IV. US&R MEDICAL PROBLEMS
A. CRUSH SYNDROME

INTRODUCTION

- Crush injury and crush syndrome are common in trapped victims of collapsed structures.

- Post-extrication medical deterioration and death occur from potentially treatable mechanisms and so this illness is a primary reason to provide the victim with prompt care within the collapsed structure.

CRUSH SYNDROME: PREDICTABLE SEQUELAE

- Patients survive entrapment for days with this injury.

- Patients may die shortly after rescue if not treated.

- Patients may die days to weeks later if not properly treated on scene.

- Patients survive if treated early and aggressively, starting "in the rubble."

CRUSH SYNDROME: FREQUENCY

- Tangshan data (Yong et al)
  - 28 July, 1976.
  - Magnitude 7.8.
  - 361,300 persons injured.
  - 242,769 persons killed.
  - 20% suffered from Crush Syndrome.

- Armenian data (Klain et al)
  - 7 December, 1988.
  - Magnitude 6.9.
  - Crush injuries were third most common injury.
  - Crush Syndrome was leading cause of death in patients reaching medical care.

CRUSH SYNDROME

- Predictable Course...
  - Patients survive for days in their entrapment
  - Patients may die shortly after rescue if untreated
  - Patients survive if treated early and aggressively "in the rubble"

VIEW GRAPH IV A - 1

FEMA US&R RESPONSE SYSTEM
TASK FORCE MEDICAL TEAM TRAINING
04/97
US&R MEDICAL PROBLEMS

CRUSH SYNDROME

- Tangshan data
  - 28 July, 1976
  - Magnitude 7.8
  - 351,300 persons injured
  - 242,769 persons died

IV. US&R MEDICAL PROBLEMS

A. CRUSH SYNDROME

DEFINITIONS

Direct mechanical crush

- Mechanical disruption of tissue secondary to severe force.
- Immediate cellular effect/injury.

Crush injury

- Muscle cell disruption due to compression.
- Time/pressure relationship.
- Cellular mechanism of injury controversial:
  - Stretch "membranopathy"
  - Cellular ischemia
  - Re-oxygenation injury

Compartment syndrome

- Crush injury caused by swelling of tissue inside confining fibrous sheath of muscle compartments.
- Causes further destruction of intra-compartmental muscle and nerves.

Crush syndrome

- The systemic manifestations caused by crushed muscle tissue.
- Occurs when crushed muscle is released from compression.

IV. US&R MEDICAL PROBLEMS
A. CRUSH SYNDROME

DEFINITIONS (continued)

Muscle tissue in compression

- Muscle tissue exquisitely vulnerable to sustained pressure.
- Compression may be caused by debris or by the patient's own body weight, especially if lying on a hard surface.
- "Time-frame" until crush injury depends upon the amount of pressure and patient factors:
  - As short as one hour if compression is severe.
  - 4-6 hours is the more common period until significant crush occurs.
- Amount of tissue injury to cause Crush Syndrome variable: usually lower extremities, buttocks or entire upper extremity/pectoralis area.

PATHOPHYSIOLOGY OF CRUSH INJURY

- Normal muscle cell function:
  - Arterial blood provides glucose/oxygen/ nutrients to the cells.
  - Cell membrane "sequesters" cellular contents and uses complex mechanisms to transport nutrients and to maintain concentration gradients across the membrane of vital electrolytes.
  - Muscle cell uses oxygen/glucose/ nutrients to produce energy for normal cell function.
  - Myoglobin rapidly transports oxygen within muscle cells to allow normal function.
  - Capillaries are the smallest blood vessels in the body and allow efficient transfer of oxygen/glucose/nutrients to tissue/cells.
  - Venous blood carries away CO_2 and waste products, including lactic acid, for disposal or metabolism elsewhere in the body.

■ Muscle tissue in compression

- Muscle tissue is exquisitively vulnerable to sustained compression
- Compression from debris or body weight
- "Time-frame" - one to six hours
- Amount of muscle tissue:
  - lower extremities
  - buttocks
  - entire upper extremity and pectoralis

IV. US&R MEDICAL PROBLEMS

A. CRUSH SYNDROME

PATHOPHYSIOLOGY OF CRUSH INJURY (continued)

- Cell function in crush situation:
  - Local arterial blood flow interrupted.
  - Lack of oxygen causes cells to function "anaerobically," creating lactic acid and other toxins.
  - Cellular membrane function is disrupted (mechanism is controversial), causing cell death and dissolution.
  - Intracellular contents, including myoglobin, potassium, purines (later converted to uric acid) and other toxic substances are released into the local tissue area.
  - Local capillaries are injured and become "leaky", allowing an increased serum portion of the blood to extrude into the tissue.
  - The re-introduction of oxygen into the tissue later may cause additional "re-oxygenation" injury by creating other toxins such as free radicals, superoxides and thromboxane.

- Effects of muscle cell crush injury (summarized)
  - Lactic acid production.
  - Potassium and other electrolytes release.
  - Myoglobin released.
  - Other toxins released/created (super-oxides, free radicals, etc.).
  - Lysosomal enzyme release.
  - Uric acid production.
  - Capillary leak.
  - Thromboxane, prostaglandins and other immune system substances generated.
  - Muscle cell enzymes (CPK, etc.) which are useful for in-hospital tests to approximate the amount of tissue destruction.

TASK FORCE MEDICAL TEAM TRAINING 04/97

- Effects of crush injury
  - Lactic acid production
  - Potassium/other electrolyte release
  - Myoglobin release
  - Other toxins created/released (superoxides, free O_2 radicals, etc.)
  - Uric acid production
  - Capillary leak
  - Thromboxane, prostaglandins and other immune system substances generated
  - Muscle cell enzymes released

IV. US&R MEDICAL PROBLEMS

A. CRUSH SYNDROME

CRUSH INJURY

- All these effects are local only until the tissue is released and reperfused by blood.
- That is why patients may remain entrapped for days with a severe crush injury and yet appear systemically stable when reached by rescuers.
- Upon release of compression, blood flow is restored to the crushed area and multiple adverse processes begin.
- Effects of releasing compressed tissue:
  - Capillary leak ⇒ Hypovolemia/hypotension/shock.
  - Severe metabolic acidosis ⇒ V-fib.
  - High serum potassium level ⇒ Cardiac arrhythmia or standstill.
  - Myoglobin/Uric acid/other "toxins" ⇒ kidney failure.
  - Leukotrienes and other cell mediators:
    - lungs ⇒ adult respiratory distress syndrome
    - liver ⇒ cellular injury

CRUSH SYNDROME: MAJOR CAUSES OF DEATH

- Hypovolemia.
- Dysrhythmia.
- Renal failure.

OTHER CAUSES OF DEATH

- Adult Respiratory Distress Syndrome (ARDS): severe lung injury.
- Sepsis.
- Other electrolyte disturbances.

- Effects of releasing compressed tissue
  - Capillary leak -
    - hypovolemia
    - hypotension
    - shock
  - Severe metabolic acidosis - V-fib
  - High serum potassium -
    cardiac dysrhythmia or standstill
- Crush injury
  - Myoglobin/uric acid/renal toxins -
    kidney failure
  - Effects are LOCAL ONLY until tissue is released and re-perfused by blood
  - Other toxins -
    lung/liver/renal injuries
  - Reason that patients survive entrapment despite severe crush injury
  - Adverse processes begin immediately upon tissue release

Error! *FEMA US&R RESPONSE SYSTEM*
TASK FORCE MEDICAL TEAM TRAINING 04/97
Error!

