

APPROACH TO CRUSH INJURIES

Jameel Abualenain

MD, MPH, FACEP, FAAEM, CHSE

Chairman, Assistant Professor & Consultant

Department of Emergency Medicine

Deputy Supervisor, Academic Affairs, Clinical Skills & Simulation Center

King Abdulaziz University, Jeddah, Saudi Arabia

abualenain@kau.edu.sa

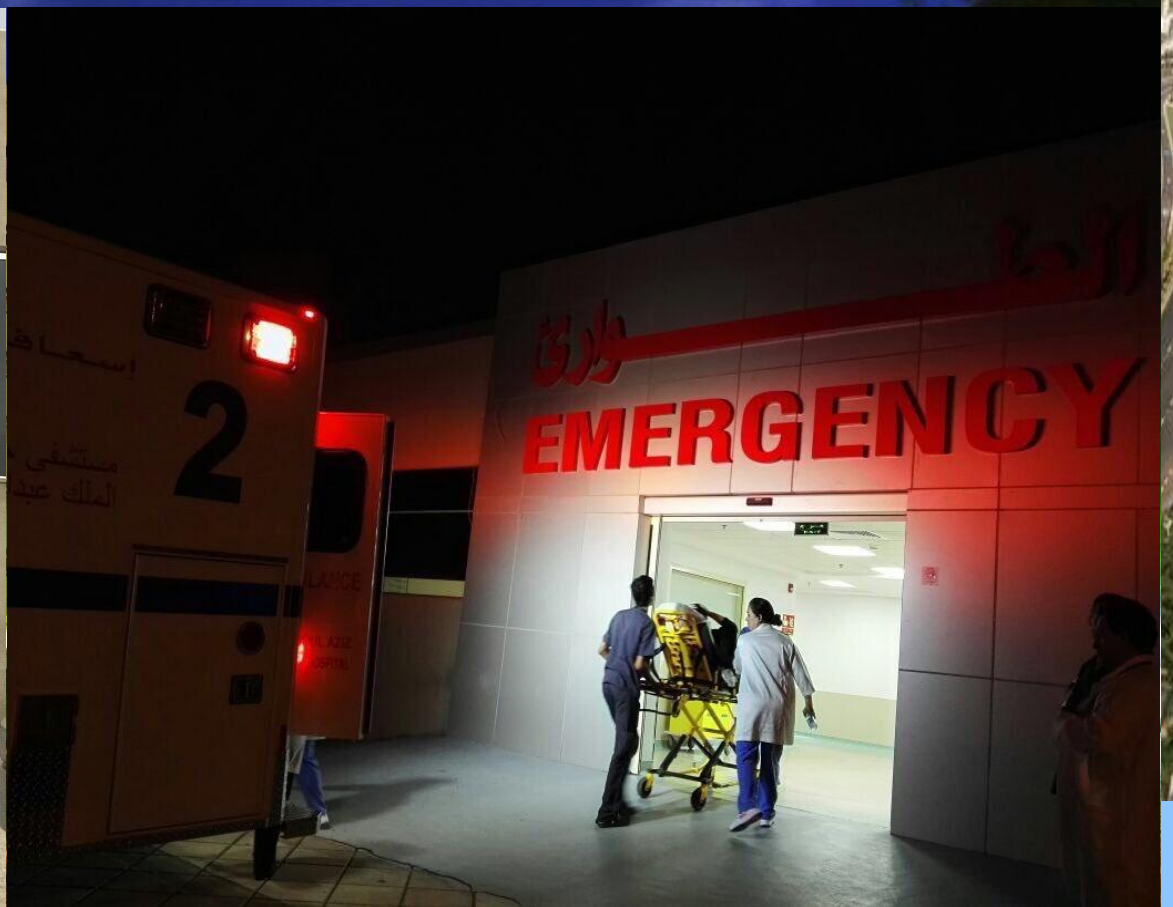


@JameelEM

NOTHING TO DISCLOSE

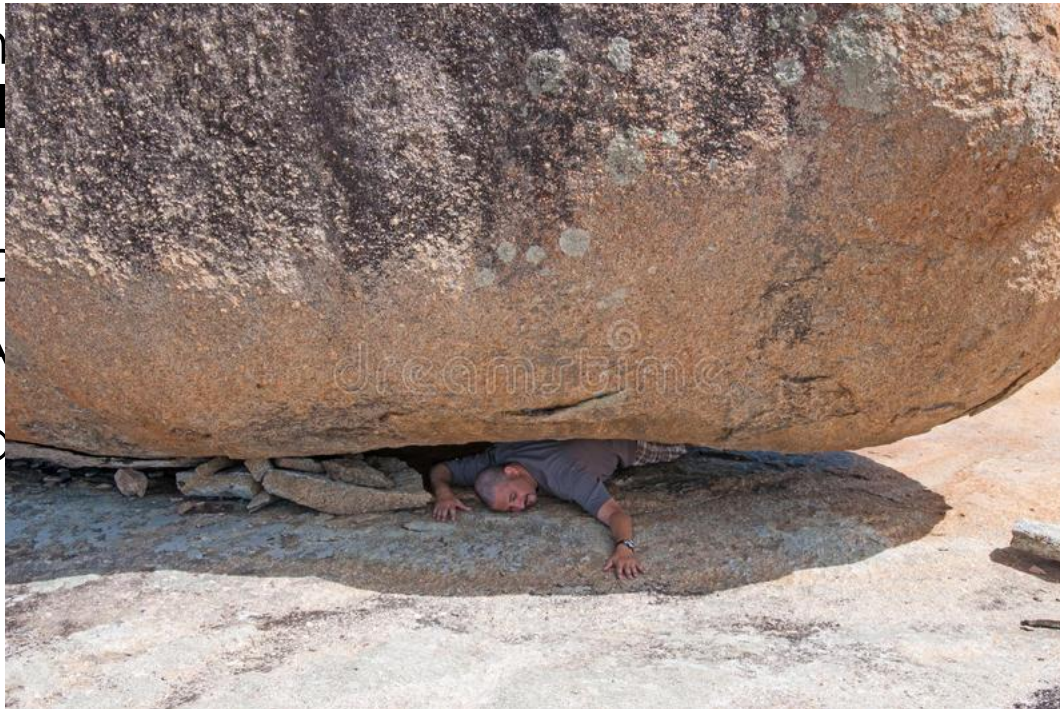


@JameelEM



CASE

- 37 Male, in
of a hill col
huge rock
- Paramedic
- Patient is A
- EMS called
doctor?



parts
/ a



OBJECTIVES

- Definitions
- Epi
- Pathophysiology
- Clinical Picture
- Management
- Home messages

DEFINITIONS

- **Crush injury**

when a body part is subjected to a high degree of force or pressure, usually after being squeezed between two heavy or immobile objects.

- Crush injury that produces ongoing ischemia of a fascial muscle compartment is termed **Compartment syndrome**, defined as increased pressure within a confined space that leads to microvascular compromise and ultimately to cell death as a result of oxygen starvation.
- **Crush syndrome** is the systemic manifestation of muscle cell damage resulting from pressure or crushing with or without subsequent compartment syndrome.

MASS CASUALTY WITH CS

- Building collapse
- Earthquakes
- Landslides
- Bombings
- Construction accidents
- Heavy snow on roof
- Mine or trench collapse

