

# Compartment Syndrome vs. Crush Syndrome

*The Difference Between Each and Their Respective  
Pre-hospital Treatments*



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# About the Instructor

- Graduated 2000 University of Delaware, BS Economics
- Member of UDECU 4 years and Past Coordinator
- 2000 Conference Coordinator at UD
- Volunteer Lieutenant w/ Delaware volunteer fire company (3 yrs)
- Career Firefighter/EMT in Burlington County, NJ;
- Certified as State NJ Fire Instructor I and EMT-B Instructor
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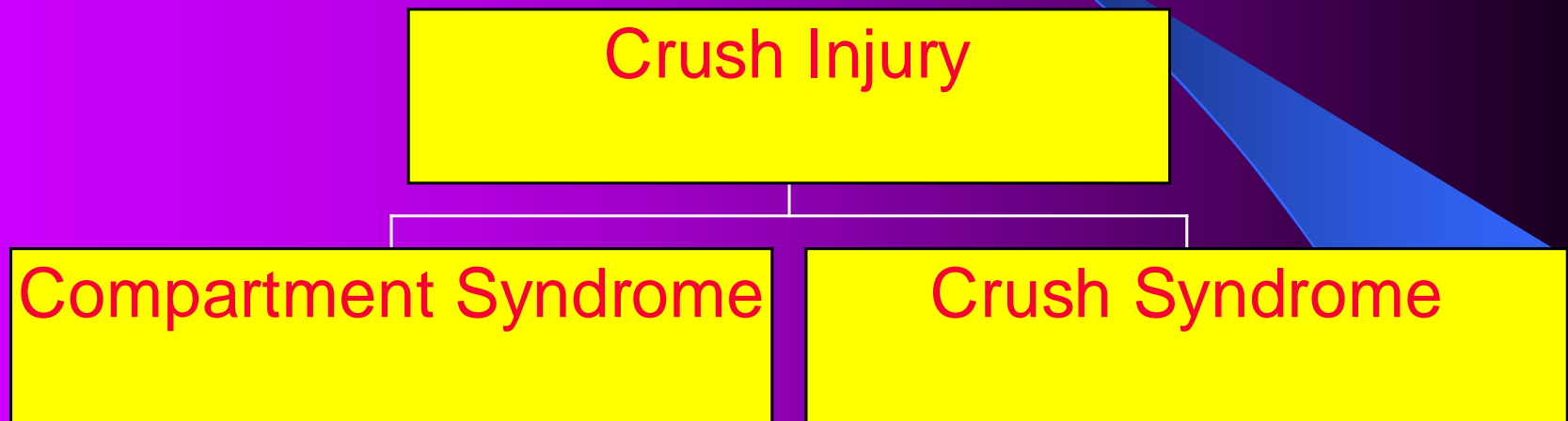


The best job in the world!

# Objective

- Identify signs and symptoms of compartment syndrome – **Segment 1**
- Identify signs and symptoms of crush syndrome-  
**Segment II**
- Explain the difference between the two injuries-**Both Segments**
- Discuss pre-hospital care of these injuries at both the BLS and ALS levels- **Both Segments**

# Word Play: What We Are Talking About Today



- *Don't get stuck on words: a **crushing injury** can cause either **Compartment Syndrome (CS)** or **Crush Syndrome!***

# Compartment Syndrome: What is it?

- Defined as an *“increased pressure within a confined space that leads to micro-vascular compromise and ultimately to cell death as a result of oxygen starvation”*
- Acute compartment syndrome can have disastrous consequences, including paralysis, loss of limb or loss of life

What is This?



# Compartment Syndrome: Anatomy

- Muscle groups -including the nerves and blood vessels that flow through them- are covered by a tough membrane (fascia) that does not readily expand-this area is called a compartment

# Compartment Syndrome: Pathophysiology



- Damage to these muscle groups cause swelling and/or bleeding; due to inelasticity of fascia, swelling occurs inward resulting in compressive force and/or collapse to blood vessels, nerves and muscle cells- without a steady supply of oxygen and nutrients, nerve and muscle cells die in a matter of hours

# Compartment Syndrome: Epidemiology

- Trauma-Fx, hematoma, animal/insect bites, crush injury
- Edema related- frostbite, burns, overuse injuries
- Coagulopathies-genetic, iatrogenic or acquired
- Other-external compression (MAST, bandaging, etc.), loss of consciousness (person down calls)

# Compartment Syndrome: Signs and Symptoms

Presents as the Five “Ps”

- ✓ **Pain**- is most common and consistent sign; described as out of proportion to normal clinical course, diffuse and intense, exacerbated with movement, touch, pressure, stretch
- ✓ **Paresthesias (or anesthesia)**- loss of feeling below CS area and radiating farther away
- ✓ **Passive Stretch**- severe pain when muscles in affected compartment are stretched