- Ischemic organ injury (gangrene).

IV. US&R MEDICAL PROBLEMS

A. CRUSH SYNDROME

CRUSH SYNDROME: POTENTIAL CLINICAL MANIFESTATIONS

- Pre-release of entrapment:
  - Painless crushed extremity (hypesthesia or anesthesia).
  - Distal pulses +/- present.

- Post-release of entrapment:
  - Agitation.
  - Continued hypesthesia/anesthesia, or
  - Severe pain in crushed extremity.
  - Muscle function decreased/paralysis.
  - Progressively marked swelling of the area.
  - Systemic problems.

CRUSH INJURY: DIAGNOSIS

- High index of suspicion.
- Identifying potential crush mechanism.
- Looking for subtle signs and symptoms.
- Urinary myoglobin post-release.

MYOGLOBIN

- "Spills" into urine at relatively low serum levels.
- Causes reddish-brown urine color in high concentrations.
- Lower concentrations detected by positive orthotolidene ("hemoglobin" test) on urinalysis dip-strip.
- May precipitate in kidney tubules, contributing to renal failure by obstruction and heme-iron-mediated lipid peroxidation process.
- Solubility in urine is markedly influenced by urine pH.

TASK FORCE MEDICAL TEAM TRAINING 04/97

■ Myoglobin

• "Spills" into urine at low serum levels

• Causes reddish-brown urine color in high concentrations

• Detectable using urinalysis "dip-strip"

• May precipitate in kidney tubules, contributing t

• Solubility in urine influenced by urine pH

IV. US&R MEDICAL PROBLEMS
A. CRUSH SYNDROME

MYOGLOBIN (continued)

- Solubility of myoglobin in urine (Zager RA, Lab Invest 1989; 60: 619-629.)
  (50 mg myoglobin/ml urine)

Urine pH	% Precipitated
8.5-7.5	0%
6.5	4%
5.5	23%
5.0	46%
<5.0	73%

THERAPEUTIC MODALITIES

- Hypovolemia
  - Normal Saline (Ringer's Lactate less desirable because it contains potassium).
  - Rapid IV flow capability .
  - Careful monitoring and replacement of vascular volume.

- Hyperkalemia and acidosis:
  - Sodium bicarbonate (limited by inability to measure serum pH).
  - Insulin + dextrose (requires follow-up glucose monitoring and administration of dextrose).
  - B_2 Selective inhaled catecholamines (Alupent, Proventil, etc.)
  - Calcium (for life-threatening cardiac effects resistant to other therapy only).
  - Other (Kaexolate, Lasix, dialysis, etc.).
  - Follow patient and cardiac monitor parameters and treat as indicated.

- EKG abnormalities — related to:
  - Potassium level.
  - Acidosis.
  - Other electrolyte abnormalities.
  - Other injuries.

FEMA US&R RESPONSE SYSTEM
TASK FORCE MEDICAL TEAM TRAINING 04/97

■ Myoglobin —
Solubility in Urine...
(50 mg myoglobin/ml urine)

Urine pH	% Precipitated
8.5-7.5	0%
6.5	4%
5.5	23%
5.0	46%
<5.0	73%

FEMA US&R RESPONSE SYSTEM
TASK FORCE MEDICAL TEAM TRAINING 04/97

■ Therapeutic modalities —
Hyperkalemia and Acidosis
- Sodium Bicarbonate
- Insulin + Glucose
  (requires careful F/U)
- B2-selective catacholamines
- Calcium
  (for life-threatening dysrhythmias)
- Others
  (Kaexolate/Lasix/dialysis/etc.)
- Follow patient and cardiac monitor parameters

IV. US&R MEDICAL PROBLEMS
A. CRUSH SYNDROME

THERAPEUTIC MODALITIES (continued)

- Responds rapidly to effective intervention.
- EKG examples.
- Renal injury:
  - Maximize renal perfusion — IV normal saline.
  - Diuresis (brisk urine flow).
  - Careful alkalinization of urine:
    - sodium bicarbonate.
    - acetazolamide.
  - Monitor urine flow and pH (bladder catheterization if critical injury).

OTHER MODALITIES

- Oxygen/Airway support.
- Mannitol (possibly low-dose as a free-radical scavenger).
- "Renal dose" dopamine.
- Other theoretical interventions.

CARE OF THE LOCAL INJURY

- Protect open wounds.
- Splint limb (non-compressive splint).
- Maintain limb at heart level.
- Pain control.
- Monitor limb (distal perfusion/compartment pressures).

■ Therapeutic modalities —
Care of the local injury

- Protect open wounds
- Splint limb
(non-compressive splint)
- Maintain limb at
heart level
- Pain control
- Monitor limb
(distal perfusion)

IV. US&R MEDICAL PROBLEMS

A. CRUSH SYNDROME

MANAGEMENT "IN THE RUBBLE"

- ABC's.
- Protect the airway.
- Psychological support.
- Assess for crush injury potential.
- If crush potential is identified:
  - Establish IV access.
  - Fluid replacement prior to lifting compression.
  - Consider pre-alkalinizing with bicarb.
  - Cardiac monitor: run baseline strip.
- Be prepared during extrication to treat:
  - Hypovolemia.
  - Acidosis.
  - Hyperkalemia.
- Re-evaluate frequently and also outside of the rubble prior to transport.
- Medical and rescue elements must cooperate throughout this process.

CONTROVERSIAL INTERVENTIONS

- Field amputations: indications:
  - Inability to extricate by ANY other means.
  - Situation where the need for rapid extrication is paramount (haz mat, very unstable rubble, etc.).
- Field amputations: complications:
  - Permanent loss of function.
  - Inadequate anesthesia/analgesia.
  - Difficulty controlling hemorrhage.
  - Infection and sepsis.

■ "Management" in the hole —

If crush potential is identified:

- Establish IV access
- Fluid replacement prior to extrication
- Consider pre-alkalinizing — alkaline diuresis
- Cardiac monitor (run baseline strip)
- Be prepared during extrication to treat:
  - hypovolemia
  - acidosis
  - hyperkalemia

- Difficult procedure in the field.

IV. US&R MEDICAL PROBLEMS
A. CRUSH SYNDROME

CONTROVERSIAL INTERVENTIONS (continued)

- Arterial tourniquets — indications:
  - Patient in extremis resistant to therapy.
  - Need for rapid extrication.

- Arterial tourniquets — complications:
  - Inadequate analgesia (tourniquets are very painful!).
  - Must monitor closely to prevent accidental (or patient) release.
  - Increases injury to involved extremity.
  - Only delays the necessary care.
  - No studies demonstrating efficacy.

- Field fasciotomies — indications:
  - To prevent severe compartment syndrome and on-going rhabdomyolysis?

- Field fasciotomies — complications:
  - Technically difficult in the field.
  - Infection almost unavoidable.
  - Inadequate analgesia for procedure and afterward.
  - Severe bleeding from crushed tissue is common.
  - NOT RECOMMENDED unless no pulses, ongoing rhabdomyolysis is severe and help is far away.

