



# Taller de Especialización en Rescate Urbano

## Lección:

### Síndrome de aplastamiento

#### Instructor:

Álvaro Mardones Rodríguez

Medico Cirujano

Voluntario de la 1ª Compañía del CBS





# Crush Syndrome (Síndrome de aplastamiento)

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**¿Porqué partir de esto?**

## ¿Por qué es importante?



- **Última década en 3850 desastres, fallecieron 780.000 personas**
- **Causa mas frecuente de muerte después de trauma**
- **No descrito en textos de nefrología**
- **“Epidemia” en Terremotos**



# Líderes y equipo médico deben conocerla!!

**Solo el 3,5% de las víctimas son atendidas por equipos especializados**



**Las intervenciones apropiadas salvan vidas**



# Objetivos

- **Conocer la Epidemiología**
- **Entender la Fisiopatología**
  - ✓ **Efectos y daños por Sistema**
- **Controversias en el manejo**
- **Algoritmos de manejo**





## Antecedentes históricos

- **1909 Messina;  
Sicilia**
- **WW1, Literatura  
Alemana**
- **1941 Bombardeo  
Londres**





Nov. 28, 1942

CRUSHING

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# War Medicine Series

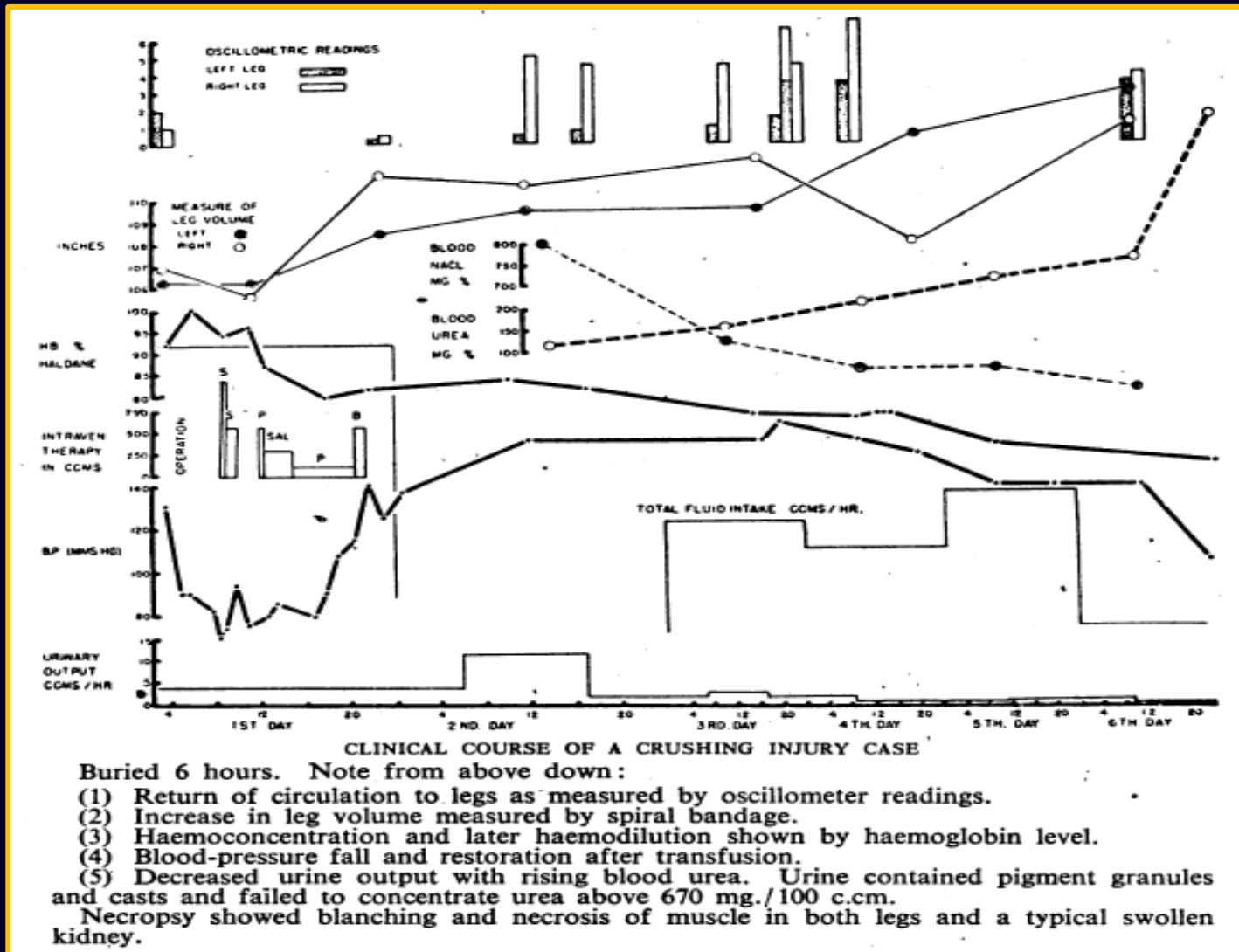
*The paper printed below is based on a lecture which was one of a series recently given at the British Postgraduate Medical School, Hammersmith*

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## CRUSHING INJURY

BY

E. G. L. BYWATERS,\* M.B., M.R.C.P.







# Conceptos

## Crush Injury o lesión por atrición

**Lesión por daño directo por parte de material colapsado que produce un aumento de volumen y/o una alteración neurológica en la parte del cuerpo comprometida**



**Nephrol Dial Transplant (2012) 27**



# Crush Syndrome

**Síndrome por Atrapamiento:**  
Lesión por atrición asociada a manifestaciones sistémicas dadas por la lesión muscular

## Las manifestaciones sistémicas incluyen:

Injuria renal aguda (AKI), Sepsis, Sd. de distrés respiratorio agudo (SDRA), coagulación intravascular diseminada (CID), sangrado, Shock hipovolémico, falla cardíaca, arritmias, alteraciones electrolíticas, y trauma psicológico.

