



## Objectives

**At the conclusion of this presentation the participant will be able to:**

- Identify the initial assessment for patients with musculoskeletal injury
- Describe upper extremity, lower extremity and pelvic musculoskeletal traumatic injuries and implications for nursing care
- Explain indications and strategies for open and closed reduction of fracture/dislocations
- Discuss the prevention, recognition and interventions for compartment syndrome and rhabdomyolysis




## Resuscitation

**A diagnosis of Musculoskeletal Injury may not occur initially, until there is significant blood loss causing hemodynamic instability.**

**The Primary Survey in ATLS/ATCN does not include a thorough assessment of musculoskeletal injuries unless gross bleeding causes a concern.**

**Radiography may/will confirm musculoskeletal injuries.**

**Prehospital information can help raise the index of suspicion.**



Musculoskeletal injuries are generally not assessed to a great extent in the primary survey of trauma care unless there is severe hemodynamic compromise or gross deformity. For this reason, gross deformity may be an attention-seeker, yet the extent of injury may not be fully recognized until the primary survey is complete. The primary trauma resuscitation within the ATLS/ATCN guidelines focuses on airway-breathing-circulation, the ABC's. If the musculoskeletal injury does not produce enough blood loss to cause hemodynamic instability, or gross deformity to grab anyone's attention, the extent of injury may go unnoticed until radiographic studies confirm otherwise, which may not occur until the secondary survey.

## Mechanism of Injury (MOI)

How's

↓

What's

↓

Where's

↓

When's



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The mechanism of Injury (MOI) may help to raise the index of suspicion for physicians and nurses in a trauma resuscitation, and understanding the importance of the *how's*, *what's*, *where's* & *when's* assists in determining the potential for serious musculoskeletal damage.

**Note the patient's left leg position! Do you anticipate a musculoskeletal injury, perhaps with an accompanying vascular injury.**

The trauma resuscitation team must obtain the following information;

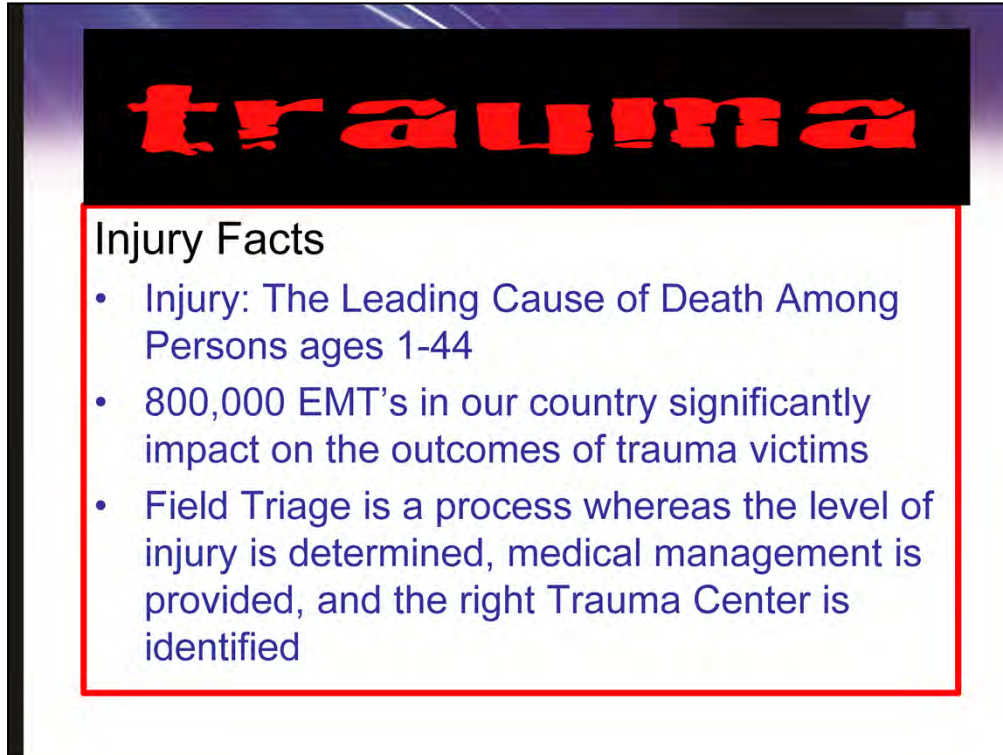
*How* did it happen? Was it a high or low energy trauma? High or low energy trauma will follow the *basic law of motion*. Energy can not be destroyed-it can only change form (absorbed and transferred). The 3-motions are as follows; vehicle hits tree-body hits vehicle-organs/skeletal structures hit body. This transfer of energy changes form or is absorbed, and keeps going until it is forced to stop.

Sir Isaac Newton's second law of motion, published in July 5, 1687; *Philosophiae Naturalis, Principia Mathematica*, says that acceleration "a" (how fast something is moving) is parallel to the force "F" (how hard its hit) and directly opposite from the mass "m" (how large it is)  $F = ma$ .  $F$  and  $a$  are vectors (they have the ability to move directions), and "m", called a scalar, can not change directions. So the trauma care provider must consider in the "forward deceleration" injuries, or motor vehicle crashes (MVC), the following; what is the extent of damage to the vehicle, what did the patient's body hit, e.g.; steering wheel, dashboard, and what organs/structure damage happened because of it, e.g.; fractures, lacerations, etc...

Knowing the position the patient was in at the time of injury also helps identify additional injuries. If the trauma is a fall and the patient landed on their feet, it is reasonable to assume the force transferred up and there may be a pelvic injury as well.

*What* happened? Get as much information as you can from the prehospital staff.

*Where* did it happen? And *when* did it happen? This information can help raise the index of suspicion in regards to the environment the injury occurred. A trauma that occurs outdoors may place the patient at a higher risk for infection. Knowing how long ago it happened can help to understand the physiologic changes that may already have occurred as time passed.



## trauma

### Injury Facts

- Injury: The Leading Cause of Death Among Persons ages 1-44
- 800,000 EMT's in our country significantly impact on the outcomes of trauma victims
- Field Triage is a process whereas the level of injury is determined, medical management is provided, and the right Trauma Center is identified

A Field Triage is the process used by emergency medical technicians (EMT), to identify the severity of injury and transport to the most appropriate trauma center. The EMT will work from an algorithm called a "Field Triage Trauma Decision Scheme" and maintain protocols that are industry standards.


Injury is the leading cause of death in people 1-44 years, taking a patient to a trauma center can reduce the risk of death by 25% (CDC).

There are 45 million Americans who do not have access to a trauma center in our country. Trauma centers have resources, processes, and protocols with the skill and expertise to manage these time sensitive injuries much more efficiently than non-trauma centers.

## 2011 Field Triage Decision Scheme

**Step One:**

- Glasgow Coma Scale score of 13 or lower (change from <14),
- Systolic blood pressure of less than 90 mm Hg, or
- Respiratory rate of fewer than 10 or more than 29 breaths/minute (<20 breaths/minute in infants aged <1 year) **or need for ventilatory support** (criterion added).



Triage is a mechanism whereas the “sorting of patients” with injuries that require immediate attention are determined. Additionally, transport to the appropriate hospital is required of the pre-hospital personnel to ensure severely injured patients are seen in a trauma center vs. a non-trauma center.

The 2011 Field Triage Decision Scheme is available as a poster from <http://www.cdc.gov/fieldtriage/>

Following the trauma decision scheme, the EMT will first measure the vital signs and level of consciousness. The vital signs will consist of a blood pressure (BP) and respiratory rate (RR). The Glasgow coma score (GCS) will determine the level of consciousness.


If the GSC **is 13 or lower**, BP < 90mmhg, and the RR is <10 or >29bpm (and <20bpm for infants <1 year of age), **or if there is a need for ventilatory support** take the patient to **the highest level of** trauma center **within the defined system**.

If **the** vitals and **GCS** are **NOT** within above parameters, then move on to **Step Two of Field Triage Decision Scheme**.

## Field Triage Decision Scheme

**Step Two:**

- All penetrating injuries to head, neck, torso, and extremities proximal to elbow or knee
- Chest wall instability or deformity (e.g., flail chest)
- 2 or more proximal long-bone fractures;
- Crushed, degloved, mangled, or pulseless extremity
- Amputation proximal to wrist or ankle
- Pelvic fractures
- Open or depressed skull fractures; or
- Paralysis





Recommend transport to a facility that provides the highest level of care within the defined trauma system if any injuries on the slide are identified.



## Step Three MOI Criteria

- Falls
- High-risk auto crash
- Automobile vs pedestrian/bicyclist thrown, run over, or with significant (>20 miles/hour) impact
- Motorcycle crash faster than 20 miles/hour



In step 3, for the mechanism-of-injury criteria, the panel recommended transport to a trauma center if any of the above are identified.

High risk falls are considered:

- for adults, more than 20 feet (1 story = 10 feet), or
- for children, more than 10 feet or 2 to 3 times the height of the child.

High risk auto crashes are considered:

- intrusion, including roof (criterion added), of more than 12 inches occupant site or more than 18 inches any site;
- ejection (partial or complete) from automobile;
- death in same passenger compartment; or
- vehicle telemetry data consistent with a high risk for injury

## Step Four: Special Considerations



- Older Adults
- Children
- Anticoagulants
- Bleeding disorders
- Burns
- Pregnancy



In step 4, for the special considerations, the panel recommended transport to a trauma center or hospital capable of timely and thorough evaluation and initial management of potentially serious injuries for patient who meet the following criteria:

Older adults:

- risk for injury/death increases after age 55 years,
- systolic blood pressure lower than 110 mm Hg might represent shock after age 65 years (criterion added), and
- low-impact mechanisms (e.g., ground-level falls) might result in severe injury (criterion added).

Children should be triaged preferentially to pediatric capable trauma centers;

Anticoagulants and bleeding disorders:

- patients with head injury are at high risk for rapid deterioration (criterion added).

Burns:

- without other trauma mechanism, triage to burn facility;
- with trauma mechanism, triage to trauma center.

Pregnancy greater than 20 weeks; and

EMS provider judgment.