GOAL OF THERAPY

- To recover patient who returns to full pre-injury level of function.

- Use standard, accepted principles as basis for therapy.

FEMA US&R RESPONSE SYSTEM
TASK FORCE MEDICAL TEAM TRAINING 04/97

- Arterial tourniquets
  - Indications
    - Patient in extremis resistant to therapy
    - Need for rapid extrication
  - Complications
    - Inadequate analgesia
    - Must monitor closely to prevent release
    - Increases injury to local area
    - Delays the necessary care
    - No studies demonstrating efficacy

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

INTRODUCTION

- Other medical considerations in confined space medicine.
- The intent of this lecture is not to be a comprehensive review of all medical problems that medical team members may encounter during a response. It is also not intended to guarantee proficiency by medical team members when caring for fellow team members or confined space patients. Rather, it is intended to provide a baseline understanding of those patient care problems that all medical team members may be called upon to address.
- Hopefully, it will refresh and supplement medical team members' current knowledge as well as stimulate these unique pre-hospital care providers to further research topics in which they feel uncomfortable.

RESPIRATORY PROBLEMS

- Confined space patients suffer from these general types of airway and ventilatory problems.
  - Airway obstruction.
  - Airway contamination.
  - Ventilation difficulties.
  - Inhalation injuries.

AIRWAY OBSTRUCTION

- Many causes of airway obstruction are the same as in traditional trauma patients.
  - Secretions/vomitus/blood.
  - Soft tissue/foreign bodies.
  - Edema.
  - Particulate matter.
  - Facial fractures with loss of bony support of upper airway/ broken teeth/chewing gum.
- However, patients with high grade obstructions will be dead by

■ Respiratory problems

• Secretions/vomitus/blood

• Soft tissue/foreign bodies

• Edema

• Particulate matter

TASK FORCE MEDICAL TEAM TRAINING 04/97

■ Respiratory problems

• Airway obstruction

• Airway contamination

the time they are reached.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

AIRWAY CONTAMINATION

- "*When the earth stopped shaking the air was filled with dust.*"
  Quote from a doctor leaving his house for a house call.
  Tangshung Earthquake, July 28, 1976

- Tremendous amounts of lingering dust are released during any building collapse.

- Rescue activities will recirculate dust that has settled, as well as create additional dust.

- "*The air was filled with a suffocating dust.*"
  Quote from a retired worker practicing calisthenics in The People's Park.
  July 28, 1976

- As the entrapped patient continues to breath this dust over many hours, inspissated (dried) secretions are created within the airways.
  - Can also suffer from irritation of the upper airway and bronchospasm.

VENTILATION PROBLEMS

- Ventilation may be compromised by debris limiting chest wall expansion. This may limit the ability to blow off CO_2.

- Most patients with significant limitations in ventilation will already be dead from suffocation. However, rescue efforts may cause debris to move and thereby create ventilation compromise as well as other harm to the patient during rescue activities.

- Thoracic Trauma:
  - Pneumothorax
  - Hemothorax
  - Pulmonary contusion — initial presentation may be confusion.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

INHALATION INJURIES

- Inhalation injuries cause injury through one or more of these mechanisms.

- Displacement/consumption of O_2.
  - For example, displacement of O_2 by methane gas released from a ruptured gas line.
  - Consumption of a limited O_2 supply by the patient or by fire.

- Obstruction from thermal Injury
  - Inhalation of hot gases causes burns of the upper airway which may result in airway edema and narrowing.

- Pulmonary thermal injury.
  - Because of the ability of hot steam to retain heat as it passes to the lower airway passages, inhalation causes burns of the upper **and lower** airways.

- Pulmonary damage from noxious gases or particles.
  - Irritant chemicals released during fires; including acids, ammonia, phosgene, and many others.

- Inhalation of cellular toxins.
  - Chemicals which are inhaled, absorbed into the bloodstream and transported to cells of the body where they do damage; including carbon monoxide and cyanide.

FEMA US&R RESPONSE SYSTEM
TASK FORCE MEDICAL TEAM TRAINING 04/97

- Inhalation injuries
  - Displacement/consumption of O_2
  - Obstruction from thermal injury
  - Pulmonary thermal injury
  - Pulmonary damage from noxious gasses or particles

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

DIAGNOSIS OF AIRWAY PROBLEMS

- Diagnosis is often difficult until late in the progression of the injury.

- High index of suspicion.

- Assume all patients have at least dust contamination of their airway. Delayed diagnosis may be fatal.

- History of environment — other injuries may not be immediately evident and only clues in environment tip you off:
  - Building collapse by definition creates tremendous dust.
  - Fire or explosion.
  - Ruptured gas lines.

- History by patient:
  - Cough.
  - Short of breath.
  - Chest pain.

- Examination should begin at the first contact with the patient even if you can't see them. If they are talking to you, they have, for now, a patient airway:
  - Tachypnea.
  - Dyspnea.
  - Stridor (upper airway obstruction).
  - Wheezing (lower airway obstruction).
  - Cyanosis.
  - Hoarseness.
  - Carbonaceous sputum.
  - Facial burns/singed nasal hairs.

- Diagnosis of airway problems
  - High index of suspicion
  - History of environment
  - History by patient
  - Examination

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

MANAGEMENT OF AIRWAY/VENTILATION INJURIES

- Prevent continued contaminant inhalation.

- Place a dust mask on the patient ASAP once the airway has been assessed, maintained, established, suctioned and foreign bodies have been removed.
  - High flow humidified O_2.
  - Ideally, 15 LPM O_2 by non-rebreather face mask.

- Be aware of possibly limited O_2 supplies however; consider using compressed air (filled by rescue team's compressors) if necessary and if high flow O_2 is not indicated (may substitute low flow nasal cannula O_2 under a mask infused with compressed air). Use a pulseox, if available, to guide judicious O_2 use. Watch the "minilator" as it rapidly will use up the O_2 bottles.

- May require "long distance O_2"/compressed air until the patient's head is accessed.

- Humidify if possible to help moisten airway secretions.

- Suctioning.
  - Encouraging the patient to cough is more effective than suctioning, but is not always possible.

- Early Intubation.
  - Intubate before any developing edema completely obstructs the upper airway and makes intubation impossible.
  - When it is not possible to place a self-contained breathing apparatus on the patient, intubation may also be necessary to isolate the patient's airway from a contaminated environment (noxious gases).
  - Ideally, laryngoscopic orotracheal intubation.
  - However, various situations (massive facial injuries, upper airway edema, inability to access the patient's mouth or nose, etc.) may necessitate other methods of intubation (nasotracheal, lighted stylet, digital, sitting, reverse).

- Management of airway/ventilation injuries
  - Prevent continued contaminant inhalation
  - High flow humidified O_2
  - Sectioning
  - Bronchodilators
  - Early intubation

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

■ Management of airway/ventilation injuries

• CPAP/PEEP

• Surgical airway

• Chest decompression

MANAGEMENT OF AIRWAY/VENTILATION INJURIES (continued)

■ Bronchodilators.
- Albuterol (Ventolin, Proventil).
- Especially if evidence of lower airway obstruction (wheezing).
- May also be mucolytic (break up mucus).