Sever MS, Vanholder R and the Workgroup on Recommendations for the management of crush victims in mass disasters. Nephrol Dial Transplant 2012

# Emergencias en MCS



- **Colapso de vivienda**
- **Terremotos**
- **Aluviones**
- **Bombazos**
- **Accidentes en construcción**
- **Zanjas**



## 10-3-7: Rescate en Colina



**10-3-7**

**Personas atrapadas  
producto del derrumbe  
de un inmueble de  
gran envergadura o de  
parte de este**

**Mardones et al. Prehospital  
& Disaster Medicine (2015)**



# Desastre Renal

**Table 1.** Major earthquakes of the last 20 years with reported statistics in the literature.<sup>9-11</sup>

Location, country (year)	Mortality	Crush syndrome
Spitak, Armenia (1988)	25,000	600
Northern Iran (1990)	>40,000	(?)
Kobe, Japan (1995)	5,000	372
Marmara, Turkey (1999)	>17,000	639
Chi-Chi, Taiwan (1999)	2,405	52
Gujarat, India (2001)	20,023	35
Boumerdes, Algeria (2003)	2,266	20 (?)
Bam, Iran (2003)	26,000	124
Kashmir, Pakistan (2005)	>80,000	118
Sichuan, China (2008)*	69,000	?
Haiti (2010)	220,000	92
<b>TOTAL</b>	<b>&gt;500,000</b>	<b>&gt;2,000</b>

**>60%**



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

INVITED CONTRIBUTION

## International dialysis aid in earthquakes and other disasters<sup>1</sup>

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,<sup>2</sup> J.P. WAUTERS,  
and YASUHIRO YAMAMOTO

- **1989 The International Society of Nephrology**
- **Renal Disaster Relief Task Force (RDRTF)**
- **Médicos sin fronteras**

**Collins AJ. Kidney dialysis treatment for victims of the Armenian earthquake. N Engl J Med 1989; 320: 1291–1292.**



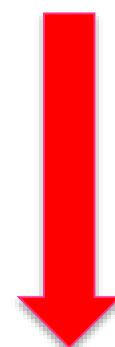
# Earthquakes and crush syndrome casualties: Lessons learned from the Kashmir disaster

R Vanholder<sup>1,2</sup>, A van der Tol<sup>1,2</sup>, M De Smet<sup>3</sup>, E Hoste<sup>4</sup>, M Koç<sup>5</sup>, A Hussain<sup>6</sup>, S Khan<sup>6</sup> and MS Sever<sup>7,8</sup>

<sup>1</sup>Renal Disaster Relief Task Force of the International Society of Nephrology, Gent, Belgium; <sup>2</sup>Department of Internal Medicine, Renal Division, University Hospital, Gent, Belgium; <sup>3</sup>Médecins Sans Frontières, Brussels Operational Center, Brussels, Belgium; <sup>4</sup>Intensive Care Unit, University Hospital, Gent, Belgium; <sup>5</sup>Department of Internal Medicine/Nephrology, Marmara University, Marmara School of Medicine, Istanbul, Turkey; <sup>6</sup>Department of Nephrology, Pakistan Institute of Medical Science, Islamabad, Pakistan; <sup>7</sup>Renal Disaster Relief Task Force for Turkey, Istanbul, Turkey and <sup>8</sup>Department of Internal Medicine/Nephrology, Istanbul University, Istanbul School of Medicine, Istanbul, Turkey

**Table 4 | Ratio of dialyzed AKI victims over number of deaths in nine recent earthquakes**

Location	Country	Year	(Dialysed AKI/deaths) × 1000
Spitak	Armenia	1988	≥ 9.0
Northern Iran <sup>a</sup>	Iran	1990	3.9
Kobe	Japan	1995	24.6
Marmara <sup>a</sup>	Turkey	1999	27.3
Chi-Chi	Taiwan	1999	13.3
Gujarat	India	2001	1.7
Boumerdes	Algeria	2003	6.6
Bam	Iran	2003	3.7
Kashmir <sup>a</sup>	Pakistan	2005	0.8



AKI, acute kidney injury.

Information extracted from Sever *et al.*<sup>2</sup>

<sup>a</sup>For the Northern Iran, Marmara, and Kashmir earthquake, the minimum estimated number of fatal victims was taken into account.