In step 4, "time-sensitive extremity injury" and "end-stage renal disease requiring dialysis" were removed.

When in doubt, transport to a trauma center.

**Initial Management**

Blood loss hypovolemia
Pain
Infection
Neurovascular damage

*The four priorities of care*

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Each of these will be addressed in the following slides

### **Neurovascular Damage**

A musculoskeletal injury often involves neurovascular damage because bones lie very close to muscle and nerves. A vascular injury is the precursor to ischemia. Once ischemia, or this hypo-perfusion state begins, its not long that edema develops and causes capillary collapse. Within 6 hours, irreversible damage occurs.



Bleeding may be overt (blood on the floor) or covert (in retroperitoneum, in muscle).

Check and secure airway first.

**Overt bleeding:** Control the bleeding with direct pressure or using pressure points. If ineffective a tourniquet may be used.

**Covert bleeding:** Splint extremity fractures, apply pelvic binder to splint pelvic fractures

Once site of bleeding is identified, suturing, angiographic embolization or surgical repair may be indicated to stop the bleeding.

**This young man arrived in the ED after a motorcycle crash, with tourniquets in place.** He came with no IV sites and a BP of 70. He was taken immediately to the OR where he was intubated, lines inserted and blood replacement begun. His BP was allowed to remain low until the amputations were completed.



The earliest known usage of tourniquets dates back to 199 BCE. It was used by the Romans to control bleeding during amputations.

In 1718, the French surgeon Jean Louis Petit came up with a screw for occluding blood flow during surgery. Above is the garrot which was tightened by twisting the rod. Hence the name tourner which means to turn.



A tourniquet is provided to all combat soldiers as part of their gear.

Studies show improved survival rates with proper tourniquet use, e.g.; wide or double tourniquets and surgical tourniquet apparatus.

The lowest effective pressure in tourniquet use is the pressure that is enough to occlude blood flow and maintain hemostasis.

In the past it was thought dangerous for limb salvage, yet military studies reveal that if the tourniquet is applied properly, and not left on for greater than two hours, there is no difference in limb salvage success. In today's EMS systems, the "scoop and run" method is advocated, and heroics in the field are not warranted.

The tourniquets purpose is to constrict arterial and venous pressure circumferentially; to provide temporary occlusion. Since it takes several hours for anaerobic metabolism and ischemia to occur, it is generally safe to use a tourniquet for short term therapy to stop hemorrhage.



Purposes:


- To splint the bony pelvis to reduce hemorrhage from bone ends and venous disruption.
- To reduce pain and movement during transfers.
- To provide some integrity to the pelvis when operative packing of the pelvis is necessary.
- To provide stabilization of the pelvis until definitive stabilization can be achieved.

Absolute indications

- The hemodynamically unstable patient with a mechanically unstable pelvis.
- The hemodynamically unstable patient with a suspected pelvic fracture.
- <http://www.trauma.org/index.php/main/article/657/>

## Covert Blood Loss

- **Blood Loss Associated with Fracture in Adults**
- Fracture site amount of blood loss in mL
- Radius and ulna 150–250
- Humerus 250
- Tibia and fibula 500
- Femur 1000
- Pelvis 1500–3000




<http://www.mdconsult.com/books/page.do?eid=4-u1.0-B978-0-323-05472-0..00046-3--s0020&isbn=978-0-323-05472-0&type=bookPage&from=content&uniqId=377062153-2>

As you are assessing your patient who has a scalp lac that has saturated the dressing, a deformity of the right upper extremity, a leg that has outward rotation and an open fracture on same leg below the knee. Even though his vitals are normal now, what is his estimated blood loss? 1500-2000 or a bit more? Should you be prepared to give blood?



## Blood Loss Hypovolemia

	CLASS I	CLASS II	CLASS III	CLASS IV
BloodLoss (ml)	<750	750-1500	1500-2000	>2000
%	15%	15%-30%	30-40%	>40%
HR	<100	>100	>120	>140
BP	normal	normal	decrease	decrease
PP	normal	decrease	decrease	decrease
RR	14-20	20-30	30-40	>35
UOP	>30	20-30	5-15	negligible
CNS	slightly anxious	mildly anxious	anxious confused	confused lethargic





### Hypovolemia

**Review the Physiologic Responses to Hemorrhage table with special note of the amount of blood loss it takes to “look shocky”.**

- As you saw on previous slide, long bone and pelvic fractures may cause significant blood loss, leading to hemorrhagic shock. The early physiologic signs of shock include tachycardia and cutaneous vasoconstriction. Systolic blood pressure may not drop until 30% of blood volume is gone, yet the narrowing difference between systolic and diastolic blood pressure may be very telling and indicative of compensatory vasoconstriction. Patients on beta blockers may not experience tachycardia so a list of current medications is essential because the compensatory mechanism in these patients will be blunted.
- Until the patient is in Class III shock, the blood pressure may be normal.
- Today’s approach to resuscitation for blood loss hypovolemia is more conservative with a goal of an SBP >~90 mm hg, using minimal crystalloid and replacing blood loss with blood products.
- End organ perfusion, which is the goal of fluid resuscitation, is evidenced by good mentation, brisk capillary refill, good color and temperature, readily palpable pulses, and urine output of at least 0.5 ml/kg/hr
- **Remember to warm all fluids and blood to prevent hypothermia..... This can be the difference between a successful outcome and death. Never forget the “Trauma Triad of Death”**

## Acute Pain from Traumatic Injury

- Leads to stress response that increases heart rate and blood pressure
- Limits recovery
- Improves clinical outcome when managed well



The slide features a purple gradient background with a white cross icon in the top right corner. The title 'Acute Pain from Traumatic Injury' is centered at the top in white. Below the title, a light blue rounded rectangle contains a bulleted list of three points. To the right of the list is a photograph of a man's face and shoulder; he has a pained expression and is holding his right shoulder with his left hand. In the bottom right corner of the slide, there is a logo for STN (Society of Trauma Nurses).

Acute traumatic pain is a combination of somatic and visceral responses. And is also a combination of mechanical, thermal and chemical stimuli. These stimuli release serotonin, bradykinin, histamine, Substance P, that activate nociceptors (e.g., pain receptors) to activate pain signaling.

## Pain Assessment

- Numeric Scale
- Visual Analogue Scale
- Faces Pain Scale

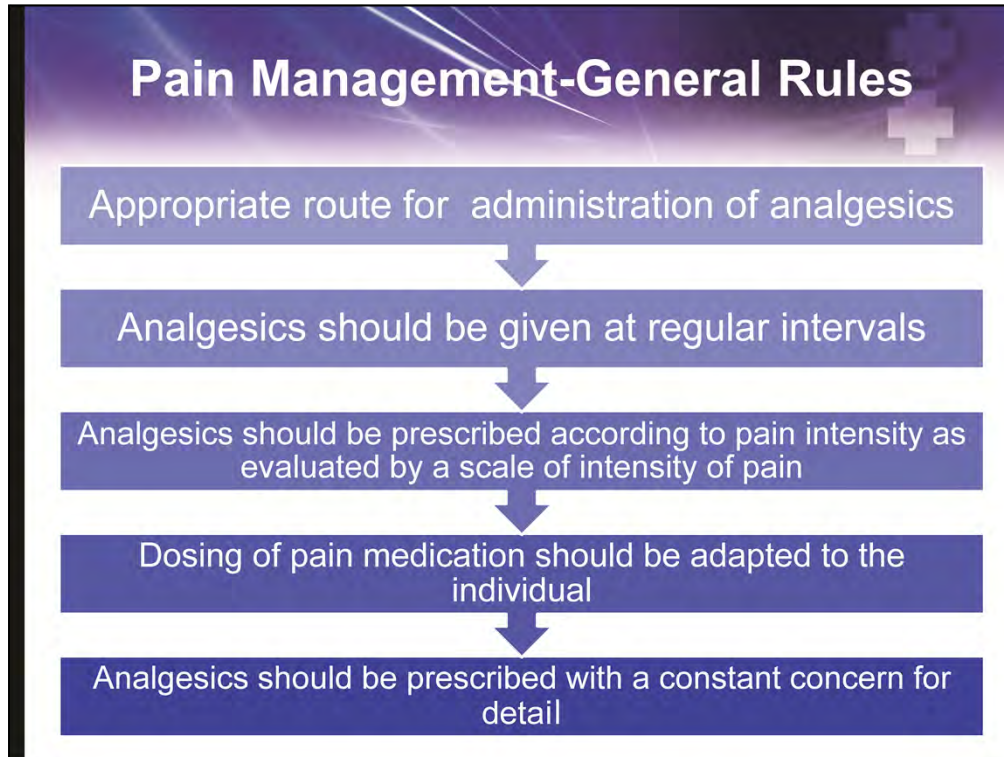
*Task* \_\_\_\_\_

*Date* \_\_\_\_\_ *Start* \_\_\_\_\_ *End* \_\_\_\_\_

Numeric Scale- patient gives that pain a score from 0-10.

Visual Analogue Scale- patient marks severity on a line

Face Pain Scale- draws facial expression to pain. Useful with children and patients with language barriers.




The pain associated with most orthopedic surgery is typically intense, making its control essential. Effective pain control improves surgical outcome, shortens hospital stay and rehabilitation, decreases the development of new chronic pain conditions, and may [by decreasing the surgical stress response and reducing the negative influence of opioids and anesthetic agents on the natural killer (NK) cells] contribute to slower progression of certain cancers.

## Prehospital

Pain starts at the point of injury (POI) and must be controlled from that initiating event

Prehospital practitioner has the first and perhaps only opportunity to break the pain cascade.

Early, effective pain control is essential to successful outcomes after traumatic injury



**Tactical Combat Casualty Care Guidelines** <http://links.lww.com/TA/A139>

**1. Able to fight:**

*These medications should be carried by the combatant and self administered as soon as possible after the wound is sustained.*

- Mobic (meloxicam, a NSAID), 15 mg PO once a day
- Tylenol, 650-mg bilayer caplet, 2 PO every 8 hours

**2. Unable to fight:**

*Note: Have naloxone readily available whenever administering opiates.*

- **Does not otherwise require IV/IO access** - Oral transmucosal fentanyl citrate (OTFC), 800 ug transbuccally

- Recommend taping lozenge-on-a-stick to casualty's finger as an added safety measure

- Reassess in 15 minutes

- Add second lozenge, in other cheek, as necessary to control severe pain.