■ CPAP/PEEP:
- **C**ontinuous **P**ositive **A**irway **P**ressure / **P**ositive **E**nd **E**xpiratory **P**ressure to maintain continuous pressure in the patient's airways and thereby prevent them from collapsing during exhalation.

■ Surgical Airway:
- Needle cricothyrotomy and jet ventilation/tube cricothyrotomy only when intubation impossible. Remember, if this is accomplished, that your time is limited by poor ventilation, even though oxygenation may appear adequate.

■ Chest Decompression:
- Needle decompression/Chest tube insertion with Heimlich Valve use.
- Although most patients who suffer a pneumothorax (PTX) from the initial trauma will be dead, the potential exists for a PTX to develop with intubation/ positive pressure ventilation/central line insertion/patient movement in presence of broken ribs, etc.

OTHER RESPIRATORY THOUGHTS

■ Ventilator
- Pre-hospital ventilators may relieve many hours of bagging the entrapped intubated patient.
- However, most are gas powered and require much O_2.

■ Pulse oximetry
- May be helpful to monitor the patient's O_2 saturation.
- Allows for judicious use of limited O_2 supply.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

OTHER RESPIRATORY THOUGHTS (continued)

- End tidal CO_2 monitoring — may be useful to:
  - Verify endotracheal tube position.
  - Monitor acid base status.
  - Regulate hyperventilation in the patient with increased intracranial pressure.

- Gastric suctioning
  - Most intubated patients should have an oro/nasogastric tube inserted to decompress their stomachs and allow for optimal lung expansion.
  - Also, any patient with nausea/vomiting/ileus (inappropriate bowel motility as is frequently seen in patients with these injuries) should receive nothing by mouth (NPO) and have their stomachs continuously decompressed.

- Esophageal Obturator (EOA) / Esophageal Gastric Tube (EGTA) / Pharyngeo-Tracheal Lumen (PTL) Airways
  - May be useful in certain situations but should not be methods of first choice.
  - Not part of equipment cache, but may be provided by local EMS agencies.

CAUSES OF STARVATION/DEHYDRATION

- Confined space patients have many reasons to suffer from starvation and volume depletion.

- No caloric/liquid intake.
  - Generally, these patients have not had any intake for many hours to days until you reach them.
  - Yet they continue, at least for some time, to loose fluids through urination, sweating, etc.
  - And they continue to burn calories through metabolism.

- Vomiting
  - As above, these patients are prone to develop an ileus which frequently leads to vomiting.

FEMA US&R RESPONSE SYSTEM
TASK FORCE MEDICAL TEAM TRAINING 04/97

- Causes of starvation/dehydration
  - No caloric intake/liquid intake
  - Vomiting
  - Blood loss
  - Edema
  - Hypothermia/Hyperthermia
  - Burns

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

CAUSES OF STARVATION/DEHYDRATION (continued)

- Blood loss
  - Again, patients with significant blood loss will be dead, but less severe blood loss will contribute to total volume depletion.
  - Note that bleeding may recur during extrication when objects compressing bleeding sites are removed.
- Edema
  - Fluid collection especially into injured extremities and into the GI tract (collectively known as "third spacing").
- Hypothermia/Hyperthermia
  - See "Hypothermia" and "Hyperthermia" below.
- Burns
  - See "Burns" below.

HYDRATION STATUS DETERMINATION AND MONITORING

- Note that no single indicator can be used to adequately determine a patient's volume status, rather all indicators must be taken into account.
- Monitoring must be an ongoing process as the patient is rehydrated.
- Patient symptoms
  - Thirst is a good indicator of volume depletion.
- Sensorium
  - All patients with an altered mental status should receive at least 1 amp D50W IV to treat hypoglycemia.
  - However, dehydration also frequently causes an altered mental status.
- Capillary Refill
  - Poor capillary refill indicates poor perfusion which **may**

be caused by volume depletion.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

HYDRATION STATUS DETERMINATION AND MONITORING (continued)

- Vital signs.
  - Tachycardia, diminished pulse pressure (systolic minus diastolic BP) and later hypotension may also indicate volume depletion.
  - **Changes**, rather than single measurements, in the above parameters are especially useful indicators.

- Mucous membranes.
  - Dry mouth, nose and eyes (no tears in children).

- Jugular Venous Distension (JVD).
  - Neck vein distension (more significant the more the upper body is elevated) may indicate over hydration (important during fluid resuscitation).
  - The actual pressure of venous blood returning to the heart (venous return) can be measured through a central line (more in the vascular access work station).
  - Alternatively, it may also be a sign of poor cardiac output (congestive heart failure, pericardial tamponade).

- Lung auscultation.
  - As the heart becomes unable to adequately circulate an increasing venous return, the fluid backs up into the most dependent portion of the lungs and causes the development of rales or crackles, which is an extremely sensitive indicator of over hydration.

- Skin turgor.
  - Increased ability of the skin to tent (poor skin turgor) is usually only seen with severe dehydration.

- Urine output.
  - When volume depleted, the body preferentially reduces blood flow to less vital organs such as the kidneys.
  - This ultimately results in decreased and eventually no urine output and can be monitored with the insertion of a urinary catheter.

- Hydration status determination and monitoring
- Lung auscultation
- Skin turgor
- Urine output
- Urine dipstick

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

REHYDRATION

- IV hydration preferable.
  - Because the patient may require surgery, and because of the high frequency of ileus and vomiting, these patients should be kept NPO.

- Oral hydration less desirable .
  - Consider oral hydration only if significant delay in gaining IV access.
  - For example, "long distance oral rehydration" through IV tubing.

METHODS OF IV ACCESS

(Also refer to Unit VII - Vascular Access Skills Station)

- Peripheral.
  - Generally easier, fewer complications and requires little patient access.
  - However, may be difficult in the hypovolemic patient.
  - Includes external jugular.
  - Catheter size can be increased using dilators and the Seldinger technique.

- Central venous catheter.
  - Invasive, more complications, requires patient positioning.
  - However, easier in the hypovolemic patient and allows for central venous pressure monitoring.

- Intraosseous.
  - Especially in children.

- Cutdown.
  - Incision over, dissection down to and direct visual cannulation of a peripheral vein.
  - Allows for peripheral IV insertion in the hypovolemic patient.
  - Requires more time, much skill and greater risk of infection.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

METHODS OF IV ACCESS (continued)

- Sterility
  - All of the above (esp. peripheral IV) are relatively invasive and require some degree of sterility including Betadine prep. Do what you can to prevent dust from falling into the field.

IV RATES DURING REHYDRATION

- Deficits replenished over time.
  - Usually a fluid bolus is administered first.
  - The healthier the patient's heart (younger patient), the quicker the fluids can be given.
  - For example, a 20 year old can tolerate 3 liters plus wide open, whereas a 60 year old with a history of CHF may be only able to tolerate 250cc wide before developing pulmonary edema.

- Clinical status should guide rehydration.
  - Treat the patient, not the numbers!

HYPOTHERMIA

- Core body temperature below 35° C (95°F).

