatory !

ANTICIPATING THE NEEDS FOR MEDICAL ITEMS



Crystalloids \Rightarrow 5L / pt./day ... $(3000 \times 5 \times 7) = 105,000$ L

Kayexalate \Rightarrow 15 g / pt/day.. $(3000 \times 15 \times 7) = 315$ kg

HD sess. \Rightarrow 11 / pt ... $(3000 \times 0,75 \times 11) = 24,750$ sets

Blood:.. $4,6 \times 3000 = 13,800$; FFP:.. $4,4 \times 3000 = 13,200$; Hum.Alb:... $4.0 \times 3000 = 12,000$

OVERALL: 39,000 U blood and blood products

CONCLUSIONS

- **Disasters and subsequent "renal disasters" will continue to be major causes of death in the future.**
- **Number of deaths due to crush s. (renal disaster victims) can be decreased by appropriate management.**
- **Medical practice during disasters differ considerably as compared to routine medical applications.**
- **National / international disaster preparedness and logistic planning can be helpful to decrease post-disaster chaos and provide effective health care.**