# FISIOPATOLOGÍA

## Rabdomiolísis





## FISIOPATOLOGÍA

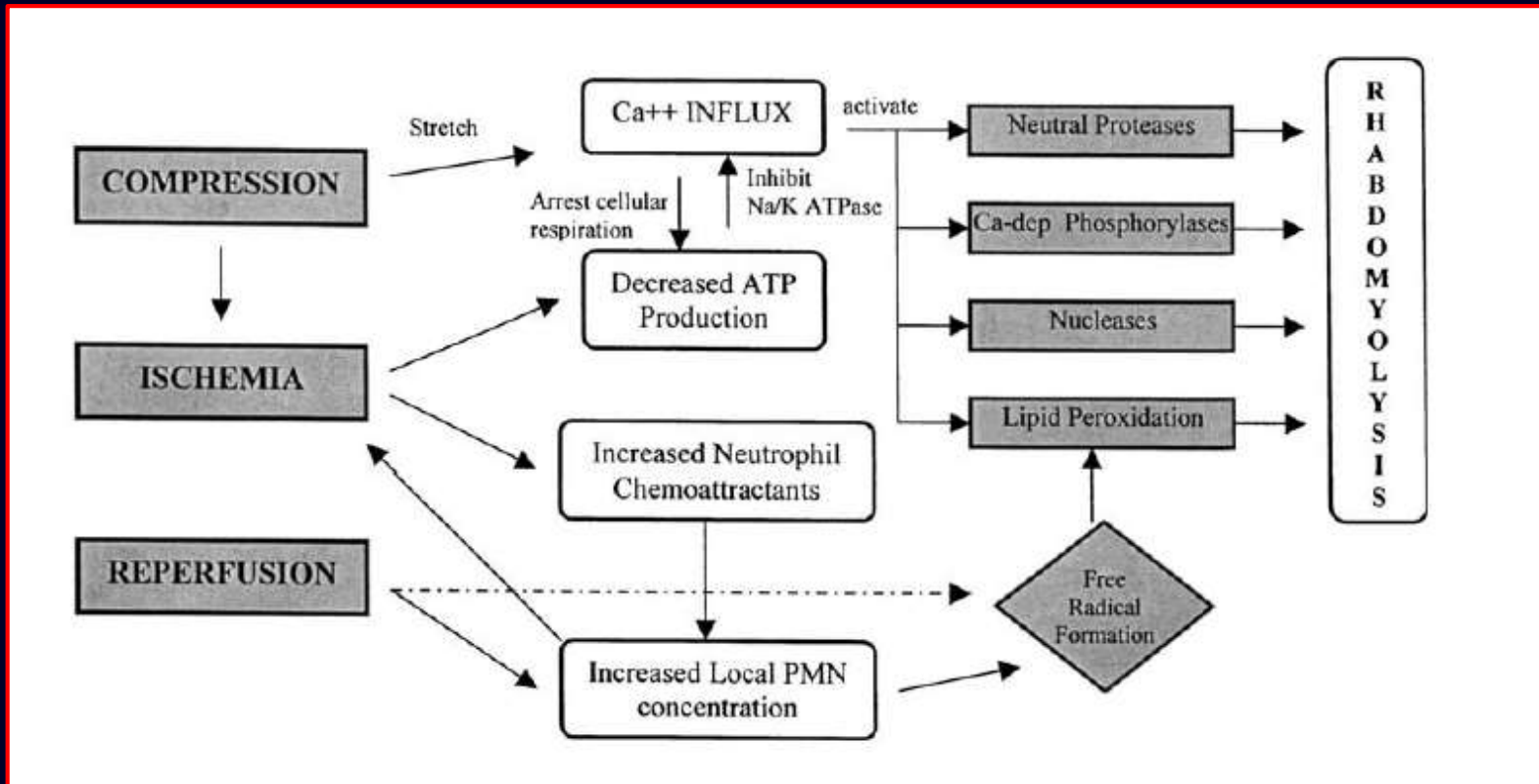
# Rabdomiolísis



**Es la liberación de los componentes del músculo esquelético dañado a la circulación**

**Knochel JP. Rhabdomyolysis and myoglobinuria. Annu Rev Med 1982;33:435-43**

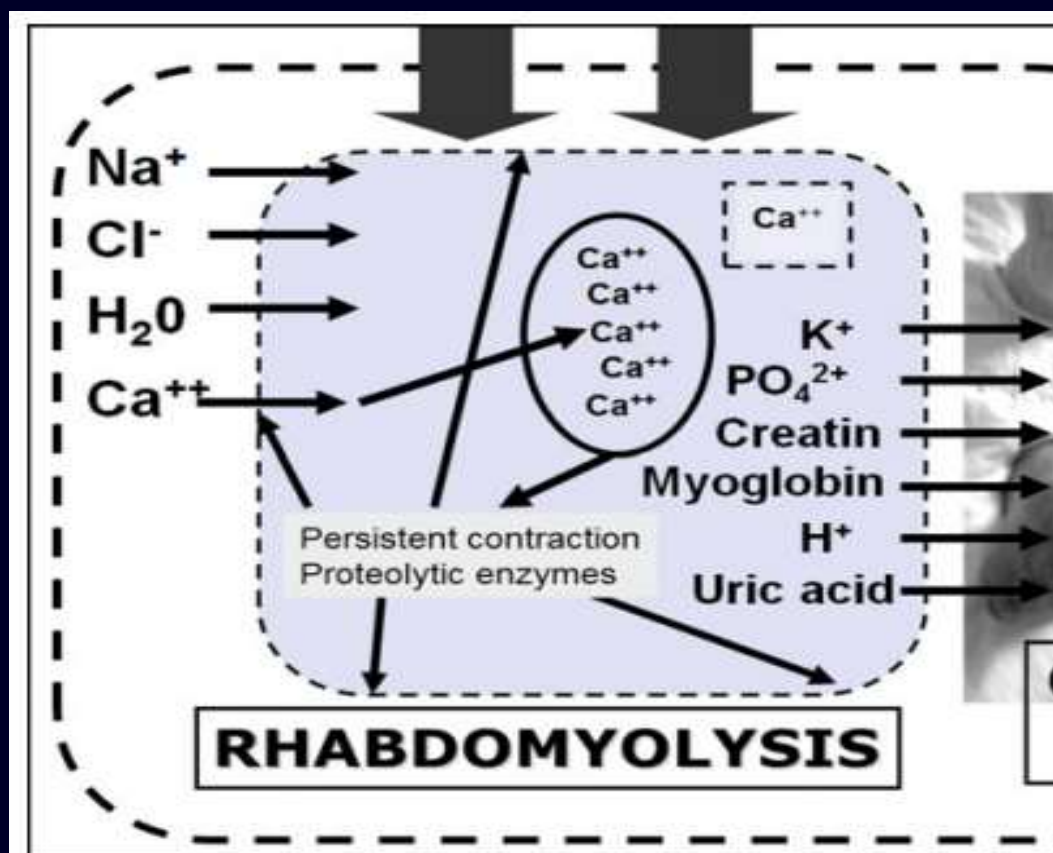
# Fisiopatología lesión muscular



Malinoski et al; Crush Injury & Rhabdomyolysis;  
Crit Care Clin 20 (2004) 171– 192

## Disaster nephrology: a new concept for an old problem

Mehmet Sukru Sever<sup>1</sup>, Norbert Lameire<sup>2</sup>, Wim Van Biesen<sup>3</sup> and Raymond Vanholder<sup>2</sup>



## 3 Pilares Fundamentales



1. **Masa muscular involucrada**