- Causes of hypothermia:
  - Decreased heat production, especially when few calories are available (starvation) resulting in decreased metabolism.
  - Impaired thermoregulation, may result from head injuries, drugs (including EtOH).
  - Increased heat loss.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

HYPOTHERMIA (continued)

- Mechanisms of heat loss:
  - Conduction — direct transfer of heat to another object (lying on concrete or in water).
  - Radiation — giving off heat directly to the surrounding air.
  - Convection — as this heated surrounding air is blown away, more heat is then radiated. The stronger the air movement, the greater the convection.
  - Evaporation — heat lost as moisture on the skin dries.
  - Transpiration — heat lost in exhaled air (a dog panting).

- Hypothermia: Who's at risk? Confined space patients have many reasons to become hypothermic.
  - Trauma — very likely.
  - Hypoglycemia — very likely.
  - Wet skin — as from vomiting and urinating, broken water lines, etc.
  - "Cold" environment — even in warmer climates as long as the environment is cooler than the patient (< 98.6° F), the patient will lose heat to the environment.
  - Poor clothing — especially if not properly dressed (as with most entrapped patients who are indoors when the quake hits) and lying against cool concrete slabs/steel debris.
  - Infection — possible (see "Infection" below).
  - Age extremes — maybe.
  - Drugs/EtOH — maybe.
  - Exercise — doubtful.

HYPOTHERMIA CONCERNS

- Drugs ineffective. Including:
  - Lidocaine.
  - Epinephrine.
  - Insulin.

FEMA US&R RESPONSE SYSTEM
TASK FORCE MEDICAL TEAM TRAINING 04/97
FEMA US&R RESPONSE SYSTEM

- Hypothermia concerns
  - Drugs ineffective
  - Decreased drug clearance
  - Death

TASK FORCE MEDICAL TEAM TRAINING 04/97

- Hypothermia — Who's at risk?
  - Trauma
  - Hypoglycemia
  - Wet skin
  - "Cold" environment
  - Poor clothing
  - Infection
  - Age extremes
  - Drugs/alcohol
  - Exercise

TASK FORCE MEDICAL TEAM TRAINING 04/97

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

HYPOTHERMIA CONCERNS (continued)

- Decreased drug clearance.
  - "A little goes a long way" - more and more drug may be given when little effect is seen due to the hypothermia.
  - The drug is not metabolized normally and then when the patient is warmed large amounts of drug begin to act.
  - Lactated ringers is not metabolized to bicarbonate by a cold liver and lactate will accumulate and cause or worsen lactic acidosis.

- Death.
  - Especially during rapid rewarming ("rewarming shock").

- Mild hypothermia: (32-35° C or 89-95° F).
  - Cold sensation — the patient feels cold.
  - Shivering — if enough fuel (glucose) is available, the muscles rhythmically contract and relax to produce heat.
  - Increased metabolic rate — also requires adequate fuel.
  - Vasoconstriction — warm blood is prevented from reaching the skin where it will lose heat to the environment.
  - Tachypnea — increased breathing to rid the body of increased CO_2 produced by increased metabolism. Also, however, increases transpiration heat loss.
  - Amnesia, fatigue, poor judgement, confusion, ataxia, apathy — the patient develops mental status changes which may make care of the patient difficult.

Error! *FEMA US&R RESPONSE SYSTEM*
TASK FORCE MEDICAL TEAM TRAINING 04/97

- Mild hypothermia —

32-35° C or 89-95° F

- Cold sensation
- Shivering
- Increased metabolic rate
- Vasoconstriction
- Tachypnea
- Amnesia, fatigue
- Poor judgement, confusion
- Ataxia, apathy

Error!

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

HYPOTHERMIA CONCERNS (continued)

- Moderate hypothermia: (27-32° C or 82-89° F).
  - Shivering response lost — compensatory mechanisms begin to be lost.
  - Decreased respirations — decreasing metabolism resulting in less CO_2 production and less O_2 requirement which translates to decreased respirations.
  - Bradycardia and decreased stroke volume — and blood flow.
  - Atrial fibrillation — also other arrhythmias.
  - Ileus common — another cause of ileus in confined space patients.
  - Dilated pupils — loss of reflexes. For example, the knee jerk.
  - 25-50% decrease in O_2 consumption — protective mechanism, less O_2 is made available to cells, but less O_2 is required because of decreased metabolism.

- Severe hypothermia: (below 27° C or 82° F).
  - Progressive decrease in metabolism until it ceases and "death" occurs.
  - Coma — note that a patient is not dead until warm and dead.
  - Respirations cease.
  - Significant hypotension.
  - Ventricular fibrillation progresses to asystole.
  - 75% decrease in O_2 consumption.

TEMPERATURE MEASUREMENT

- Core temperature.
  - Oral, axillary, skin temperatures are inaccurate.
  - Rectal is better. Esophageal and central venous are the best.
  - Tympanitic (ear drum) also may be accurate.

- Requires special thermometer.
  - Most thermometers will not register temperatures under 35° C.

FEMA US&R RESPONSE SYSTEM
TASK FORCE MEDICAL TEAM TRAINING 04/97
FEMA US&R RESPONSE SYSTEM
TASK FORCE MEDICAL TEAM TRAINING 04/97

- Moderate hypothermia — 27-32° C or 82-89° F
- Severe hypothermia — Below 27° C or 82° F
  - Shivering response lost
  - Decreased respirations
  - Coma
  - Bradycardia and decreased stroke volume
  - Respiration cease
  - Atrial fibrillation
  - Ileus common
  - Significant hypotension
  - Dilated pupils
  - Loss of reflexes
  - Ventricular fibrillation progressing to asystole
  - 75% decrease in O_2 consumption

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

TEMPERATURE MEASUREMENT (continued)

- Osborn "J" Waves.
  - J point elevation.
  - Seen below 32° C.
  - Especially in leads II and V_6.

TREATMENT OF HYPOTHERMIA

- The patient's **core** should be rewarmed.

- Warming the skin and periphery can lead to vasodilation and "rewarming shock".

- Warm IV fluids.
  - Initially, as the patient becomes hypothermic and vasoconstricts, the blood from the periphery is diverted to the core organs including the kidneys.
  - The kidneys subsequently "see" a false increase in blood volume and therefore make more urine.
  - This leads to hypovolemia which is at least partially compensated by a smaller vascular space to fill while the patient remains hypothermic and vasoconstricted.
  - May be difficult to warm IV fluids, but at least keep containers inside your clothing. Consider using a microwave to heat the IV bag. One bag on small sandwich setting will give fluid room temperature.

- Warm O_2 — A temperature of ~ 39^o.
  - May be difficult but at least keep O_2 tank warm. Wrap in towels, store in warm environment prior to use.

- Warm irrigation.
  - All body cavities (stomach, bladder) can be flushed with warmed fluids via tubes introduced (NG, Foley catheter).

- Environmental mitigation:
  - Space heater (if enough room).
  - Shield patient from wind.
  - Pump water out, remove wet clothes, wrap in space

blanket.

- Place insulator (blanket) between patient and concrete.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

HYPERTHERMIA

- Heat edema
- Heat cramps
- Heat exhaustion
- Heat stroke
- Response team members are especially susceptible to hyperthermia.
- Various degrees of hyperthermia are possible.

HEAT EDEMA

- Edema of hands, feet and ankles.
  - Especially in the distal dependent extremities.
  - Especially in women.
  - Usually only during the first few days of heat acclimatization.
- Salt and water retention.
  - Probably from increased aldosterone (a hormone).
- Self-limiting.
  - No treatment is required.