EPI

- Single v
- Most co
 - Crus
 - Asso



loving



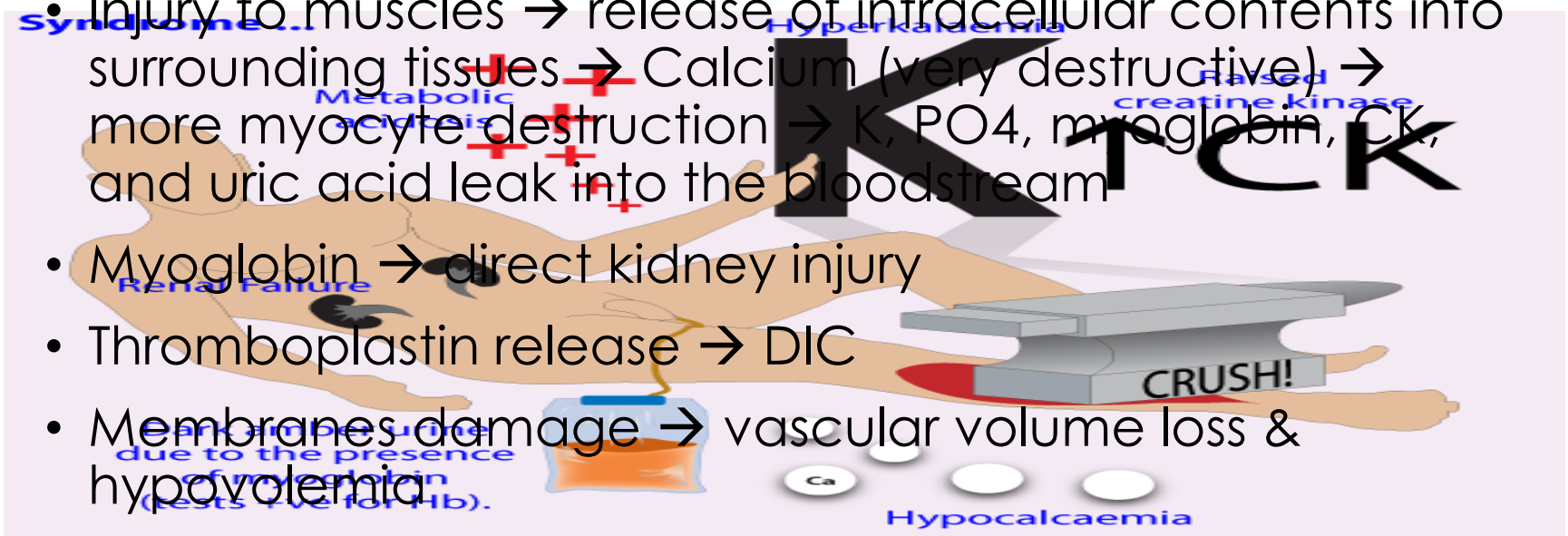
EPI

d

Table 1. Statistics Related to Major Earthquakes in the Past 18 Years.*

Location and Year	Death	Crush Syndrome <i>overall number of crush victims</i>	Dialysis
Spitak, Armenia, 1988 ¹⁵⁻¹⁷	25,000	600	225-385
Northern Iran, 1990 ¹⁸	>40,000	?	156
Kobe, Japan, 1995 ^{19,20}	5,000	372	123
Marmara region, Turkey, 1999 ²¹	>17,000	639	477
Chi-Chi, Taiwan, 1999 ²²	2,405	52	32
Gujarat, India, 2001 ²³	20,023	35	33
Boumerdes, Algeria, 2003 ²⁴	2,266	20?	15?
Bam, Iran, 2003 ²⁵	26,000	124	96
Kashmir, Pakistan, 2005 ^{26†}	>80,000	118	65
Total	>217,000	>1900	>1200

PATHOPHYS & CLINICAL

- Injury to muscles → release of intracellular contents into surrounding tissues → Calcium (very destructive) → more myocyte destruction → K, PO₄, myoglobin, CK, and uric acid leak into the bloodstream
 - Myoglobin → direct kidney injury
 - Thromboplastin release → DIC
 - Membranes damage → vascular volume loss & hypovolemia
 - Hyperkalemia and hypocalcemia → arrhythmias and cardiac arrest
 - Metabolic acidosis
- 

PATHOPHYS & CLINICAL

- **The most serious complication is Renal Failure**
- The pathogenesis of renal failure is multifactorial:
 - Systemic hypoperfusion
 - Renal vasoconstriction
 - Nephrotoxicity from myoglobin
 - Uric acid and phosphate precipitation in the distal tubules
 - Low urine pH and renal vasoconstriction promote precipitation of nephrotoxins.

CLINICAL FEATURES

- Crush injury
- Compartment Syndrome
- Crush Syndrome
- Electrolytes disturbance:
 - Hyperkalemia
 - Hypocalcemia
 - Metabolic Acidosis
- Renal Failure
- DIC
- Hypovolemia & Shock

MANAGEMENT

- **Extrication/Pre-hospital care:**
 - Patients may be saved even after > 24hrs entrapment
 - Prevent hypovolemia and ARF
 - Massive fluid replacement may be needed
 - Start during/shortly after extrication
 - IV NS at rate high enough to maintain adequate UOP at 200-300 ml/hr initially

MANAGEMENT

- **ED care:**
 - Airway, Breathing, Circulation
 - Full monitoring
 - Continue IVF, ensure urinary cath (0.5 ml/kg/hr)
 - Prevent & treat Rhabdomyolysis
 - Check for compartment syndrome
 - Watch for and treat:
 - Hyper-K
 - Acidosis
 - Hypo-Ca
 - Hyperuricemia