2. **Compresión prolongada (usualmente 4–6 hrs. pero posiblemente 1 hora)**
3. **Compromiso de la circulación local**



# Rescue Death

- **Liberación extremidad--- Contenido celular a sangre**
- **Componentes principales: Exposición de Toxinas e Hipovolemia**

## Intracellular contents released during rhabdomyolysis and their effects

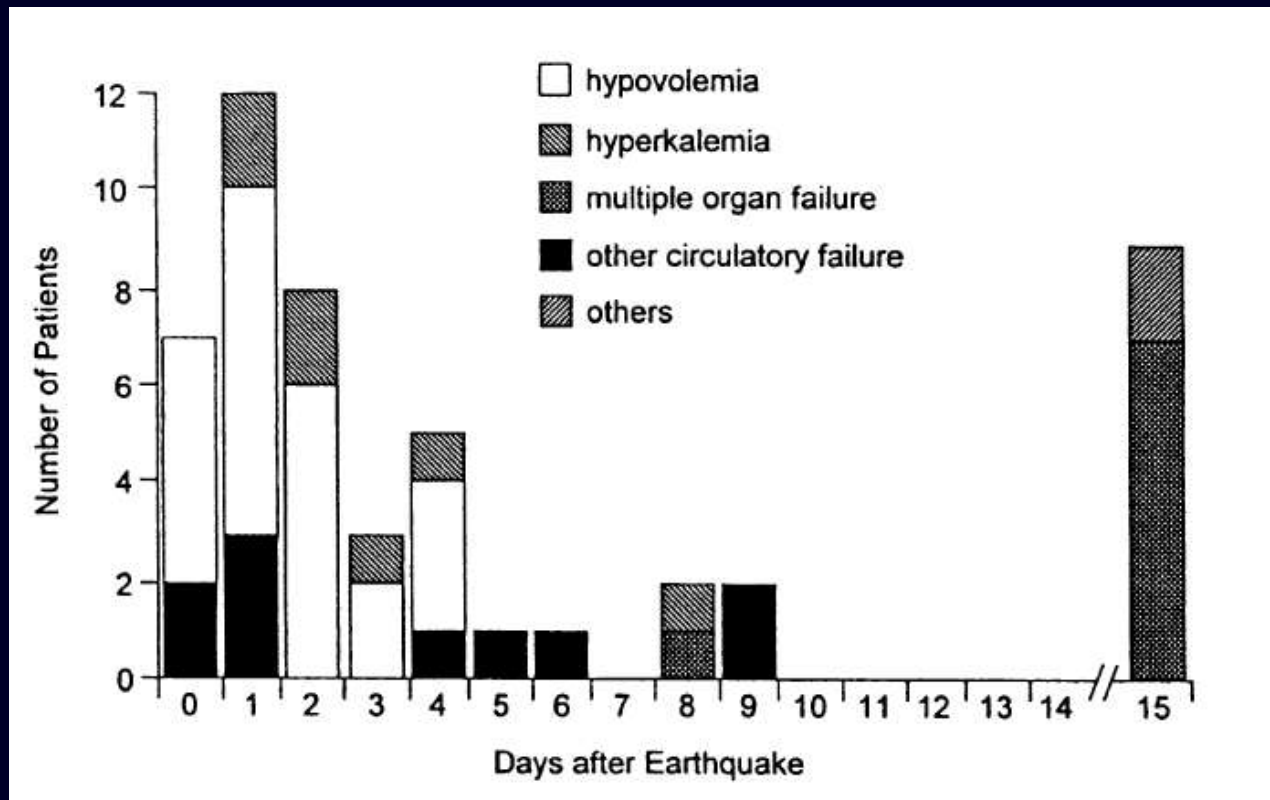
Agent	Effect
Potassium	Hyperkalemia and cardiotoxicity, provoked by hypocalcemia and hypovolemia
Phosphate	Hyperphosphatemia, worsening of hypocalcemia, and metastatic calcification
Organic acids	Metabolic acidosis and aciduria
Myoglobin	Myoglobinuria and nephrotoxicity
Creatine kinase (CK)	Elevation of serum CK levels
Thromboplastin	Disseminated intravascular coagulation