HEAT TETANY

- Results from hyperventilation.
  - The body attempts to get rid of excess heat through hyperventilation (transpiration).
- Respiratory alkalosis.
  - A decrease in CO_2 causes an increase in pH which results in a decrease in blood calcium.
- Carpopedal spasm.
- Tetany.

Error! *FEMA US&R RESPONSE SYSTEM*
TASK FORCE MEDICAL TEAM TRAINING 04/97

- Heat tetany
  - Results from hyperventilation
  - Respiratory alkalosis
  - Carpo-pedal spasm
  - Tetany
  - Parathesias
  - With or without heat exhaustion/stroke

- This decrease in calcium causes muscles to contract resulting in flexion contractions especially of the fingers, hands, wrists.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

HEAT TETANY (continued)

- Parathesias.
  - Numbness and tingling especially of the hands, lips and feet.

- With or without heat exhaustion/stroke.
  - See "Heat Exhaustion" and "Heat Stroke" below.

HEAT CRAMPS

- Salt loss through sweating.
  - Sodium is lost during sweating. This depletes the body's sodium concentration.
  - This depletion will be exaggerated if water without salt is replaced.
  - The sodium concentration will then be further diluted.

- Exercised muscles.
  - This low sodium (hyponatremia) will cause muscles, especially those that are heavily exercised, to contract or cramp.

- Cool, rest, replace fluid **and salt**.
  - Water and salt must be replenished either IV or orally.

HEAT EXHAUSTION

- Electrolyte and/or water loss.
  - Salt and/or water may be depleted (usually both).

- Nonspecific Symptoms.
  - Including headache, nausea, vomiting, lightheadedness, malaise, myalgias (muscle aches), etc.
  - Be aware when there are many team members requesting OIC's for a headache.

- Temperature < 39° C.

- Heat exhaustion
  - Electrolyte and/or water loss
  - Nonspecific symptoms
  - Temperature < 39° C
  - No mental status changes
  - Marked elevation of liver function tests
  - Cool, replace salt and water

- Heat cramps
  - Salt loss through sweating
  - Exercised muscles
  - Cool, rest, replace fluid and salt

- Usually the patient's temperature is not excessively elevated (39^{o} C = 102.2^{o} F).

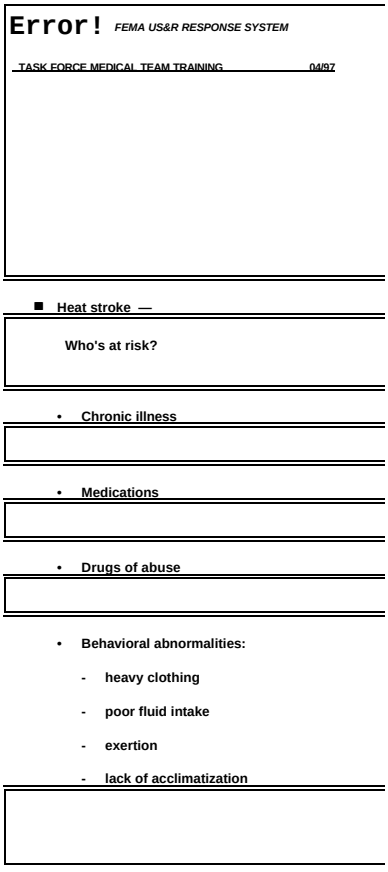
IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

HEAT EXHAUSTION (continued)

- No mental status changes.
  - This differentiates heat exhaustion from heat stroke, but if any doubt, treat for heat stroke.
- Marked elevation of liver function tests.
  - Not available in the confined space however.
- Cool, replace salt and water.
  - Judicious rehydration to avoid fluid overload.

HEAT STROKE: WHO'S AT RISK?

- Chronic illness.
  - Including cardiovascular disease, prior heat stroke, dehydration, previous major burn scarring (sweat glands destroyed), fever, age extremes, etc.
- Medications.
  - Including diuretics, many psychiatric drugs, antihistamines, salicylates, and many others.
- Drugs of abuse.
  - Including ethanol, cocaine, hallucinogens, sympathomimetics, etc.
- Behavioral anomalies.
  - Including inappropriate clothing, poor fluid intake, injudicious exertion, lack of acclimatization (requires 90 minutes of activity daily for one week in a hot environment).
- Note that team members may have many of these risk factors.



IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

PHYSIOLOGY

- Temperature regulation lost.
  - Temperature may exceed 42° C (107.6° F).
- Metabolism deregulated.
- Organ failure.
  - As more and more cells die organs cease to function.
- Death.
  - Eventually the patient succumbs.

HYPERTHERMIA COMPLICATIONS

- Mental status changes.
  - Including obtundation, seizures, delirium, posturing, focal deficits, etc.
- Adult Respiratory Distress Syndrome (ARDS).
  - Noncardiogenic pulmonary edema, that is not because of blood backup into the lungs from heart failure, but from water influx into the lungs through "leaky" capillaries.

FEMA US&R RESPONSE SYSTEM

- Hyperthermia complications
  - Mental status changes
  - Adult respiratory distress syndrome (ARDS)
  - Liver failue
  - Rhabdomyolysis
  - Acute renal failure (ARF)
  - Disseminated intravascular coagulation (DIC)

TASK FORCE MEDICAL TEAM TRAINING 04/97

- Physiology
  - Temperature regulation lost
  - Proteins denature
  - Oxidative phosphorylation uncoupled
  - Sodium Influx through membranes and capillaries
  - Widespread necrosis
  - Organ failure
  - Death

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

HYPERTHERMIA COMPLICATIONS (continued)

- Liver failure.
  - The liver is especially sensitive to hyperthermia.

- Rhabdomyolysis.
  - As with crush syndrome, muscle cells break down and release myoglobin into the blood.

- Acute Renal Failure (ARF).
  - Myoglobin is only one cause of ARF; See "Crush Syndrome."

- Disseminated Intravascular Coagulation (DIC).
  - Microscopic blood clots form and lodge in capillaries.
  - Eventually clotting factors are used up and the blood can no longer clot when necessary.
  - The patient subsequently bleeds.
  - Usually the cause of death.

PHYSICAL EXAMINATION

- Tachypnea and tachycardia.
  - Respiratory rates may be > 50 per minute and the patient may be panting.

- Hypotension or normotension.

- Hot and dry, **or cool and clammy**.
  - Note that the skin is **not** always hot and dry.

- Mental status changes.
  - As above.

- Pulmonary edema.

- Rales, dyspnea, cyanosis, etc.

- Bleeding.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

HYPERTHERMIA TREATMENT

- A,B,C's.
- Cool, cool, cool.
- Remove heat source.
- The patient should be cooled as soon, and as quickly as possible.
  - Wet skin and allow air to evaporate it (convection). Use a spray bottle and fan on naked patient in the shade.
  - May also place ice in the groins, neck and axillae, but avoid shivering (this will increase heat production).
  - Monitor core temperature closely to avoid overshoot hypothermia.
- Judicious fluids.
  - These patients are not necessarily hypovolemic.
  - Note that cooling will shift blood being shunted to the periphery (to promote cooling) back to the core and potentially exacerbate volume overload.
  - Avoid fluid overload which may result in congestive heart failure, ARDS, etc. but ensure adequate urine output especially if rhabdomyolysis is present.
- Prevention.
  - Careful monitoring may avoid this complication (in team members at least).