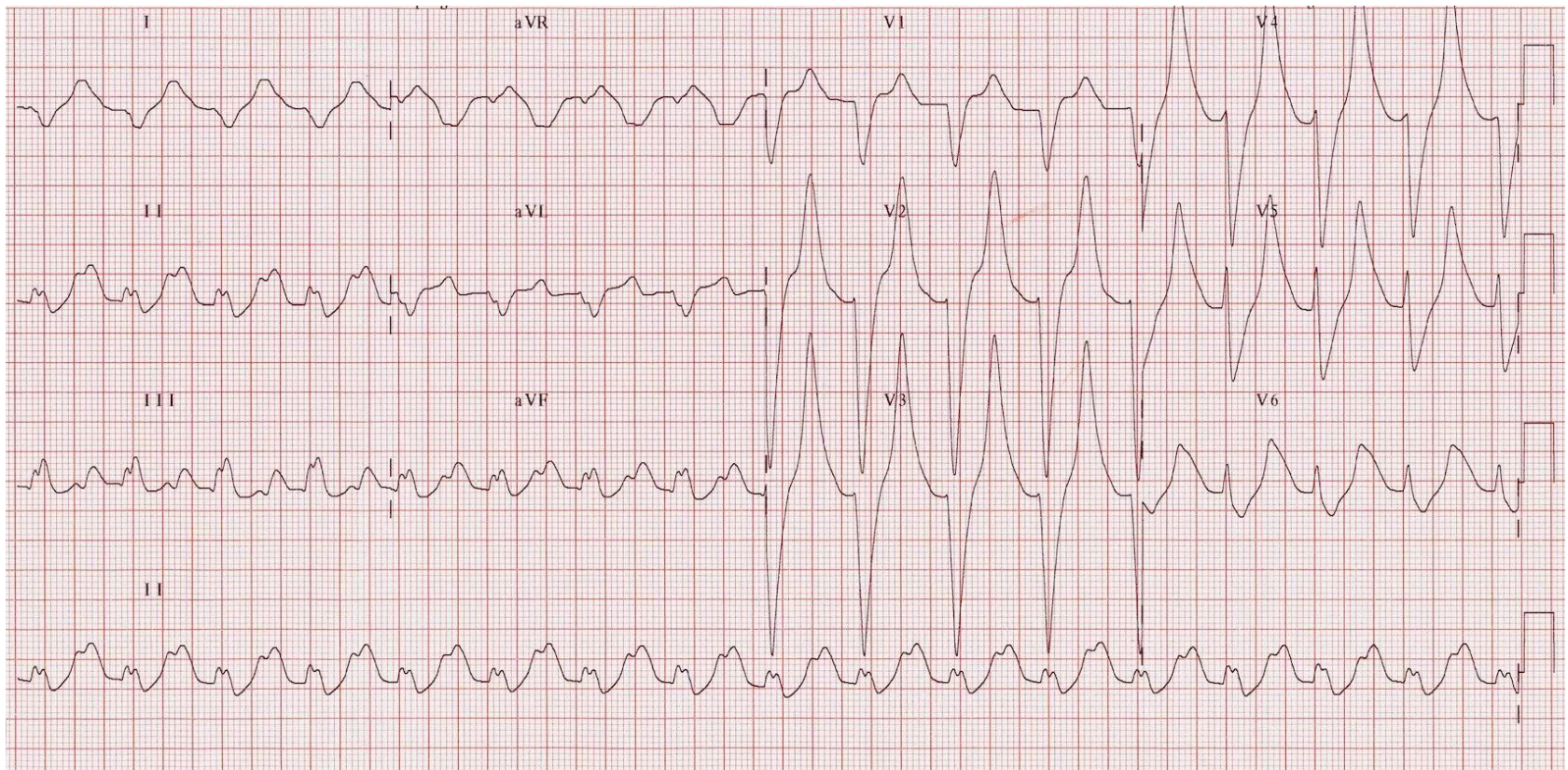
DIAGNOSTICS

- EKG
- POC
- CBC, platelets, type and screen, electrolyte panel, BUN, creatinine, CPK, liver panel, urinalysis
- ABG, myoglobin, PT, PTT
- Chest X-ray
- Other radiographs, computed tomography, etc. to evaluate for other injuries

FLUIDS

- Avoid Ringer's Lactate → Hyper-K
- Normal Saline
 - Initiate IV fluid rate at 1000 mL/h, and then reduce to 500 mL/h after 2 hours
 - 20 cc per kg per hour for children
 - 10 cc per kg per hour for elderly
- Goal:
 - Urine output should be approximately 200 to 300 mL/h (5 to 7 L every 24 hours) for an adult

HYPER-K



HYPER-K

- Normal saline IV fluid bolus
- IV calcium
- IV NaHCO₃ 50 to 100 meq
- Aerosolized albuterol (2.5 mg in 3 cc)
- IV dextrose (25 grams) & insulin (5 units IV)
- Ca^{2+} : PO or PR kayexalate
- Emergent hemodialysis

ALKALIZATION OF URINE

- 1st: Bicarbonate:
 - Supplement the NS with 50 meq (1 amp) doses
 - Add 3 amps (150 meq) to one liter D5W and infuse as first or second IV bolus
 - Up to 300 meq per 24 hours may be needed
- 2nd: Acetazolamide (250 mg PO TID)
- GOAL:
 - Urine pH b/w 6-7; (check with pH paper)
 - Prevent myoglobin and uric acid deposition in kidneys

MANNITOL

- Eliminate myoglobin from the kidney & prevent RF
- UOP < 2 cc per kg per hour, or if adequate UOP is still not achieved 4 hours after treatment started
- Maximum dose : 2 g/kg/d (or 200 g/d)
- Watch for hypovolemia...
- CI in established anuria...