# Shock Hipovolémico





# Shock Hipovolémico



Oda J, Tanaka H, Yoshioka T, et al. Analysis of 372 patients with crush syndrome caused by the Hanshin-Awaji Earthquake. *J Trauma* 1997;(42):470-6;



# Shock Hipovolémico

- **1ª Manifestación del CS**
- **Multifactorial**
  - ✓ **Hemorragias evidentes**
  - ✓ **Fracturas de extremidades-pelvis**
  - ✓ **Deshidratación**
- **Grandes Volúmenes de plasma acumulados en extremidades (permeabilidad capilar aumentada)**

**Blalock A. Experimental shock: the probable cause for the reduction in the blood pressure following mild trauma to as extremity. Arch Surg 1931;22:598–609**





# Efectos Cardiovasculares

## Sobrecarga de Toxinas

Intracellular contents released during rhabdomyolysis and their effects

Agent	Effect
Potassium	Hyperkalemia and cardiotoxicity, provoked by hypocalcemia and hypovolemia
Phosphate	Hyperphosphatemia, worsening of hypocalcemia, and metastatic calcification
Organic acids	Metabolic acidosis and aciduria
Myoglobin	Myoglobinuria and nephrotoxicity
Creatine kinase (CK)	Elevation of serum CK levels
Thromboplastin	Disseminated intravascular coagulation

# Hiperkalemia

Cardiotoxicidad en el ECG por hiperpotasemia:

- $\pm 6.5$  mEq/l  $\rightarrow$  ondas T picudas
- $> 7$  mEq/l  $\rightarrow$   $\uparrow$  PR, se pierde la onda P y  $\uparrow$  QRS.
- $> 8$  mEq/l  $\rightarrow$  arritmias ventriculares (taquicardia o fibrilación ventricular)  $\rightarrow$  paro cardíaco.





# Efectos Renales

- Es la complicación mas seria del CS
- 40% van a desarrollar AKI
- 5-75% Diálisis
- Mortalidad 3-50%

Nephrol Dial Transplant (2002) 17: 33-40

*Dialysis and Transplantation News*

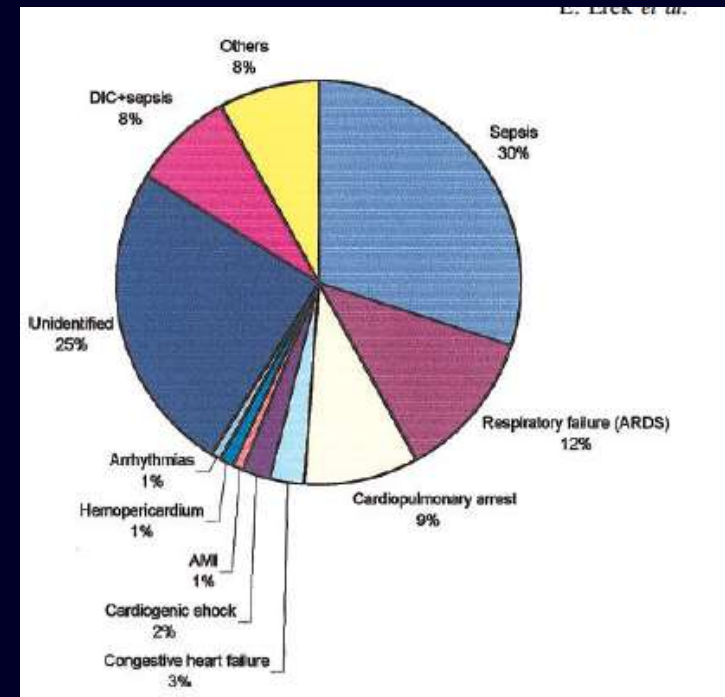
**Nephrology  
Dialysis  
Transplantation**

An overview of morbidity and mortality in patients with acute renal failure due to crush syndrome: the Marmara earthquake experience