- Monitor for respiratory depression.

**- IV or IO access obtained:**

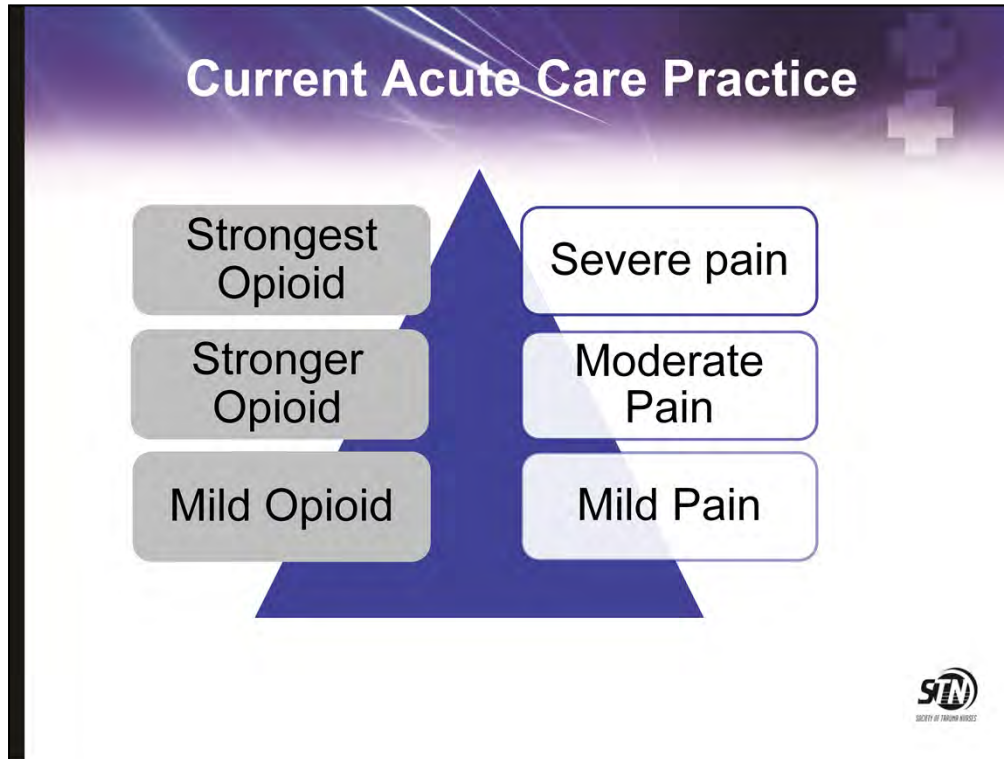
- Morphine sulfate, 5 mg IV/IO

- Reassess in 10 minutes.

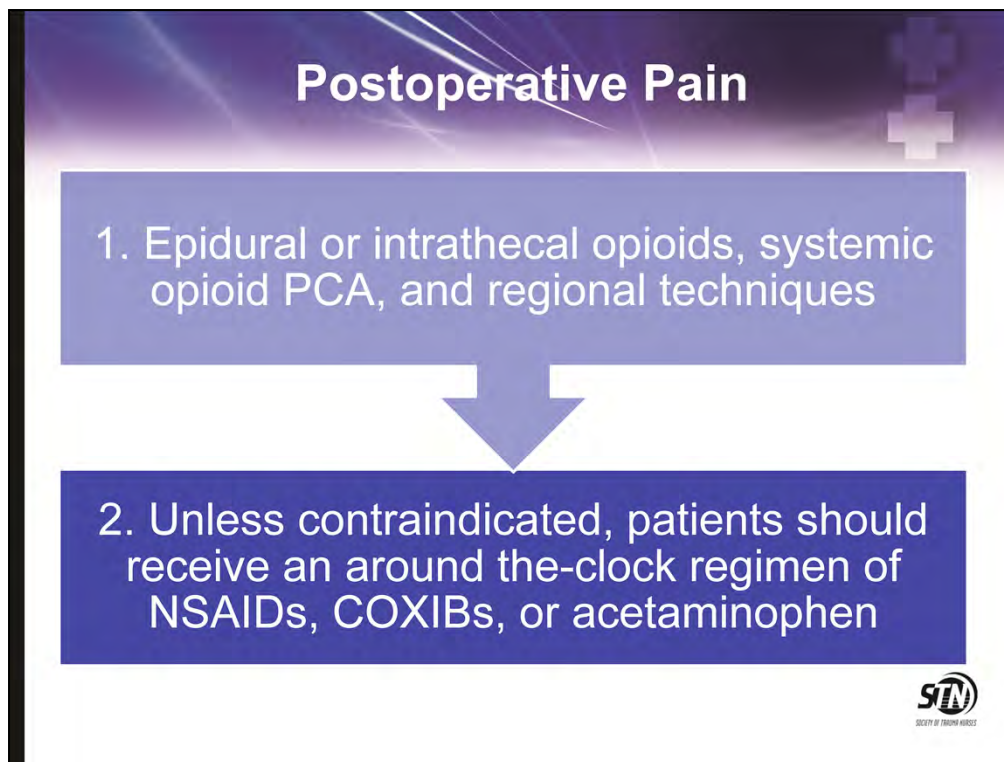
- Repeat dose every 10 minutes as necessary to control severe pain.

- Monitor for respiratory depression

- Promethazine, 25 mg IV/IM/IO every 6 hours as needed for nausea or for synergistic analgesic effect



Contrary to today's use of opiates almost as the sole treatment for acute pain **multimodal therapy** encompasses a wide range of procedures and medications, including regional analgesia with continuous epidural or peripheral nerve block infusions, judicious opioids, acetaminophen, anti-inflammatory agents, anticonvulsants, ketamine, clonidine, mexiletine, antidepressants, and anxiolytics as options to treat or modulate pain at various sites of action.



**Complications (in order of frequency) of systemic opioid use are:**

- GI (nausea and vomiting, constipation, ileus)
- CNS (mental status changes)
- Urinary retention
- Pruritis
- Respiratory depression
- Adjuncts**
- NSAIDs** (e.g., ketorolac, ibuprofen and now Ibuprofen IV (Caldolor®) and COX-2 (celecoxib)
  - Peripherally inhibit prostaglandin synthesis and nociceptor stimulation
  - Limitation: bleeding risk, limited in ability to manage severe pain
- Centrally acting analgesics** (e.g., acetaminophen and now Acetaminophen IV (Ofirmev®)
  - True MOA in pain unknown
  - Limitation: liver toxicity
- Alpha-2 agonists** (e.g., clonidine)
  - Stimulates central alpha2 receptors
  - Limitation: hypotension
- Anticonvulsants** (e.g., Neurontin® [gabapentin], Lyrica® [pregabalin])
  - Antineuropathic
  - Limitation: requires other treatments, limited ability to manage severe acute pain
- NMDA antagonists** (e.g., ketamine)
  - Sensory blockade and prevention of central sensitization
  - Limitation: many side effects such as visual and psychological

## Procedural Medications



Etomidate	Midazolam
Propofol	Ketamine

Fentanyl



Procedural sedation is a frequent occurrence in the musculoskeletal trauma population in the Emergency Department. The following drugs are commonly used.

Drugs like **Etomidate** (an hypnotic agent) are used for their amnesiac and sedating appeal, but with no analgesic properties. It is a commonly used drug for sedation in short procedures such as: reducing dislocated joints, tracheal intubations and immediate cardioversion. Etomidate has a rapid onset (< 30 sec), short duration (5 min), and has great muscle relaxation properties. No pain relief.

Drugs like **midazolam** (Versed, a benzodiazepine) facilitate the inhibitory action of GABA (gamma-aminobutyric acid) in the brain, reduce excitatory impulses, act as amnesic, anxiolytic, and muscle relaxant. When used for sedation/anxiolysis/amnesia for a procedure, dosage must be individualized and titrated. Midazolam hydrochloride should always be titrated slowly; administer over at least 2 minutes and allow an additional 2 or more minutes to fully evaluate the sedative effect. No pain relief

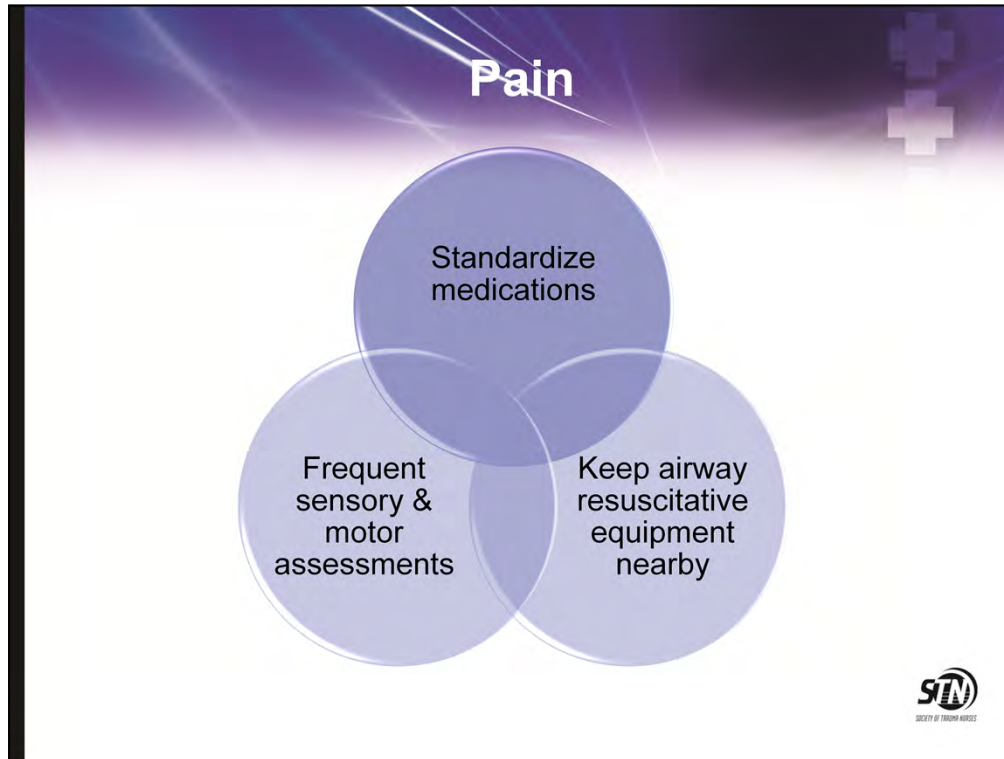
**Propofol** (Diprivan , a short acting hypnotic agent) is also used because of its lipid solubility that enhances rapid onset (30-60 sec) and short half-life (1-4 minutes) that cause rapid awakening while plasma concentrations decline quickly post procedure. No pain relief.