MANNITOL

- May scavenge free radicals in muscle thus limiting necrosis
- Positive inotropic effect on the heart
- May help decompress compartment syndrome by mobilizing fluid from damaged muscle (thereby preventing need for fasciotomy)

HYPERBARIC OXYGEN

- Supplements O₂ availability to the hypoxic tissues
- Therapy at 2 atm, blood O₂ content is increased 125%
- Edema reduction secondary to O₂-induced Vasocon.
- Reduces blood flow by 10% to 20%, thereby reducing tissue edema caused by blood flow
- Long-term effects:
 - improved wound repair after fasciotomy
 - diminished infection rates
 - improved outcome of skin grafts

FASCIOTOMY

- Normal muscle compartment pressure is < 15 mm Hg
- Pressure > 30 mm Hg \rightarrow muscle ischemia, so fasciotomy indicated if pressure is persistent
- Irreversible muscle damage occurs after 6 hours, & irreversible nerve damage may occur after 4 hours of ischemia
- Patients with higher DBP can tolerate higher tissue pressure without ischemia, so fasciotomy recommended when 20 mm Hg below DBP

FASCIOTOMY

- In most reports of mass casualties from earthquakes, most of the fasciotomies were done more than 12 hours after the time of trauma
- Reviews of these cases showed high infection rates with increased mortality and amputations, and poor long term function
- So fasciotomy would be indicated if the victim can be extricated and receive definitive medical care within 6 hours of injury, but not later

ADDITIONAL POINTS

- Don't forget oxygen supplementation (even if the patient is not hypoxemic, O₂ may help ischemic muscle)
- Don't forget pain medications
- Address tetanus immunization status
- Furosemide may initiate diuresis but not favored since it makes acid urine

MONITORING

- Urine output and urine pH (hourly)
- Serial electrolytes (particularly K) : every 6 hrs initially
- CK, BUN, creatinine : 8-12 hours
- ABG (if initially acidotic or on ventilator): every 4 hrs
- Compartment pressures : every 4 hrs initially

MASS CASUALTY

- Extrication may be delayed
- Medical treatment during extrication may be unavailable
- Initial management may occur in suboptimal conditions
- Medical personnel may have little experience working under such conditions
- Transportation to definitive care may be prolonged
- Critical equipment, such as dialysis machines, may be in short supply
- Laboratory, monitoring, and intensive care facilities may be insufficient for the volume demands

SUMMARY



- Safety 1st
- IV before extrication
- Aggressive IVF (avoid LR)
- UOP, Alkaline urine, Mannitol
- Hyper-K → Kills
- Fasciotomy only if viable
- Hyperbaric O₂
- Monitor closely
- Pain, tetanus, other injuries



REFERENCES

- Bono MJ, Halpern P. Bomb, Blast, and Crush Injuries. In: Tintinalli JE, Stapczynski J, Ma O, Yealy DM, Meckler GD, Cline DM. eds. Tintinalli's Emergency Medicine: A Comprehensive Study Guide, 8e New York, NY: McGraw-Hill; 2016. <http://accessmedicine.mhmedical.com.proxygw.wrlc.org/content.aspx?bookid=1658§ionid=109384514>. Accessed April 19, 2018.
- Sever MS, Vanholder R: Management of crush victims in mass disasters: highlights from recently published recommendations. *Clin J Am Soc Nephrol* 8: 328, 2013.
- Strauss MB: The effect of hyperbaric oxygen in crush injuries and skeletal muscle-compartment syndromes. *Undersea Hyperb Med* 39: 847, 2012.
- Sellei RM, Hildebrand F, Pape HC: Acute extremity compartment syndrome: current concepts in diagnostics and therapy. *Unfallchirurg* 117: 633, 2014.



THANK YOU!

Jameel Abualenain

Mobile: (+966)-505671651

e-mail:

- abualenain@kau.edu.sa
- jameel.abualenain@gmail.com



@JameelEM