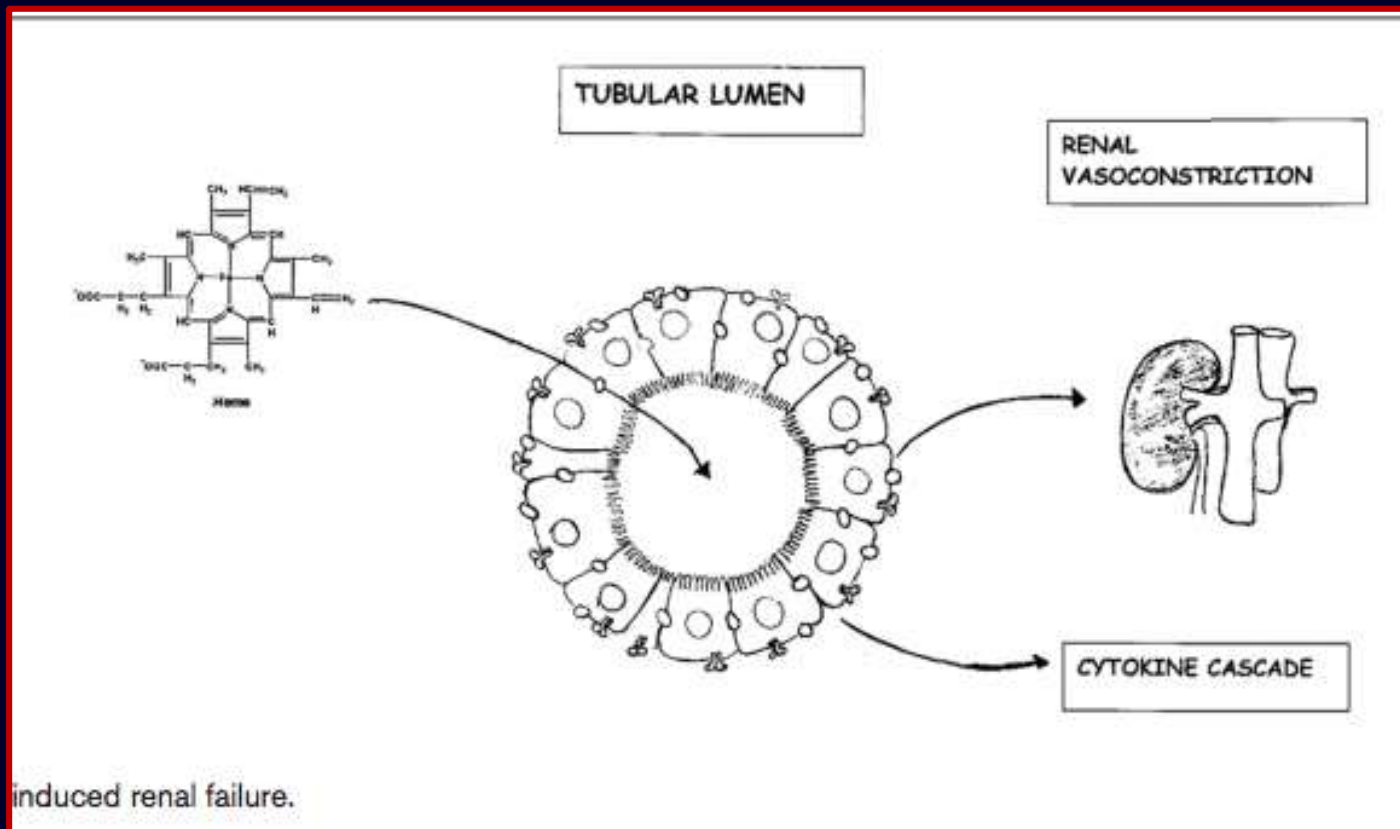
**Table 2. Dialysis experience of ARF patients with crush injuries (n = 639)**

Type of dialysis	Number of patients	(%)
Not dialysed	162	25.3
HD alone	437	68.3
HF alone	11	1.7
PD alone	4	0.6
HD+HF	21	3.5
HD+PD	2	0.3
PD+HF+HD	2	0.3

HD, haemodialysis; PD, peritoneal dialysis; HF, haemofiltration.



# Efectos Renales



**Huerta-Alardín, Bench-to-bedside review: Rhabdomyolysis – an overview for clinicians, Critical Care 2005, 9:158-169**



# Efectos Renales



**Huerta-Alardín, Bench-to-bedside review: Rhabdomyolysis – an overview for clinicians, Critical Care 2005, 9:158-169**



## Crush Injury and Crush Syndrome: A Review

Jason Smith, MD, and Ian Greaves, MD

### Mecanismos

- **Vasoconstricción renal secundaria a shock**
- **Nefrotoxicidad secundaria a mioglobinuria**
- **Daño tubular agudo**
- **Obstrucción Luminal**
- **Falla renal aguda**



# Pulmonar

- **SDRA por mediadores inflamatorios**
- **Émbolo graso**
- **Fx Costales/  
Pneumotórax**

## SDRA

**Síndrome de Distrés Respiratorio Agudo**



# Algoritmos de manejo

## RECOMMENDATIONS FOR THE MANAGEMENT OF CRUSH VICTIMS IN MASS DISASTERS

### **Nephrol Dial Transplant (2012) 27**



Official Publication of the European  
Renal Association -European Dialysis  
and Transplant Association

## Management of Crush Victims in Mass Disasters: Highlights from Recently Published Recommendations

*Mehmet Sukru Sever\* and Raymond Vanholder†*

**Clin J Am Soc Nephrol 8: 328–335, 2013**





- **NIVEL DE EVIDENCIA 3-4**
- **GR C-Sin Grado de Recomendación**



# Principios Médicos

- **Comenzar la evaluación a penas entre en contacto con la víctima**
- **Realizar todos los esfuerzos para determinar el status físico de la víctima (tipo y lugar de atrapamiento, posición, presencia de lesiones vitales o sangrado, volemia)**
- **Cuando establezca el contacto, puede que la evaluación sea indirecta**



# ATLS™

Primary Survey	Under Rubble	Just Extricated
Airway	Assume airway may be compromised	Assess
Breathing	Assume ventilation impaired secondary to dust and/or noxious gases inhalation and direct trauma	Assess
Circulation	Assume hypovolemia, crush injury	Assess
Disability	Assume neurologic examination incomplete	Assess
Exposure	Assume hypothermia, expose body parts only if deemed absolutely necessary for saving life	Expose and cover

**Ashkenazi I et al: Prehospital management of earthquake casualties buried under rubble. Prehosp Disast M<sup>2005</sup>;20(2):122-133.**



# CONTROVERSIAS

## ¿Qué Suero?





# CONTROVERSIAS

## Ringer Lactato





## Lactated Ringer's is Superior to Normal Saline in the Resuscitation of Uncontrolled Hemorrhagic Shock

S. Rob Todd, MD, Darren Malinoski, MD, Patrick J. Muller, BS, and Martin A. Schreiber, MD

**Background:** Normal saline (NS) and lactated Ringer's solution (LR) continue to be used interchangeably for the resuscitation of hemorrhagic shock in some institutions. We hypothesized that, aside from hyperchloremic acidosis, NS resuscitation would be similar to that of LR in a swine model of uncontrolled hemorrhage.

the baseline MAP for 90 minutes postinjury. Laboratory values were obtained at baseline and upon completion of the 2-hour study period.