The dissociative agent **ketamine** facilitates painful emergency department procedures in children. Ketamine dissociation appears at a dosing threshold of approximately 1.0 to 1.5 mg/kg intravenously (IV) or 3 to 4 mg/kg intramuscularly (IM). potent analgesia, sedation, and amnesia while maintaining cardiovascular stability and preserving spontaneous respirations and protective airway reflexes.

**Fentanyl** is a very potent synthetic opioid and one of the commonly used analgesic adjuncts in the ED. It rapidly crosses the blood-brain barrier and thus has a rapid onset of analgesia (< 90 s). With duration of action approximately 30 minutes. And Fentanyl is great for short procedures because of its minimal hypotensive properties.



Each organization is required to have and follow strict standards for procedural sedation in order to be in compliance with regulatory agencies. **What are the significant details of your hospital's standards?)**



Pain is managed with the use of various medications.

What's most important in medication administration is that nurses understand the "pain" associated with trauma and how suffering with pain can often be the most traumatic part of the traumatic injury experience.

Nurses should become familiar with the drugs they are administering and the more a nurse uses "familiar" medication, the more a "comfort zone" with the drugs they administer will occur. The constant use of standardized or protocol driven pain management strategies will likely cause a greater familiarity with the onset of action, peak times, side effects and expected outcomes with varying doses.

Airway equipment should always be ready in case overdose or respiratory depression occurs.

Frequent sensory & motor assessments must be performed throughout medication regimen.

**Do you have pain protocols at your institution? What are they? Do the nurses use them effectively?**



## Infection

Any open wound that occurs outdoors or in a dirty environment is at greater risk for infection.

## Open fractures: it doesn't come out in the wash

<http://www.ncbi.nlm.nih.gov/pubmed/21929370>

## Open Fracture Wound Care

[http://www.ota.org/international/Salta/Dr\\_Anglen\\_Open%20Fracture%20Wound%20Care.pdf](http://www.ota.org/international/Salta/Dr_Anglen_Open%20Fracture%20Wound%20Care.pdf)

The wounds must be cleansed and dressed, and early antibiotic therapy should be considered.

## What fluid do you use?

## Infection

Antibiotics are often necessary in the prophylaxis and treatment of orthopedic infections post-operatively

The characteristics of implantable materials makes them a generous host for bacterial colonization

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Rates of orthopedic infections are reduced with the use of prophylactic antibiotic therapy.

The Staphylococci are Gram-negative bacteria that live on skin and mucosa. Staphylococci Aureus (S. Aureus) is a common infection in orthopedic injury. S. Aureus becomes resistant to many antibiotics and is often the culprit in bone and soft tissue infections, and is the most common bacteria causing osteomyelitis.

The operating room can be primary source of infection and an empty operating room is less contaminated than an operating room full of people.

## Prophylaxis and Surgical Infections

- Staphylococci
- Pseudomonas Aeruginosa
- Klebsiella
- Acinetobacter baumani



•Prophylaxis prior to surgery is strongly recommended and up to 24 hours. A 1<sup>st</sup> generation Cephalosporin for gram-positive coverage coupled with a aminoglycoside for gram-negative coverage is the combination of choice. Quinolones also show promise for broad spectrum coverage and can be given in oral form.

•Osteoarticular infections with resistant *S. Aureus* take months to heal. But antibiotic therapy will be meaningless unless the infected hardware is removed.

*Pseudomonas* is found in the external environment and best treated with Imipenem. Yet resistant strains do occur.



•*Klebsiella* can be airborne infection or by contact. Patients who are immunocompromised, nutritionally depleted or the elderly are at risk and the prognosis is poor.

•*Acinetobacter baumani* is widespread and found almost anywhere. It is best treated with cephalosporins and fluoroquinolones.

Note: Solid Intramedullary nails are least prone to infection as opposed to hollow nails which are larger and have a lumen that is not easily accessible.

## Assessment

- What is baseline status?
- Are splints applied correctly
- Past Medical History



**Assessment of the musculoskeletal system is part of the secondary assessment.**

•The best and easiest way is to compare it to the uninjured limb. Check the color and pulse quality of the unaffected limb prior to assessing the injured limb

**Remember the 5 p's of assessment. Is there a Pulse, Pain, Pallor, Paresthesia, Paralysis?**

• Note any obvious dislocations, angulations, rotations, shortenings, abrasions, road rash, and protrusions.

•Palpate or dopple pulses.

•Pale color could indicate arterial injury and dusky or bluish color can signal venous congestion. Ecchymosis could mean vascular injury with blood seeping into the soft tissue

• Assess for location and severity of pain.

•Swelling will happen if there is injury to soft tissue and/or venous/lymph are disturbed.

•Muscle spasms are a protective mechanism. These contractions will occur over the injury in an effort to splint the injury. If there are no muscle contractions when obvious fractures are noted- there may be a degree of neurologic injury directly above the fracture.

•Crepitus is noted when a fracture is present.

•Check for capillary refill. **Should be < 2 seconds.**

•Check for movement but avoid range of motion until confirmatory tests are completed.

•Are splints applied correctly? Is limb in alignment? Are pulses palpable? Were they palpable at the scene?

Past Medical History- Use the pneumonic **AMPLE** to find out if the patient has **a**llergies, **m**edications, (high level of concern if patient is on anticoagulants), **p**ast medical illness or pregnant, last **m**eal, **e**nvironment-mechanism of injury (MOI). An assessment of last Tetanus must be obtained.

## Diagnostic Studies



- Plain films
- CT, CT angio
- MRI
- Angiography

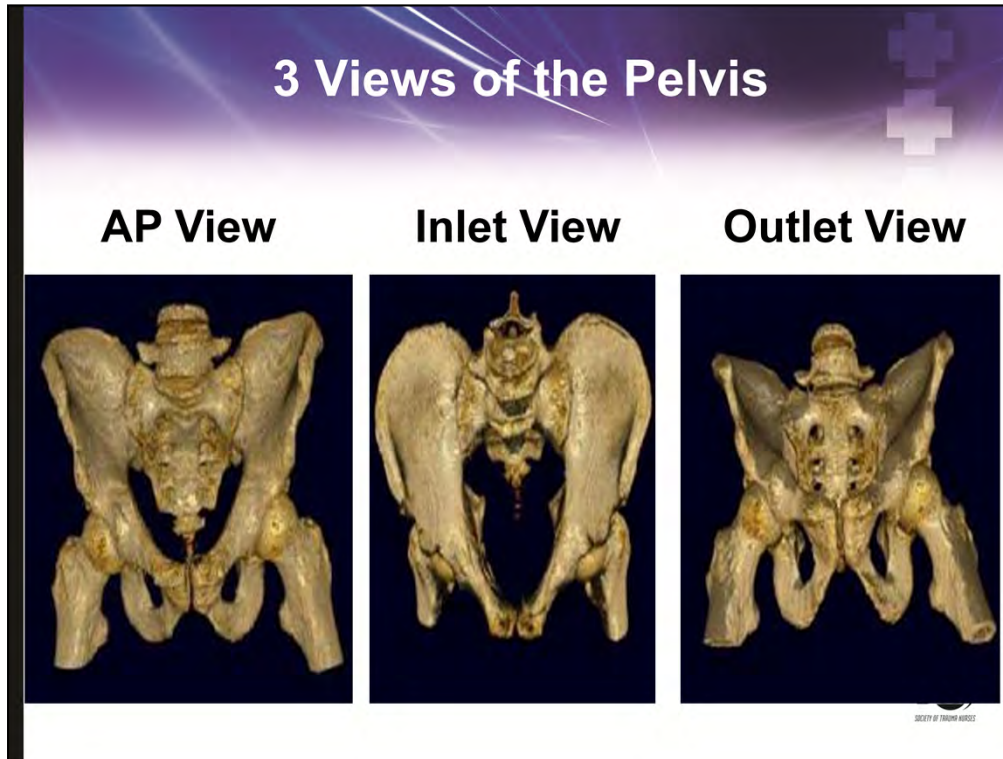


Plain films are not as effective for noting the degree of injury in many skeletal injuries. Please note at least two views will be necessary. The anterior-posterior (AP) view is most often utilized, and is considered the initial radiographic examination.

- The AP views the pelvis on a frontal plane, and it is often difficult to notice any misalignments in the pelvis. The AP view demonstrates a widening of the pubic symphysis (less than 1 cm wide). This view also identifies the Pubic Rami clearly.
- Inlet views (patient in the supine position, with the x-ray tube positioned at the patient's head and angled 45° toward the feet ) can detect any rotations of the pelvis, are used to determine the degree of displacement of the Sacroiliac (SI) joint, the degree of internal/external rotation, the degree of pubic diastasis or overlap, and sacral fractures.
- The Outlet views (patient in the supine position, with the x-ray tube positioned at the patient's feet and angled 45° toward the head ) can detect any vertical displacement of the hemipelvis and the sacral neural foramina.

