Crush Syndrome Made Simple
Objectives

Recognize the differences between Crush Injury and Crush Syndrome

Understand the interventions performed when treating someone with Crush Syndrome

Assessing the Crush Injury victim

S&S of crush injuries

Treatment of crush injury
INJURY

- Cell Disruption/injury at the point of impact.
- Occurs < 1 hour

SYNDROME

- Systemic effects when muscle is RELEASED from Compression
- Occurs after cells have been under pressure >4 hours*
- Suspect Syndrome with lightening strikes
CRUSHING MECHANISM OF INJURY

• Building and Structure Collapse
• Bomb Concussions
• MVAs’ and Farm Accidents
• Assault with blunt weapon
AKA: COMPRESSION SYNDROME

First described by Dr. Minami in 1940
INVOLVED ANATOMY

Upper Arms
Upper Legs
Thorax and Buttocks
Crush Injuries

Crush injuries occur when a crushing force is applied to a body area.

Sometimes they are associated with internal organ rupture, major fractures, and hemorrhagic shock.

Early aggressive treatment of patients suspected of having a crush injury is crucial.

Along with the severity of soft tissue damage and fractures, a major concern of a severe crush injury is the duration of the compression/entrapment.
Crush Injuries

Prolonged compression of a body region or limb may lead to a dangerous syndrome that can become fatal.

Crush Syndrome is difficult to diagnose and treat in the pre-hospital setting because of the many complex variables involved.
Variables to Consider

- Extent of tissue involvement/damage
- Duration and force of the compression
- Patient’s position and condition
- Patient’s age and overall health
- Any associated/additional injuries
With Crush Injury Syndrome:

The initial injury is at the site of the body/muscle crushed by a heavy object (mechanical force).
With Crush Injury Syndrome:

The muscle cells begin to die, as a result of the following:

1. The force of the crushing object ruptures muscle cells.
2. The direct pressure of the object on the limb causes muscle cells to become ischemic. The combination of mechanical force and ischemia can cause muscle death within an hour.
3. The force of the crush injury compresses large vessels, resulting in the loss of blood supply to muscle tissue.
With Crush Injury Syndrome:

A. Muscles can survive circulatory ischemia for up to four hours before cell death.

B. After four hours, the cells begin to die as a result of the circulatory compromise. The damaged muscle tissue produces and releases many toxins that can have detrimental effects on the body.
With Crush Injury Syndrome:

4. **Toxin**: Histamine  
   **Effect**: Vasodilation and bronchoconstriction

5. **Toxin**: Lactic Acid  
   **Effect**: Metabolic acidosis & dysrhythmias

6. **Toxin**: Nitric Oxide Vasodilation  
   **Effect**: Worsens hypovolemic shock

7. **Toxin**: Potassium  
   **Effect**: Hyperkalemia (*refers to an elevated concentration of the electrolyte potassium (K⁺) in the blood.)*

8. **Toxin**: Thromboplastin Disseminated  
   **Effect**: Intravascular coagulation
With Crush Injury Syndrome:

The longer the victim is trapped, the more toxins build up distally to the crush injury.

The crushing forces act as a dam preventing the toxins from being released to the rest of the body.

When the force is removed, the toxins are allowed to quickly flow through the body, causing a multitude of problems.

Along with the release of toxins after extrication, the victim can become severely hypovolemic from the third spacing of fluid.
With Crush Injury Syndrome:

The rapid swelling of an injured extremity can cause acute compartment syndrome.
“SMILING DEATH”

“In Prolonged entrapment, “smiling death” may occur……. In this situation, the trapped person is alert and conversing with rescuers; however, when the entrapped body part is freed, cardiac arrest is almost instantaneous.”

Emergency Care in the Streets: American Academy of Orthopedic Surgeons
HYPERKALEMIA

Usually the thing that kills after the weight has been lifted....
Assessing Potential Crush Injury Syndrome

When trying to determine if a trauma victim is suffering crush syndrome; consider the following:

- Involvement of a muscle mass
- Prolonged compression
- Compromised blood circulation
Assessing Potential Crush Injury Syndrome

For instance, entrapment of a hand is unlikely to initiate the syndrome.

Most of the victims who develop crush injury syndrome usually exhibit with a large area of involvement, such as one or both lower extremities.
Signs and Symptoms of Crush Injury Syndrome

- Skin may be bruised and discolored, but skin can remain intact
- Swelling usually appears rapidly after pressure is released
- Pain after pressure is released; it can become excruciating
- Pulses may or may not be present
Signs and Symptoms of Crush Injury Syndrome

Note: EMS personnel should suspect crush injury syndrome with the above signs and symptoms. EMS should begin treating the victim well in advance of extrication. It may be too late, if you wait to begin treatment until after the victim is freed. CS patients can remain stable without any signs/symptoms while trapped; even after being extricated, they may exhibit only a few signs or symptoms and deteriorate very rapidly.
Signs and Symptoms of Crush Injury Syndrome

Be Suspicious with potential crush injuries!
Compartment Syndrome

Occurs when injured tissue swells within the fascia and connective tissues inside of a limb causing an increase in the pressure within that “compartment”.