**Results:** Initial blood loss was 25 mL/kg in the NS group and 22 mL/kg in the LR group ( $p = 0.54$ ). Animals required  $256.3 \pm 145.4$  mL/kg of fluid in the

cantly lower fibrinogen levels mg/dL versus  $123 \pm 20$  mg/dL. The serum lactate was  $4.7 \pm 2.2$  group and  $1.7 \pm 1.7$  in the NS s (0.01) at the end of the study.

**Conclusions:** Resuscitation trolled hemorrhagic shock with N significantly greater volume and

Proporciona: mEq/L	
Sodio	130,0
Potasio	4,0
Calcio	2,7
Cloruro	109,0
Lactato	27,7



## RECOMMENDATIONS FOR THE MANAGEMENT OF CRUSH VICTIMS IN MASS DISASTERS

**Principio 3:** Las soluciones que contengan potasio deben evitarse a toda costa en pacientes víctimas de crush en desastres

Proporción: mEq/L	
Sodio	30,0
Potasio	4,0
Calcio	2,7
Cloro	109,0
Lactato	27,7



# Manitol







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### Table 3 Effects of Mannitol<sup>a</sup>

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#### Prerenal

Intravascular volume expansion

Increases cardiac output and contractility

Possibly reduction in intracompartment pressure in compartment syndrome

#### Renal

Increases glomerular filtration rate

Increases intratubular pressure and flow

Dilatation of renal vasculature

Causes osmotic diuresis

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<sup>a</sup> Data from Moore et al., 1998.<sup>22</sup>

### Prevention of Kidney Injury Following Rhabdomyolysis: A Systematic Review

Elizabeth J Scharman, William G Troutman



## Considerar:

- **Los efectos colaterales (ICC)**
- **Contraindicaciones (anuria)**
- **Reportes inconsistentes de su eficacia**

**No hay consenso en los grupos de trabajo y algunos sugieren una prueba de respuesta**



# Soluciones + Bicarbonato

**Profilaxis** en evitar la nefropatía por pigmentos del grupo heme

- **Alcalinización de la orina previene la precipitación de la mioglobina en los túbulos renales**
- **No existe evidencia de que la resucitación activa tenga beneficios**



# Crush Injury “cocktail”

**1.5 L SF 0.9%/hr agregar:**

- **1 amp bicarbonato**
- **10 g de manitol a cada litro.**
- **Post extricación, agregar 500 ml cristaloide/hr**

Crush syndrome

Dario Gonzalez, MD, FACEP

Crit Care Med 2005 Vol. 33

# Suero Fisiológico 0,9%



- **Cristaloide de elección por sociedad Americana y Europea**
- **Simplicidad**
- **Eventos víctimas masivas**



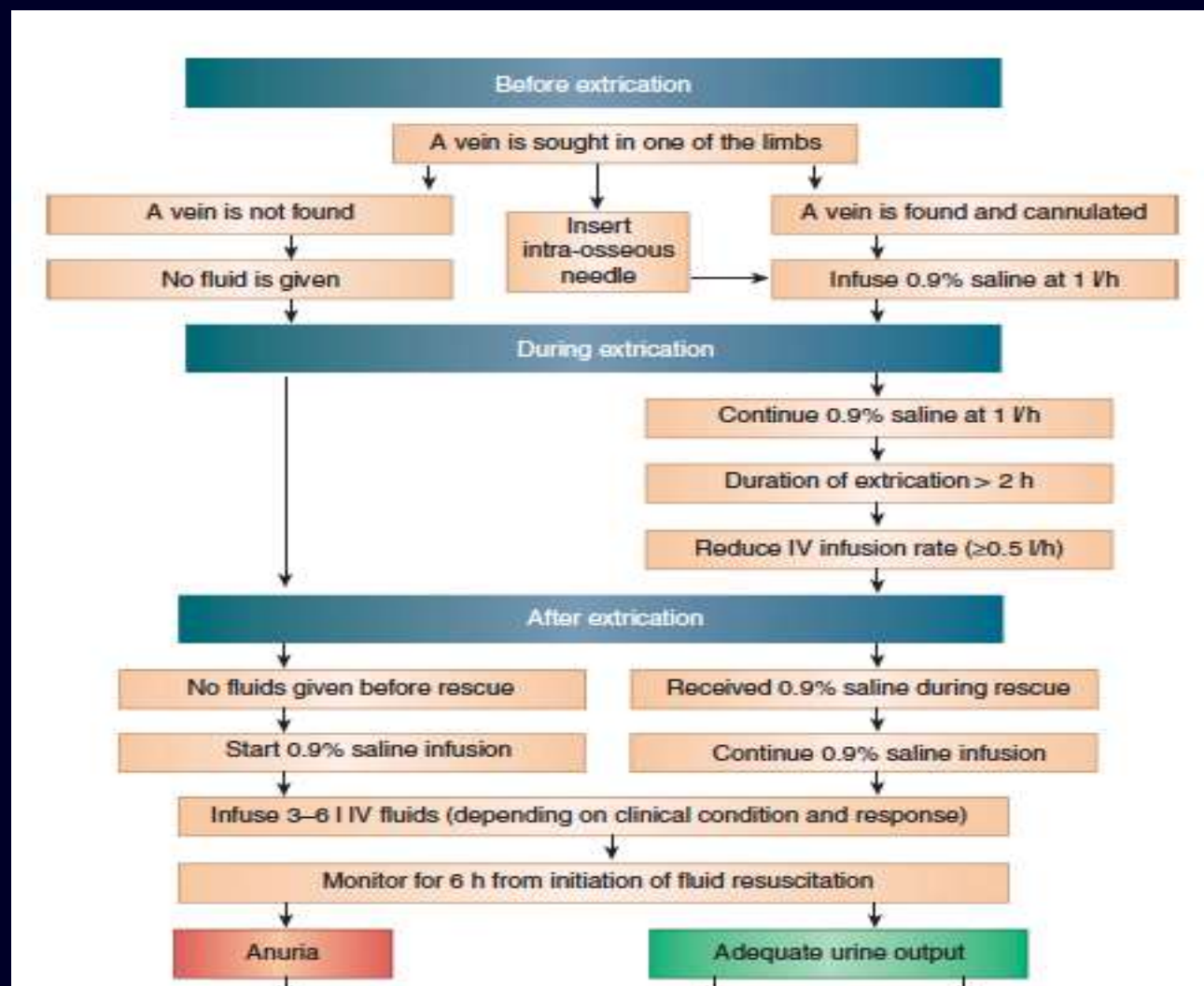
**Cuerpo de Bomberos de Santiago**  
**Escuela de Bomberos de Santiago**  
**Grupo USAR/CBS**