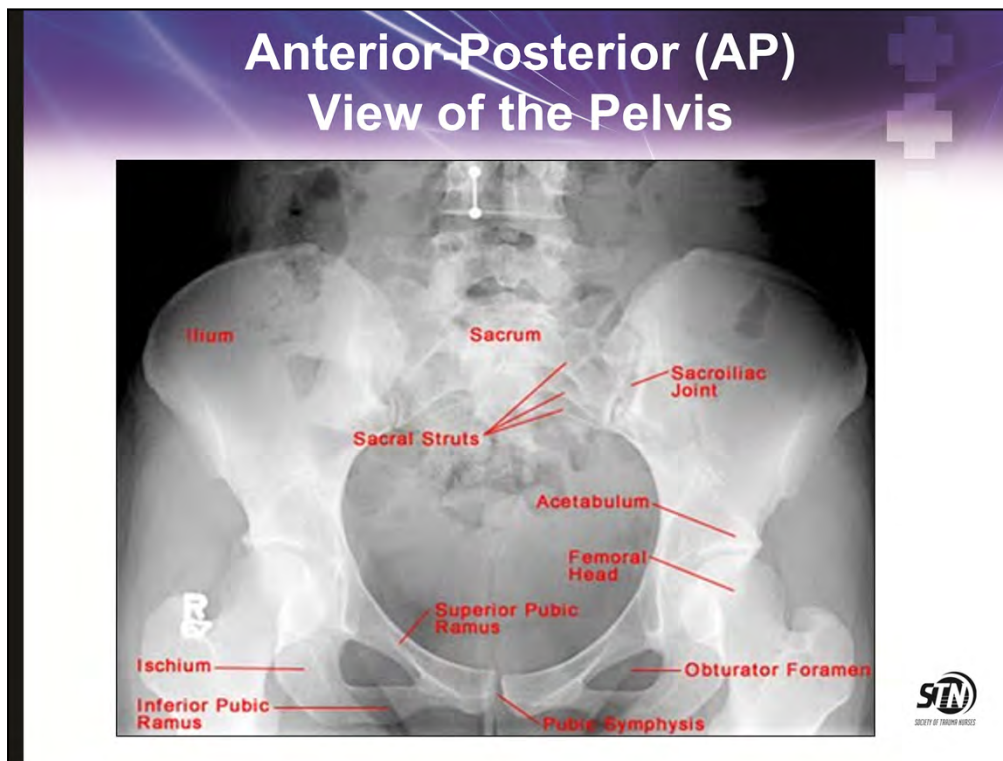
The test to confirm musculoskeletal injury is most often the CT scan.

MRI may be indicated for further review and Angiography to control bleeding.

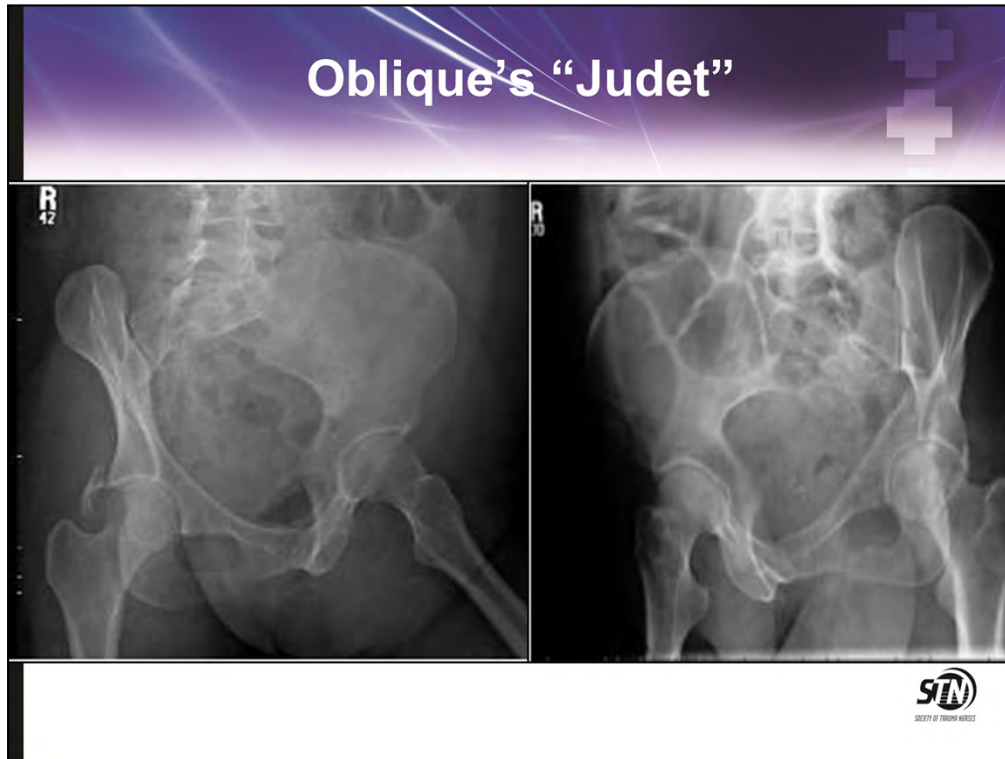


The anterior-posterior view is often the first and most common view selected for most pelvic injuries and is usually performed in the Trauma Bay. The additional inlet and outlet views provide in depth views of the same pelvis but from different angles.





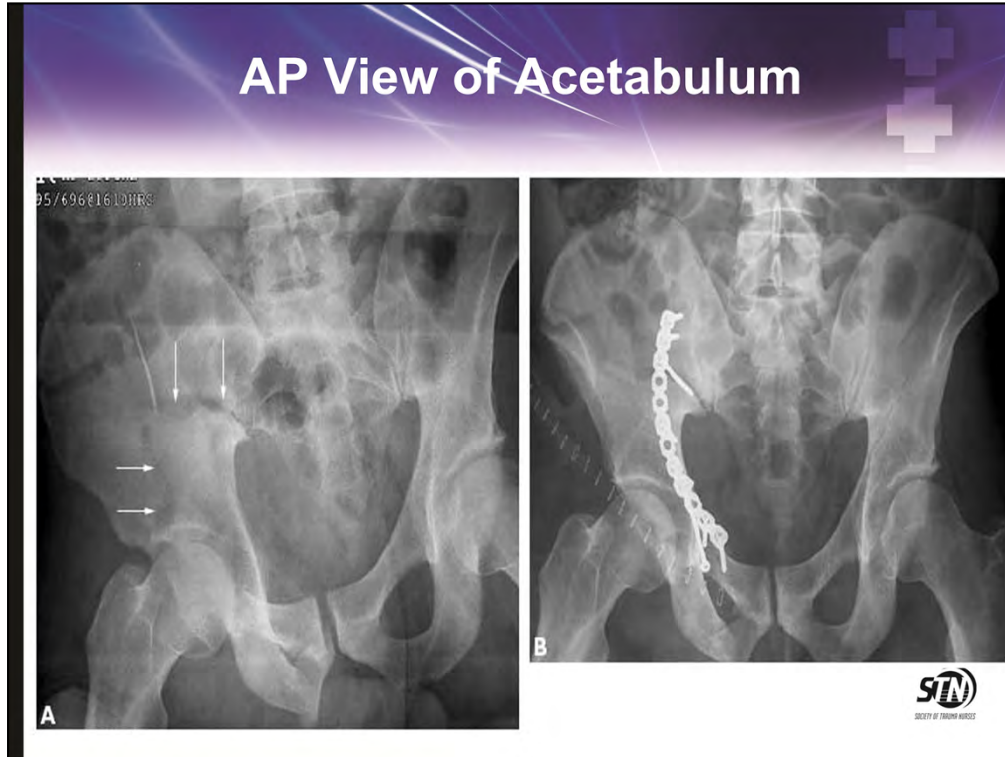
The first and most common radiologic view the physician will request. The AP view is a frontal view.



Additional Views used when the acetabulum (hip socket) must be visualized for suspected fracture. e.g., Judet view.

For this view the patient must be tilted 45 degrees medially or laterally.

This is often very painful for the patient, so assure that pain medication is given prior and is available during the imaging if necessary.

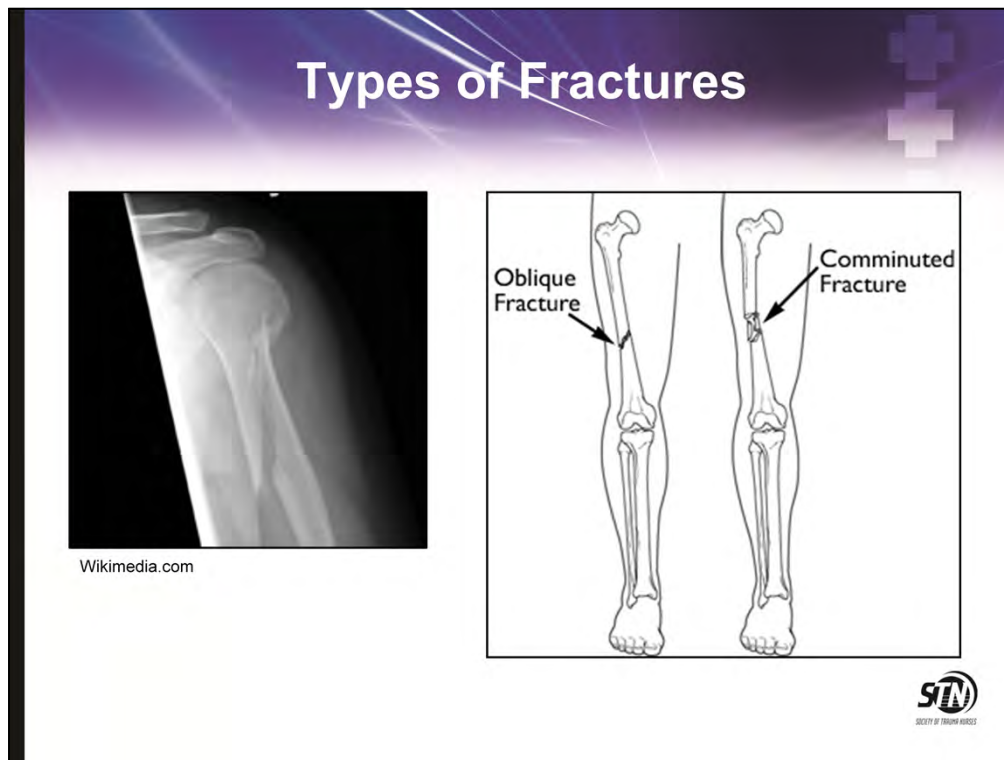


Radiograph showing an AP view of a displaced acetabular fracture (A) that was treated with internal fixation (B).