# Compartment Syndrome: Signs and Symptoms- 5 Ps

- ✓ Pressure- palpable tenseness in affected compartment (very tight to feel, sometimes warm)  
[would not recommend palpation for diagnosis]
- ✓ Pulselessness- least reliable and often late stages;  
CS affects microvasculature, typically, major vessels not affected
- *CS is TYPICALLY a localized injury!*

# Compartment Syndrome: Pre-hospital Treatment

- BLS

- Oxygen; high flow
- Do NOT ice; ice increases vasoconstriction
- Do NOT elevate; keep in position where found or position of comfort
- Splint for comfort and protection only when necessary (i.e. long transport)
- Transport to appropriate medical facility (trauma?); heads up to receiving medical facility

# Compartment Syndrome: Pre-hospital Treatment

- ALS
  - Same as BLS
  - IV TKO
  - MS or Fentanyl (Fentanyl preferred because it provides same pain control as MS without vasodilation)
- USAR/Military Protocol- field fasciotomy may be performed; “dirty” procedure: cut through tissue and fascia, tweeze muscle fibers apart, don’t cut muscles

# Compartment Syndrome: Sequela After Initial Injury

- Tissue damage- irreversible tissue death within 4-12 hours depending on tissue type and compartmental pressure; permanent disabilities can develop from undiagnosed compartment syndrome
- Amputation- sometimes tissue beyond repair and only measure to prevent gangrene and death is amputation
- Renal failure and/or death- can occur due to chemical imbalance, infectious etiology or through cardiac complications (Atypical as independent injury; CS migrates from CS injury to Crush Syndrome!)

# Answer: What is This?



X



+



=



# Additionally...



(CNN)

# Compartment Syndrome: Images



Fasciotomies

# Compartment Syndrome: Images



More Fasciotomies



# Compartment Syndrome Summary

- Typically an independent injury
- Acute care has more impact than pre-hospital care
- Typically no migration to Crush Syndrome
- A crush injury, but completely different than Crush Syndrome
- Questions, Comments Concerns on CS

# Crush Syndrome: Objectives

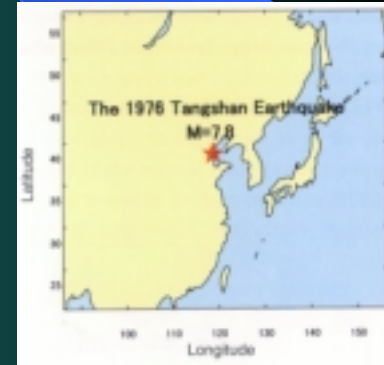
- What is Crush Syndrome
- What causes Crush Syndrome
- Signs and Symptoms of Crush Syndrome
- How do you treat it pre-hospitally at the BLS and ALS levels

# History of Crush Syndrome

- Recognition of medical consequences of Crush Syndrome date back to WWII.
- Reports of the treatment of Crush Syndrome were published after the disasters described on the following slides.

# History of Crush Syndrome

- July 28, 1976 / Tangshan, China / 7.8 on Richter Scale
- 242,769 died, 164,851 crushed; Crush Syndrome occurred in 2% to 5% of injured people
- Lessons learned:
  - Patients...crushed..be observed...Crush Syndrome...may appear as minimal injury
  - Area crushed and duration of being buried did not predict..renal failure.



# History of Crush Syndrome

- November 11, 1982 / Tyre, Lebanon / 8-Story Collapse
- 100 buried; 20 extricated in subsequent 28 hours, 8 with Crush Syndrome
- Lessons learned:
  - 7 of 8 received aggressive treatment; none required dialysis, all but one survived
  - Non-survivor developed renal failure requiring hemodialysis and later died



# History of Crush Syndrome

- December 7, 1988 / Armenia USSR / 6.9 Richter
- 100,000 injured; 15,254 extricated from rubble
- “little to no” care given PTA at hospital
- Lessons learned:
  - Crush injury was 3<sup>rd</sup> most frequent, but leading cause of death
  - Deterioration noted upon release of crushed extremities
  - Acute renal failure and need for dialysis common



# History of Crush Syndrome

- 1987 Amtrak Derailment / Silver Spring, MD
- Middle aged woman pinned for 12 hours before she was freed.
- Conscious, Alert and Oriented x 4 throughout with stable vitals
- Within 15 minutes of extrication, pt went into sudden v-fib arrest and died despite rapid ACLS and transport to an area trauma center

# Crush Syndrome: What is it?

*Crush Syndrome is a  
**reperfusion** injury as a  
result of traumatic  
rhabdomyolysis!*

# Crush Syndrome: Epidemiology

- War (rubble)
- Earthquakes and mine cave-ins (other collapse/trench rescues)
- Vehicular disaster (occasionally)
- New trend: terrorist acts (9/11, Oklahoma City)

# Crush Syndrome: Pathophysiology

- Begins with muscle injury and muscle cell death
- Initially, 3 mechanisms are responsible for muscle cell death:
  - Immediate cell disruption: local force causes immediate disruption; effects are immediate, but least important
  - Direct pressure on muscle cells: muscle cells become ischemic under direct pressure and begin to leak; this occurs during first hour