**¿Cuánto?**



# Manejo

- **Primeras 2 horas 1L/Hora o 15-20 mL/Kg/hr Niños**
- **Si el rescate dura mas...0,5 L/Hora**
- **Dependiendo de la dimensión del desastre (en desastres masivos, si no se puede monitorizar 3-6L/Día)**
- **Características del paciente: Viejos, Niños, Pacientes con Bajo IMC**
- **Condiciones del ambiente: En casos de bajas temperaturas...menos volumen**







*The Journal of TRAUMA® Injury, Infection, and Critical Care*

## Predictive Model for Estimating Risk of Crush Syndrome: A Data Mining Approach

Noriaki Aoki, MD, Janez Demsar, PhD, Blaz Zupan, PhD, Martin Mozina, BSc, Ernesto A. Pretto, MD, Jun Oda, MD, Hiroshi Tanaka, MD, Katsuhiko Sugimoto, MD, Toshiharu Yoshioka, MD, and Tsuguya Fukui, MD

### Initial Triage Data

Urine Color	Pulse Rate	Rescue Time	
		<3 h	≥3 h
Normal	<120/min	4% (<9)	18% (10–25)
	≥120/min	1% (<4)	23% (11–34)
Abnormal	<120/min	16% (4–28)	45% (38–51)
	≥120/min	19% (5–32)	100% (>99)

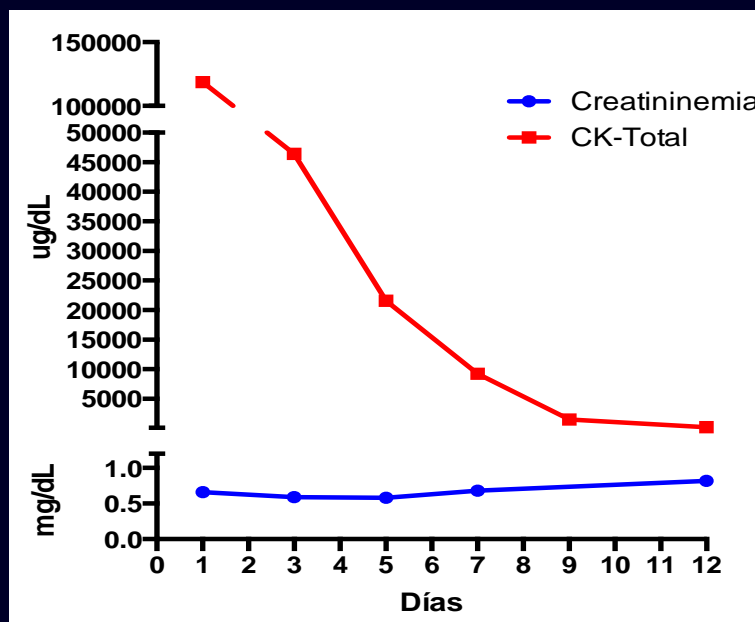


CASE REPORT

## Prevention of Crush Syndrome through Aggressive Early Resuscitation: Clinical Case in a Buried Worker

Alvaro Mardones, MD;<sup>1,2,3</sup> Pablo Arellano, MD;<sup>4</sup> Carlos Rojas, MD;<sup>5</sup> Rodrigo Gutierrez, MD;<sup>5</sup> Nicolas Oliver, MD;<sup>1</sup> Vincenzo Borgna, MD, PhD<sup>1,6</sup>

**1L / hr SF**  
**Todo el rescate**



PREHOSPITAL and  
DISASTER MEDICINE

**FALTAN  
PROTOCOLOS!!**



# Conclusiones

- **Patología alta incidencia en Terremotos**
- **De alta mortalidad tardía**
- **Prevenible y tratable si se conoce**



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