It is usually not a concern for pre-hospital providers because it occurs several hours or days after the initial injury. But, it is important for the EMT to understand the possible outcome of a critically injured extremity, so the potential is not overlooked.
Compartment Syndrome

Pressure builds up within the ‘compartment’ and compresses nerves and vessels. Occurs several hours after initial time of injury.
THE 5 P’S OF COMPARTMENT SYNDROME

Pain........................................unpleasant feeling
Paresthesia.............a morbid or abnormal sensation
Pallor..............................paleness
Pulselessness...............Lack of blood flow
Paralysis....................complete loss of strength
Treatment

If prolonged extrication (> 4 hrs.), treat the patient for CS/CI.

Do not wait for clinical signs to develop, as the patient may already be in renal failure with metabolic acidosis worsening.
Our Protocol

Universal Patient Assessment
Rapid Trauma Assessment
Maintain Body Temperature
Consider Rapid/Air Transport
C-Spine Clearance
Airway Protocol

Post-Extrication
Continue aggressive fluid resuscitation with NS
Widen QRS complexes-0.12 seconds or greater, PVC’s, V-Tach, V-Fib
CARDIAC ARREST UPON RELEASE?

Appropriate Arrest Protocol

Sodium Bicarbonate
50mEq in 1 liter NS, begin maintained infusion of 1500ml/hr and then administer 1 ½ liter bolus just prior to extrication

Cardiac monitoring
Obtain monitor tracing prior to and sequentially during further treatment

Contact receiving ED of Crush Injury
Anticipate Crushing syndrome and possible cardiac arrest upon extrication

Pre-Extrication
IV Protocol
Treatment

**EMT**

1. Provide airway and ventilatory support (12-15 lpm O2 via NRB/BVM)

2. Maintain the patient’s body temperature

3. Treat for shock
Treatment

**Paramedics:**

4. Attach EKG; monitor patient closely for hyperkalemia and other dysrhythmias.
Treatment

EKG Changes in a Hyperkalemic Patient

- Mild condition: peaked T waves
- Moderate condition: prolonged PR interval, flattening of P waves
- Segment elevation or depression, QRS widening
- Severe condition: loss of P waves, AV blocks, BB blocks, PVCs
Treatment

5. Gain IV access via 2 large bore catheters (14g-16g). *Aggressively hydrate the patient to manage hypovolemia and maintains kidney function/urine output.

6. Administer sodium bicarbonate to control hyperkalemia and acidosis, preventing dysrhythmias and renal failure.

**Note:** The use of bicarbonate in the prehospital phase of care is actually controversial - no actual studies have documented its effectiveness. The key is FLUIDS.
Treatment

8. The use of arterial tourniquets before the release of a crushing injury site may be beneficial.

9. After extrication, immediate care may include transporting the patient to a facility with hyperbaric chamber capabilities in order to decrease tissue necrosis and muscle edema.

Note: The use of hyperbaric therapy is controversial in these cases
**IV Treatment**

The basic principle of replacing lost fluid seems valid; however, replacing lost whole-blood with vast amounts of normal saline creates a state of hemodilution and leaves the remaining components of the blood less potent.

Hemodilution is defined as a decreased concentration of cells and solids in the blood resulting from the gain of fluid, which in effect renders all of the functions of the blood less effective.

The most important of these functions, in relation to trauma, are oxygen transportation and coagulation properties.

When fluid is administered to raise the systolic pressure back to a “normal” range, the liver will not release what the body needs to sustain itself.
**IV Treatment**

*Raising the systolic pressure to traditionally acceptable levels by administering IV fluid actually placed too much pressure behind freshly created blood clots, causing the clot to dislodge and hemorrhage to resume.

The effect of artificially raising the pressure to within normal limits provides no benefit and essentially does more harm.

Monitoring the mean arterial pressure, or MAP, provides insight to perfusion.

Targeting a **MAP of 65 mmHg**, allows providers to insure perfusion without the negative effects associated with aggressive fluid resuscitation in trauma patients. (Systolic pressure of 70-80.)

*A 1993 study published by the Annals of Emergency Medicine*
IF

the patient survives the initial release of the toxic by-products and makes it to the hospital…

They remain at GREAT risk for developing RENAL FAILURE with severe morbidity

*It should also be pointed out that some of the poor outcomes of crush are due strictly to tamponade of bleeding rather than release of toxins (may be true in your case presentation with pelvic hemorrhage)*
TRUE STORY....

A cattle farmer was found pinned under the rear wheel of his tractor. Estimated to have occurred in the early afternoon. It is now dusk.

Alert and Oriented, complains of severe back pain and no sensation in his legs.
FIRST RESPONDERS ARRIVE.....

Appears to have Crush Injuries to pelvis and bilateral lower extremity injuries.

Patient still Alert and Oriented and complains only of lower back pain.

ALS units enroute urge responders NOT to extricate until they arrive.
THE REST OF THE STORY......

Due to family’s increasing anxiety and demands, Incident Command ordered the extrication.

(ALS not on scene yet.....)
THE REST OF THE STORY......

Just as the tractor is lifted from the patient, his condition deteriorated rapidly.

ALS arrived to find patient had arrested and never responded to resuscitative efforts.
Reference

Dr. Howard Werman-M.D., FACEP

Dr. David Parrett-M.D
QUESTIONS?