# Pathophysiology Con't

- Vascular compromise: force compresses large vessels resulting in loss of blood to supply muscle tissue. Normally, muscles can withstand approx 4 hours without blood flow before cell death occurs. After this time, cells begin to die
- Toxins may continue to leak into body for as long as 60 hours after release of crush injury!
- **Major problem** is not recognizing the potential for its existence and removing the compressive force **prior** to arrival of medical assistance

# Toxins and Their Effects

- Amino acids-dysrhythmia
- Creatine phosphokinase-CPK, marker
- Free radicals- oxygen re-iterated further damage
- Histamine-vasodilation, bronchoconstriction
- Lysozymes-cell-digesting enzymes
- Myoglobin-renal failure
- Phosphate and Potassium-hyperkalemia causes dysrhythmias
- Purines (uric acid)-further renal damage
- **NO correlation between toxic levels of substances and severity or length of time that the patient was entrapped!**

# Crush Injury: Onset Criteria

- As a general rule, requirement for consideration is based on **3 criteria**:
  - Involvement of a muscle mass
  - Prolonged compression (as little as 1 hour, but typically 4-6)
  - Compromised blood circulation
- Example: entrapment of hand is unlikely to initiate the crush injury syndrome

# Crush Syndrome: Signs and Symptoms

- Compression in excess of 60 minutes
- Involvement of a large muscle mass
- Absent pulse and capillary refill return to distal limb
- Pale, clammy, cool skin
- Weak, rapid pulse
- Usually absence of pain in affected region
- Onset of shock
- **MAINTAIN HIGH INDEX OF SUSPICION!**

# Crush Syndrome: Considerations

- Absolutely imperative that an assessment is made **prior** to beginning any extrication activities!
- Dually imperative that the rescue team be made aware of the importance of treating the patient **prior** to extrication

# Crush Syndrome: BLS Pre-hospital Treatment

*Scene Safety!*



# Crush Syndrome: BLS Pre-hospital Treatment

- Coordinate time of release with rescue personnel!
- Treated as any other multiple trauma victim
  - AED? Let's discuss...
- Airway secured and protected from dust impaction
- Adequate oxygenation (NOT necessarily high flow, maintain SPO<sub>2</sub>, extended operation)
- Maintain body temperature throughout operations!

# BLS Pre-hospital Treatment

- Rapid transport to Trauma Center
- Circulation must be supported and shock aggressively treated:
  - Trendelenburg
  - High flow oxygen during transport
  - Warm patient! They were just trapped in a building or soil for extended period!
- Aeromedical transport when available!
- **NO PASG! Can complicate and even cause CS or Crush Syndrome!**

# Crush Syndrome: ALS Pre-hospital Treatment

- Coordinate time of release with rescue personnel!
- Establish 1 or 2 large bore Ivs with NS or LR
- Administer 1 to 2 L bolus just prior to extrication
  - 2 exceptions to above
    - If prolonged ex, infuse at 1500cc/hr
    - Pts under 12, elderly and those with RI or RF should only get 500cc boluses and check lung sounds repeatedly

# Crush Syndrome: ALS Pre-hospital Treatment

- Administer 2 amps of Sodium Bicarb just prior to extrication
  - Prolonged, administer Bicarb 1 amp/hr
- Establish Cardiac Monitoring and watch for EKG changes
- Pain control PRN
  - Recommend Fentanyl; same as MS but no vasodilation which might contribute to hypovolemia
- Extricate

# Crush Syndrome: ALS Pre-hospital Treatment

- During transport, suspect hyperkalemia if T waves become peaked, QRS becomes prolonged, HTN develops
- Administer 1 amp of Calcium Chloride if dysrhythmias continue
- Give standard dose of Albuterol via neb if dysrhythmias continue

# ALS Pre-hospital Treatment: Science Behind Treatment

- Bicarb keeps myoglobin floating in circulation postponing renal casting and heads off hyperkalemia
- Early treatment was 2 amps D50 and 10 units Insulin
  - As Insulin transports dextrose through cell membranes pulls Potassium with it
  - Few ALS systems carry Insulin, but Docs do!
  - Monitor BS if this is an option
- Albuterol lowers serum Potassium case by driving it back into the cells
  - Short term, but very effective until other measures in place

# Crush Syndrome: Summary

- Crush Syndrome is frequently under recognized and under treated medical condition that frequently results in a preventable death!
- Treatment begins as soon as possible in the rescue process!
- Aggressive treatment is necessary to prevent loss of life!

# For CS and Crush Syndrome!

- You need to educate your medical director, receiving facilities and coworkers on Crush Injuries and their treatment prior to the event.
- The time to get these treatments accepted and authorized is before the need exists, not after a crush injury happens and you call in from the field requesting fairly radical deviations from standard ALS and BLS protocols!