BURN CONCERNS

- Tremendous water loss.
  - Up to 15 times the normal insensible water losses (the normal water losses one is not aware of (sweating, transpiration, etc.) through weeping of the burned skin.
- Significant heat loss.
  - Much heat is lost when this water evaporates.

■ Burn concerns

- Tremendous water loss
- Significant heat loss
- Enormous caloric needs
- Increased susceptibility to infection

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

BURN CONCERNS (continued)

- Enormous caloric needs.
  - Maintenance of body heat and reconstruction of damaged tissues requires many calories.

- Increased susceptibility to infection due to loss of the skin's protective barrier allows bacteria to invade.

BURN CARE

- Stop the burning.
  - Including removing burned clothing, but prevent hypothermia.

- A,B,C's.
  - As with all patients.

- Fluid replacement.
  - Initial rate of hydration is based upon the percent of body surface burned (see below).

- Control pain.
  - May not be needed with 3rd degree burns because pain sensation is lost with the destruction of nerves.
  - However, often needed to allow cleansing and further burn care (See "Pain" below).

- Gentle cleansing.
  - Soap and water. Careful: Anything >15% BSA and you may make the patient hypothermic — better to just cover with a dry, sterile dressing.

- Debride devitalized tissue.
  - Remove loose dead tissue.

- Antibiotic ointment.
  - Cleanse, debride and apply Silvadene Cream daily to small burns.

- Burn care
  - Antibiotic ointment
  - Dry sterile dressing
  - Splint and elevate extremity
  - Tetanus prophylaxis
  - Consider gastric sectioning
  - Consider escharotomy

- Although there is a high rate of infection, prophylactic antibiotics are not indicated.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

BURN CARE (continued)

- Dry sterile dressing.

- Splint and elevate extremity.
  - Especially during extrication - to prevent further wound contamination/injury.
  - Especially important in circumferential burns.

- Tetanus prophylaxis.
  - Tetanus and Diphtheria toxoids (Td) 0.5mL IM if no Td within the past 5 years.
  - Also Tetanus Immune Globulin (TIG, Hyper-Tet) 250 Units IM in another extremity if uncertain, incomplete or no baseline tetanus immunizations (3 DPT's usually given as a child).

- Consider gastric suctioning.
  - These patients also frequently develop an ileus.

- Consider escharotomy.
  - Circumferential burns cause the skin to loose its elasticity.
  - If burns surround the chest, inhalation may be inhibited.
  - If around an extremity may cause compartment syndrome.
  - An incision through the burned skin (eschar) will flay open and allow an area for expansion.

ESTIMATION OF BURNS

- Rule of Nines.
  - Major sections of the body comprise 9% (or a multiple of 9%) of the surface area.
  - This formula is modified for children who's head and arms are disproportionately larger and who's trunk and legs are disproportionately smaller.

- Rule of Palms.

FEMA US&R RESPONSE SYSTEM

TASK FORCE MEDICAL TEAM TRAINING 04/97

- Estimation of burns
- Rule of Nines
- Rule of Palms
- Lund and Browder chart

- The area equivalent to the size of a patient's palm is approximately 1% of the surface area.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

ESTIMATION OF BURNS (continued)

- Lund and Browder Chart.
  - A chart that provides estimates of percent surface area for each major portion of the body based upon the age of the patient.

REHYDRATION

- Lactated Ringers.
  - LR is the solution of choice.
  - Total Volume in 1st 24 hrs = 2-4cc X Wt(kg) X %TBSA.
  - For example, a 70kg patient with 2nd and 3rd degree burns of 50% surface area would require:
    2-4cc X 70kg X 50% = 7,000-14,000 cc in first 24 hrs.
  - ½ over first 8 hours
    3,500-7,000 cc in the 1st 8hrs = 440-880 cc/hr.
  - ½ over next 16 hours.
    3,500-7,000 cc in the next 16hrs = 220-440 cc/hr.

- Guideline only.
  - As with any IV hydration rate, this is only an estimation of the volume the patient will require, and the patient's clinical status (especially urine output) should direct adjustments in the IV rate.

INFECTION

- Usually not seen for at least 48 hours.

- Most wounds will not appear infected for at least 48 hours .

- This is the time it takes for enough bacteria to multiply and for the body to mount a defense (increased blood flow = redness and increased warmth, invasion of white blood cells = pus, etc.).

■ Infection

- Usually not seen for at least 48 hours
- Abscess = drainage
- Less defined and deep infections = local wound care and antibiotics
- Tetanus prophylaxis

■ Rehydration

- Lactated ringers
- Total volume in first 24 hrs = 2-4cc X wt (kg) X % TBSA
- 1/2 over first 8 hours
- 1/2 over next 16 hours
- Guideline only

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

FEMA US&R RESPONSE SYSTEM
TASK FORCE MEDICAL TEAM TRAINING 04/97

INFECTION (continued)

- Abscess = drainage.
  - Incision and drainage when the localized collection of pus (abscess) becomes fluctuant (soft) is usually all that is needed.

- Less defined and deep infections = local wound care and antibiotics.
  - However, most infections are not localized and cannot be drained (cellulitis = diffuse skin infection, pneumonia, urinary tract infection, etc.).

- Soap and water, Betadine and/or Peroxide should be used to cleanse all wounds.

- Antibiotics can be given orally, IM or IV depending on the seriousness of the wound and the clinical state of the patient.

- Tetanus Prophylaxis.
  - Same rules as for burns.

PARENTERAL ANTIBIOTICS (in cache)

- Usually, administered IM and/or IV for more serious infections or if unable to take po (vomiting).

- Each has different indications, contraindications, dosages, etc. which are beyond the scope of this lecture.

- **Always check allergies before administering any medication**.

■ Parental antibiotics

- Cephazolin

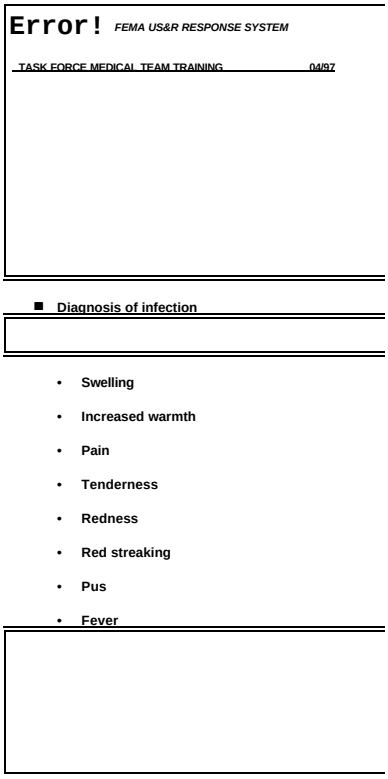
- Ceftriaxone

- Vancomycin

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

DIAGNOSIS OF INFECTION

- The body's attempt to combat an infection is manifested by these signs and symptoms.
- In other words, one does not see the actual infection, rather the body's reaction to the infection.
- Swelling.
- Increased warmth.
- Pain.
  - Pain is a symptom, or something the patient tells you.
- Tenderness.
  - Tenderness is a sign, or something you elicit when you palpate the infected area.
- Redness.
- Red streaking.
  - Red streaking up extremity (commonly known as "blood poisoning") indicates that infection has spread to the lymph vessels which normally return fluid (lymph) from tissues back into the bloodstream via the major veins.
- Pus.
  - Pus is a collection of white blood cells which migrate out of the blood stream to fight the infection.
- Fever.



IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

ORTHOPEDIC INJURIES

- Splint.
  - Check neurovascular status of extremity before and after splinting and periodically thereafter.
- Reduce obvious fractures and dislocations only if severely deformed or if neurovascular status compromised distally.
  - Including open fractures with protruding bone edges: only if definitive care is significantly delayed.
  - As a rule, reduce fractures and dislocations by distracting (pulling apart) the extremity on each side of the injury then reversing the motion that caused the injury.
  - Strongly consider pain meds! They will not only make the patient more comfortable, but also less combative.
- Prophylactic antibiotics for all open fractures.
  - Open fractures have a high incidence of infection.
- Elevate extremity and apply ice.
  - This will help reduce swelling and thereby help to alleviate pain and increased tissue pressure (compartment syndrome and sequelae).
- Consider clearing the C-spine (if able) prior to immobilization and extrication.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

ORTHOPEDIC INJURIES (continued)

- Field amputation:
  - Should be procedure of last resort.
  - Communicate with the patient.
  - Definitely sedate and give pain control.
  - Betadine prep.
  - Proximal hemostasis with BP cuff tourniquet.
  - Guillotine muscle with scaple.
  - Hemostasis achieved with clamp (no ties).
  - Periostical elevator.
  - Bone saw, bone wax, compressive dressing.
  - Have destination predetermined.

HAZARDOUS MATERIALS EXPOSURE

- Look Out For Number One!
  - Becoming a victim will help no one; and in fact will hinder the team and patient care.
  - Requires continuous communication with the rescue team, incident commander, etc.

- Prevent further exposure.
  - Ideally, remove the patient from the source (difficult with entrapped patients).
  - Alternatively, remove the material from the patient.
  - Generally, gentle skin cleansing and flushing with large amounts of water will remove most of the contaminant.

- A,B,C's.
  - Including high flow O_2.

- Administer specific antidote.
  - If there is an antidote; and if it is included in the cache (see below).

- Supportive care.
  - As with any patient.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

CARBON MONOXIDE

- Reduces O_2 delivery.
  - Binds 250 times better than oxygen to hemoglobin, and therefore inhibits oxygen uptake into the blood in the lungs.

- Impairs oxygen usage.
  - Also inhibits use of the reduced oxygen supply that does reach cells.

- Treatment of carbon monoxide (CO) poisoning.
  - Prevent further inhalation.
  - A,B,C's.
  - Administer 100% O_2.
  - The body will normally rid itself of CO via exhalation, but this process is very, very slow in room air.
  - This can be speeded up somewhat by administering 100% O_2.
  - It can be speeded up even more by hyperbaric O_2, but this is not practical in the field; but should be considered when planning transfer of these patients if hyperbaric centers are available.

SEDATION/PAIN MANAGEMENT AND OTHER "DOWNERS"

Why administer pain medications?

- Prolonged patient care.
  - In most traditional EMS systems pain medications are usually not administered until the patient is completely evaluated by emergency/trauma physicians to prevent masking injuries (internal bleeding).
  - Confined space patients, however, may not see these physicians for many hours and may require pain control to facilitate evaluation, extrication, cooperation and for humanitarian reasons unless otherwise contraindicated.

- Sedation/pain management and other "downers"
- Prolonged patient care
- Facilitate procedures
- Facilitate extrication

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

SEDATION/PAIN MANAGEMENT AND OTHER "DOWNERS" (continued)

- Facilitates procedures.
  - Various procedures (intubation, IV cannulation, etc.) may be difficult or even impossible in the patient who is uncooperative for various reasons (pain, CNS injury, anxiety and other psychological reasons, etc.)
  - Pain control/sedation/paralysis can often facilitate management of these patients.

- Facilitates extrication.
  - The patient may experience great pain during extrication and may resist extrication efforts.

METHODS OF PAIN CONTROL

- Narcotics.
  - Morphine, meperidine (Demerol), oxycodone/ acetaminophen (Tylox), hydroxyzine (Vistaril) can be added to potentiate narcotic pain control and to alleviate unwanted side effects (nausea).
  - Watch for hypotension in these patients who may already be volume depleted.
  - Watch for respiratory depression in these patients who's airways may be difficult to control in the confined space.
  - Naloxone (Narcan) can be given to reverse narcotics.

- Aspirin/Tylenol.
  - Mild to moderate pain can be controlled in many patients with aspirin or Tylenol.

- Motrin.
  - Ibuprophen (oral administration) for mild/moderate pain.

- Nitrous Oxide.
  - Nitrous oxide is self administered by the patient and has a quick onset of action and quick elimination.
  - Has few side effects; but should not be used in

unventilated confined space because the environment will become contaminated and rescuers intoxicated.

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

METHODS OF PAIN CONTROL (continued)

- Local anesthetics.
  - Injected around a wound or around the nerves supplying a painful area (nerve block).
  - Relatively short acting and requires much skill.

SEDATIVES AND PARALYTICS

- Benzodiazepines.
  - Diazepam (Valium) and midazolam (Versed) (shorter acting than Valium).
  - Again, watch for hypotension and respiratory depression.
  - May mask developing mental status changes.

- Paralytics.
  - Vecuronium (Norcuron) can be extremely useful, especially for intubation; but must be used with extreme caution because failure to intubate and/or adequately ventilate the patient will lead to death.

- Ketamine.
  - Ketalar - a general anesthetic.
  - Useful for intubation or short painful procedures.

- Brevital.
  - A short-acting barbiturate.

- Haldol.
  - Better as an anxlolytic.

- Topical anesthetics.
  - Lidocaine jelly for mucous membranes.
  - Alkaine ophthalmic for some eye pain.

■ Sedatives and paralytics

- Benzodiazepines
- Paralytics
- Ketamine
- Brevital
- Haldol

IV. US&R MEDICAL PROBLEMS
B. OTHER MEDICAL PROBLEMS

PSYCHOLOGICAL CONCERNS

- Imagine being buried under an entire building for days without food, water, bathing, using restroom facilities or even moving; **and** not knowing whether anyone will ever rescue you!

- While this statement says it all, remember to communicate with your patient especially when doing patient care procedures, using extrication equipment, leaving him/her for any reason (backing out to get equipment, repositioning, etc.).

- If necessary, may also need to consider sedation.

PREVIOUS MEDICAL CONDITIONS

- Remember, many of these patients have medical problems that predate their acute situation.

- Elicit a good history.
  - Perform a good history to ascertain any previous medical conditions, medications, allergies, etc.

- Provide maintenance medications.
  - Make up decreased blood levels of relevant medications (seizure drugs, digoxin and other antiarrhythmics, etc.) and then provide maintenance doses.

- Treat decompensation.
  - Continuously monitor for and treat any decompensation of chronic diseases including but by no means limited to:
    - seizure disorders.
    - ischemic heart diseases (angina).
    - asthma and emphysema.
    - diabetes.
    - hypertension.