CT scan and 45-degree oblique (Judet) radiographs



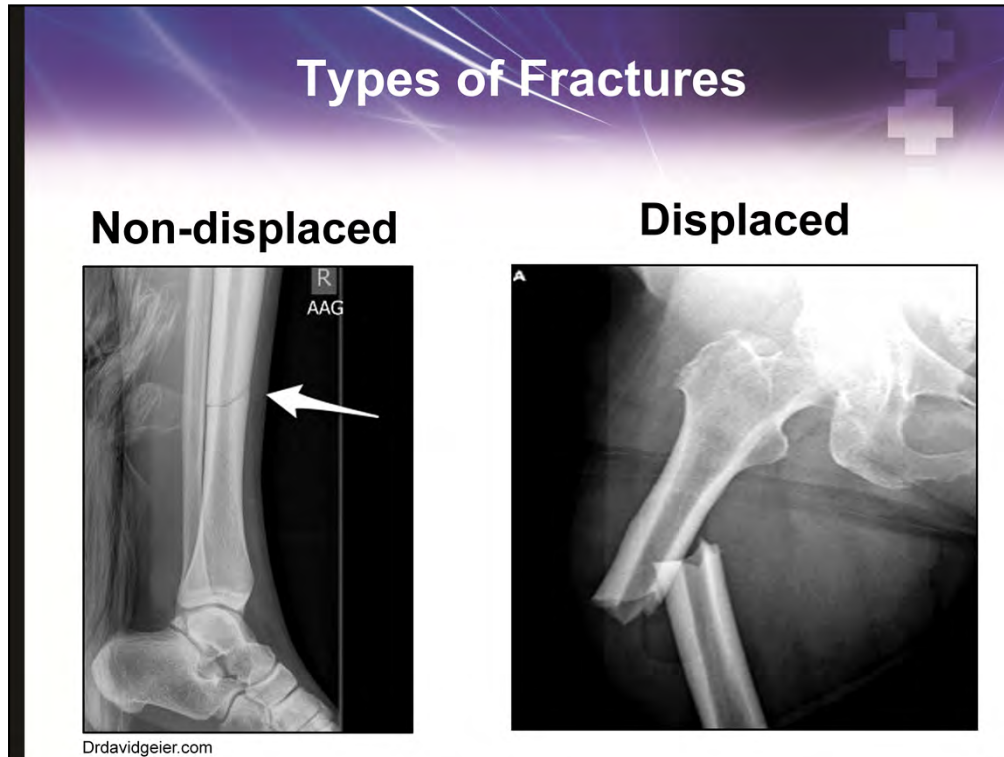
**Image is a displaced tibia-fibula fracture.** The Tibia/Fibula are the long bones of the calf. These fractures can be very serious if not managed appropriately. A closed fracture is less at risk for the development of osteomyelitis since skin breakage is not an issue. Yet an open or “compound” fracture can affect the prognosis as well as a comminuted fracture “bone is broken into many pieces”. Immobilization and peripheral pulse checks, at the top of the foot :Dorsalis Pedis, and behind, posterior tibial artery.



The pieces of bone may line up correctly or be out of alignment (displaced), and the fracture may be closed (skin intact) or open (the bone has punctured the skin). **Any fracture or suspected fracture with an over-riding laceration is an open fracture until proven otherwise.**

Fractures classified depending on:

- The location of the fracture (the shaft is divided into thirds: distal, middle, proximal)
- The pattern of the fracture
  - Displaced vs. non-displaced
  - Transverse fracture- a straight horizontal line going across the femoral shaft.
  - Oblique fracture- is an angled line across the shaft.
  - Spiral fracture- encircles the shaft like the stripes on a candy cane. A twisting causes this type of fracture.
  - Comminuted fracture- the bone has broken into three or more pieces. Usually the number of bone fragments indicates the amount of force required to break the bone.
  - Open or compound fracture- bone fragments stick out through the skin and constitutes more damage to the surrounding muscles, tendons, and ligaments, and have more complications such as delayed healing and infection.



**Image of non displaced fracture on the left.**

There are many types of fractures. But displaced and non-displaced fractures indicates “the way” the bone breaks.

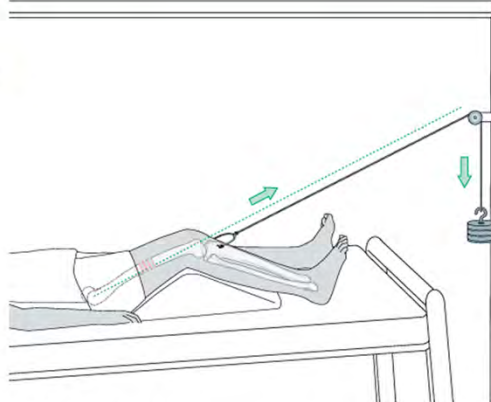
In non-displaced fractures the bone cracks either part or all the way through, but has not moved from proper alignment.

**Image of displaced fracture on the right.**

In displaced fractures the bone snaps into two or more parts and moves and are not lined up straight.


## Skeletal Traction

- Indications
  - Unstable patient (damage control)
  - Preparation for surgery



The diagram shows a patient lying on a hospital bed with skeletal traction applied to their right leg. A wire is attached to the distal femur and runs along the length of the leg to the ankle, where it is attached to a boot. A second wire is attached to the proximal femur and runs up the leg to the hip, where it is attached to a boot. A weight is suspended from the proximal wire, and a downward arrow indicates the direction of the traction force. A green arrow points from the proximal wire towards the distal wire, indicating the direction of the traction force. The text 'AO Foundation.org' is visible below the diagram, and the 'STN' logo is in the bottom right corner.

AO Foundation.org



Nursing responsibilities in caring for patient with skeletal traction include:

Pin Care meticulous wound care at the pin insertion site

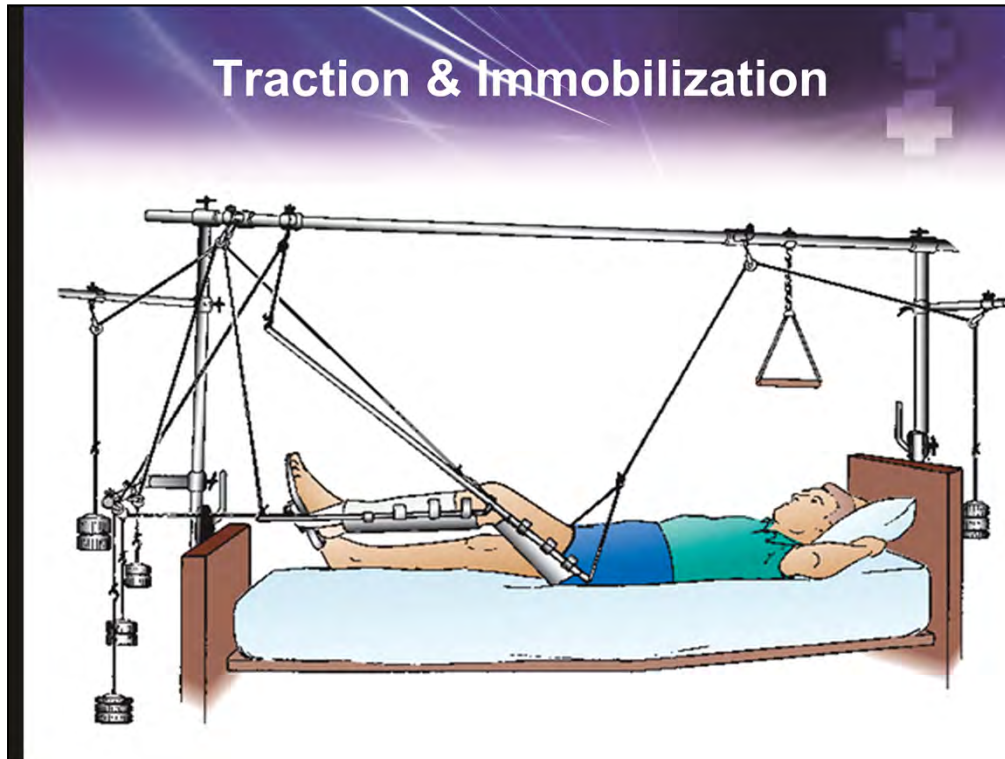
Immobilization- engage physical therapy

Nutrition- Diets with good protein

Prevention of Deep vein Thrombosis- Pneumatic Teds, earl mobilization

Prevention of Pneumonia/Atelectasis- Get patient out of bed, cough/deep breathing, Incentive Spirometry

Skin breakdown- Get patient out of bed, turning schedule



Traction applies tension to decrease pain, realign broken bones that overlap, and maintain alignment and must be balanced by counter traction. Just by tilting the bed can be enough counter traction in the opposite direction. Traction is used short term until surgery.



## Reduction

- **Reduction** is a medical procedure to restore a fracture or dislocation to the correct alignment. For the fractured bone to heal without any deformity the bony fragments must be re-aligned to their normal anatomical position



Closed reduction is the manipulation of the bone fragments without surgical intervention. Once the fragments are reduced, the reduction is maintained with casts, traction, implants. It is crucial to confirm proper alignment with x-rays.

Open fractures will be treated based on the degree displacement, comminution, bone loss, risk of nonunion and avascular necrosis. In open reduction, Screws, Plates, Wires and Pins, intramedullary rods and nails may be used.

Open reduction will be considered if closed methods have failed or run the risk of high degree of failure, for displaced intra-articular or pathologic fractures, avascular necrosis, and if prolonged immobilization is not beneficial.

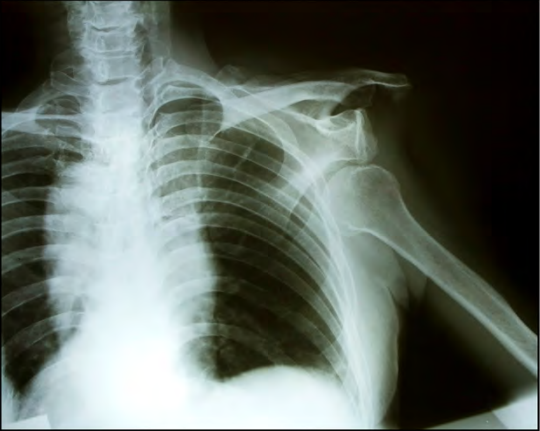
Thus for nurse, pre-medication for the patient must be a priority as the procedure is painful. Institutional Guidelines as well as National recommendations for proper sedation must be maintained.

Open Reduction is an operative procedure, whereas the fragments are surgically exposed and tissue is dissected.


The open-operative reduction strategy decreases the risk of nonunion and avascular necrosis.

## Dislocations

- Shoulder
- Knee
- Hip



The image is a lateral X-ray of a human shoulder. The humeral head is displaced from its normal position in the glenoid fossa, indicating a dislocation. The surrounding bony structures, including the scapula and ribs, are visible.

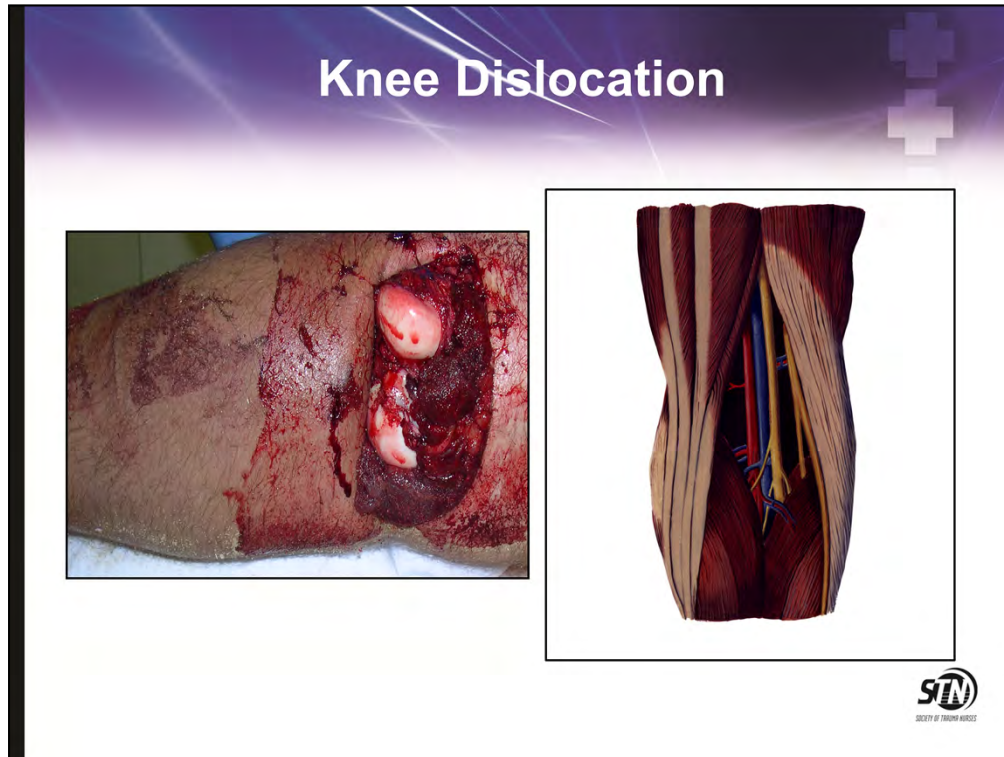


**Image is shoulder dislocation.**

Reduction is urgent.

There are a number of methods of closed reduction, depending upon patient's age, history, signs and symptoms, anterior or posterior dislocation and physician preference.

Pain management ranges from intra-articular lidocaine to procedural sedation.



Knee dislocation is an emergency. The popliteal fossa contains arteries, veins and nerves that are often disrupted.

The popliteal artery may be damaged with incidence ranging from 7-64%.

Hard signs of arterial injury require immediate surgical revascularization.

Hard signs of vascular injury include

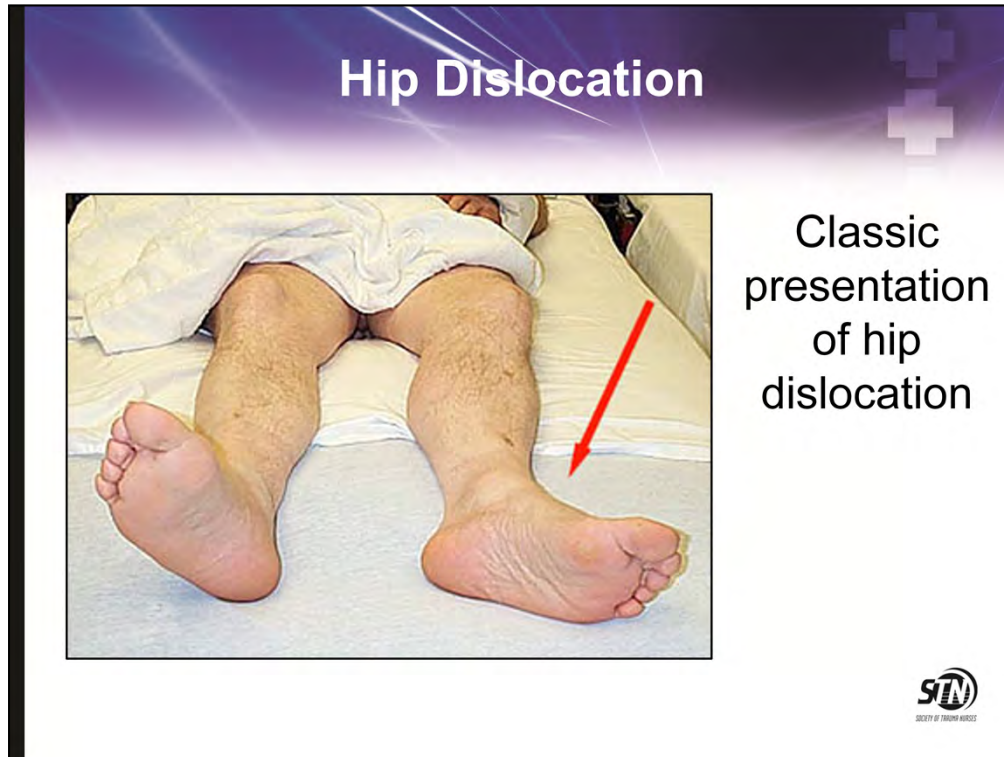
- the absence of pulses
- expanding or pulsatile hematomas
- palpable thrills or audible bruits
- history of pulsating hemorrhage.

In cases that do not present with "hard" arterial findings, it is advised to perform ankle-brachial or arterial-pressure indices since the presence of normal pulses does not rule out the presence of clinically significant vascular injury.

Peroneal nerve injury occurs in 25-35% of patients:

- decreased sensation at the first webspace
- impaired dorsiflexion of the foot.

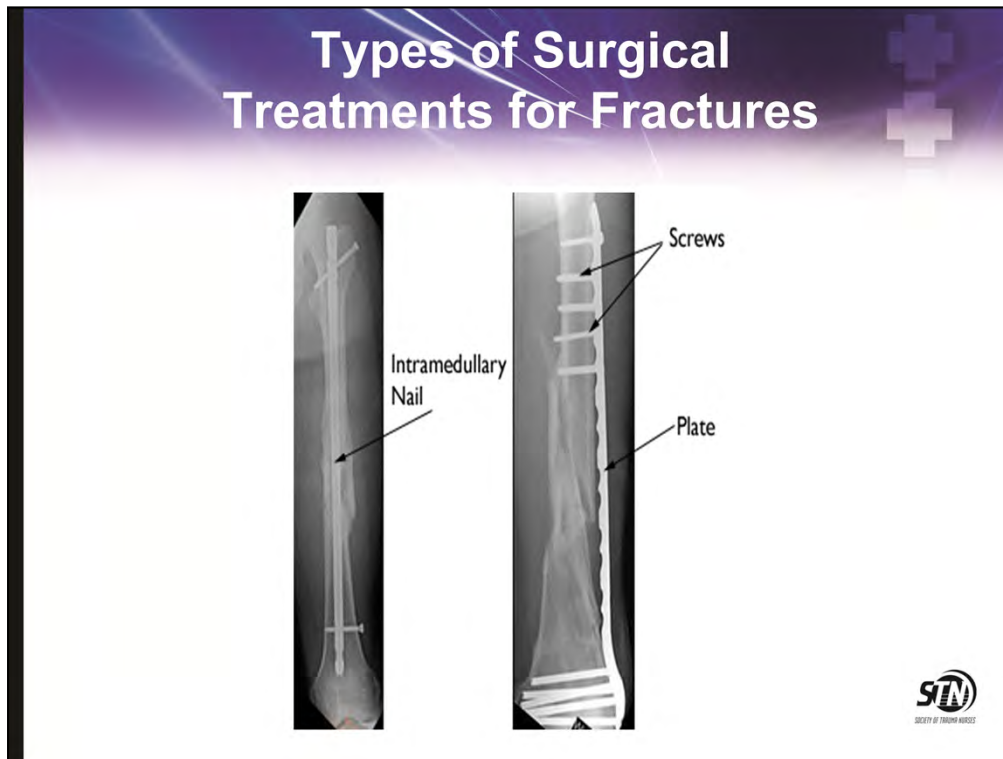
- Closed reduction is accomplished with procedural sedation.



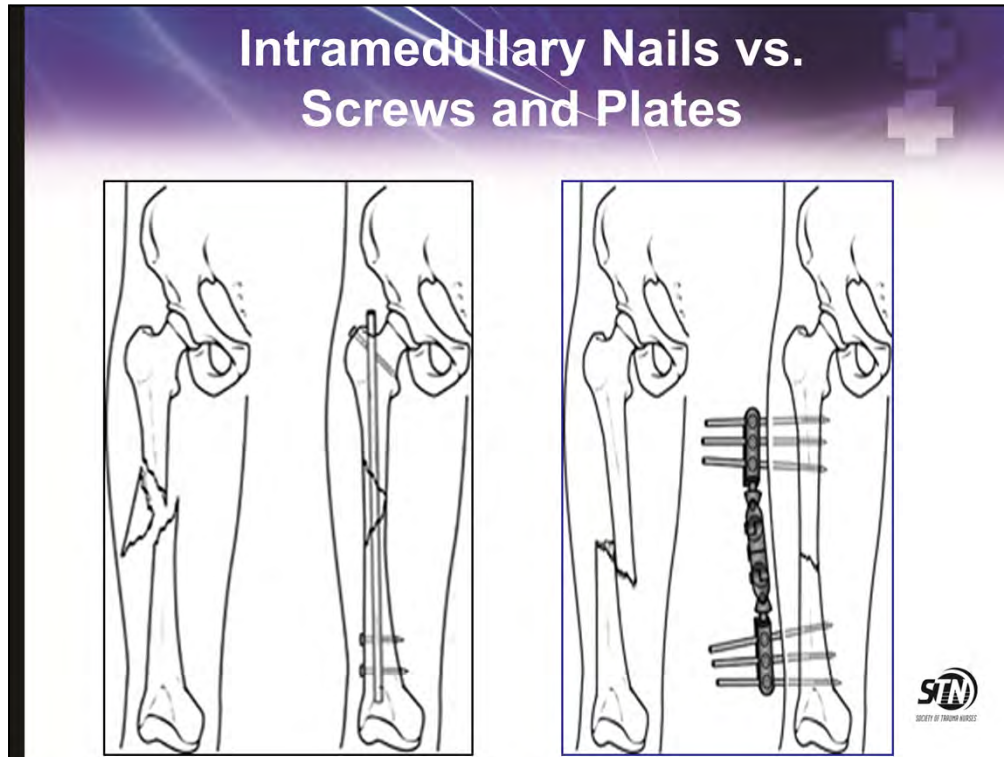
Closed reduction for traumatic hip dislocation is an emergency.

- Closed reduction is indicated for a dislocation with or without neurologic deficit when no associated fracture is present.
- Closed reduction is indicated for a dislocation with an associated fracture if neurological deficits are not present.
- Closed reduction attempt before open surgical reduction for traumatic hip dislocation
- Closed reduction is accomplished with procedural sedation.
- Open surgical reduction is usually required:
- Open traumatic hip dislocation (suggests extremely large forces) Such injuries are associated with high infection rates and up to 50% mortality from the injury.
- If operative management is delayed, closed reduction may be attempted, with follow up operative management as soon as possible.
- If the hip cannot be relocated after multiple (2-3) reduction attempts, then emergent operative exploration is indicated.

**Further closed reduction attempts should not be initiated at this point.**



Intramedullary Nailing and Surgical screws and plates.



Most femoral shaft fractures require surgery. There are some cases where traction is selected and with pediatric patients a cast is sometimes used. But more often than not, surgery is the treatment option. It is unusual for femoral shaft fractures to be treated without surgery. While awaiting surgery, the patient will need to wear a long splint or skeletal traction to maintain alignment and the leg's length. With external fixation, screws and pins are set into the bone above and below the injury and accompanies a stabilizing frame to hold the bones in position. This approach is used for patients who are not yet stable for surgery due to other injuries.

Plates and screws are placed after the bone is repositioned (reduced) into normal alignment. Then the bone is held together with screws and metal plates attached to the outer surface of the bone.

Plates and screws are often used when intramedullary nailing is not an option, possible, as with fractures that extend into the hip or knee joints.



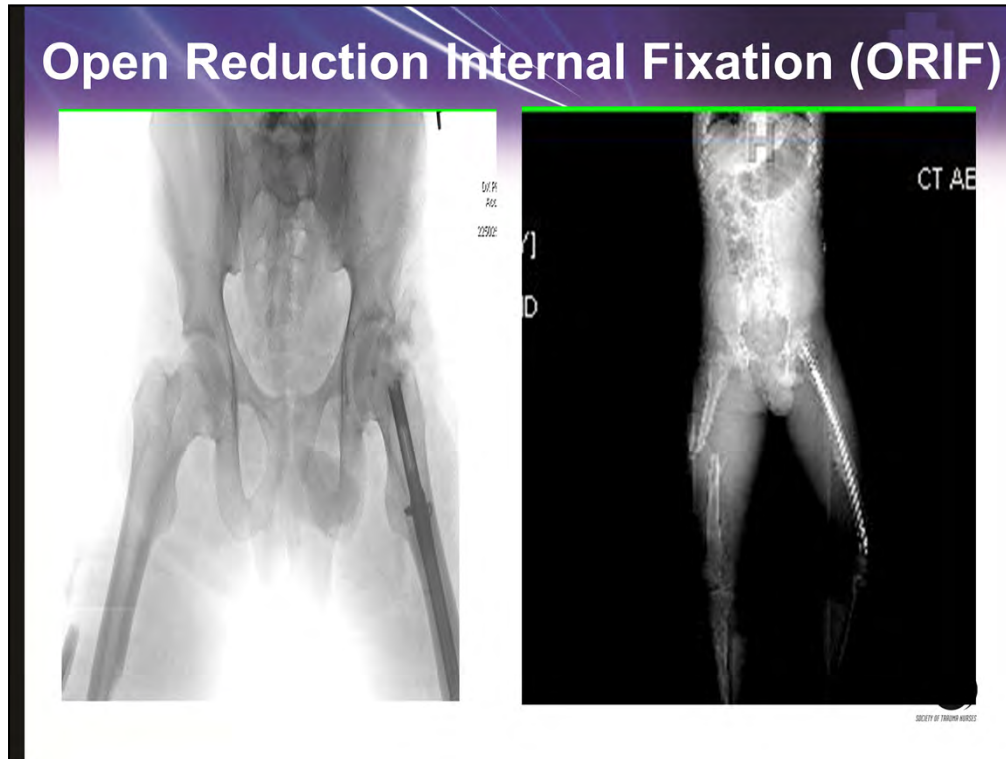
Gamma and intramedullary nails used to stabilize fracture

## Screw Holds Intramedullary Nail in Place to Avoid Migration



Screws and nails prevent migration and support stabilization in preparation for mobilization.







Hardware to support femur fractures via open reduction internal fixation (ORIF)

## External Fixation

- Indications
- Nursing Responsibilities



Bone is living tissue and requires axial loading (weight bearing) to stimulate electrical activity. The stimulation of electrical activity causes osteogenesis (osteoclasts activity- bone cells) to promote bone healing.

The external fixator allows for maintaining bone in position while allowing axial loading.

In external fixation, pins and screws are inserted into bone above and below the fracture site. The Monolateral Fixator places pins/screws above and below site, while the Ilizarov fixator encircles the leg. The major advantage is early mobilization, yet infections put the patient at high risk.

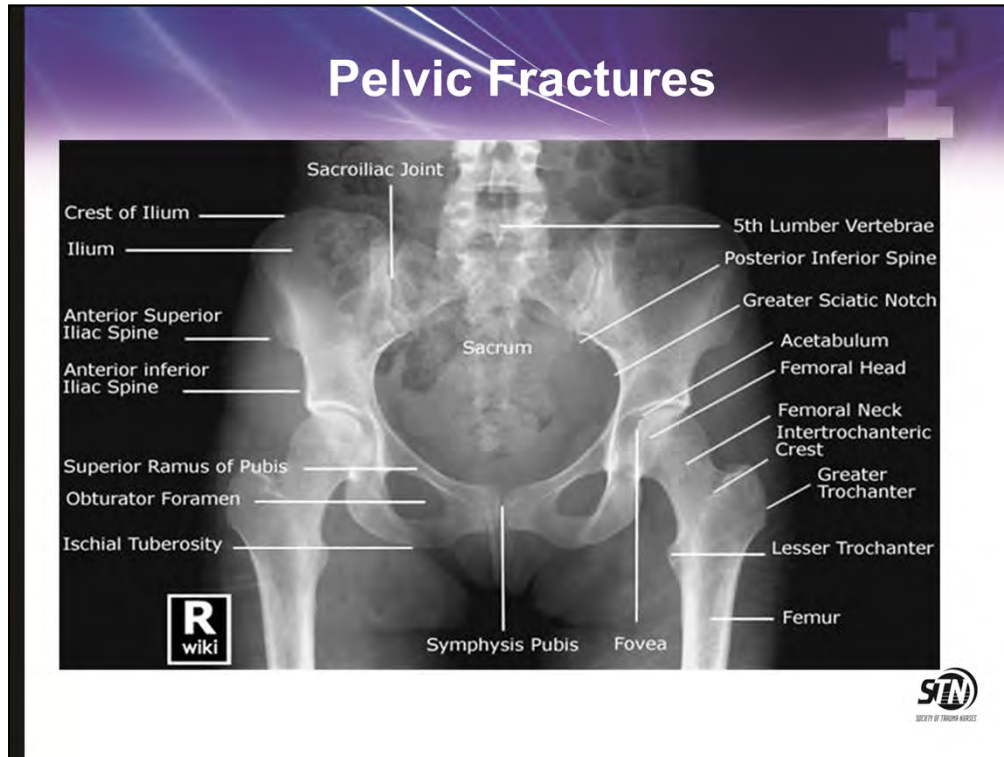
#### Nursing Care:

Site Care is to be done daily. Nurse must allow exudate (normal drainage) to occur, and must be careful to remove crusting at site. Nurse must also differentiate between normal exudate and pussy drainage, which is cloudy with an offensive odor (infection), and microbiologic testing must be ordered.

The pin is a foreign body and may even be rejected, manifesting as a soft tissue reaction.

Cleaning the site may be accomplished with normal saline or sterile 3water. And in uncomplicated pin sites, and dry gauze may be enough.

The nurse must also evaluate Neuromuscular function, mobility, pain, hygiene, and psychosocial care

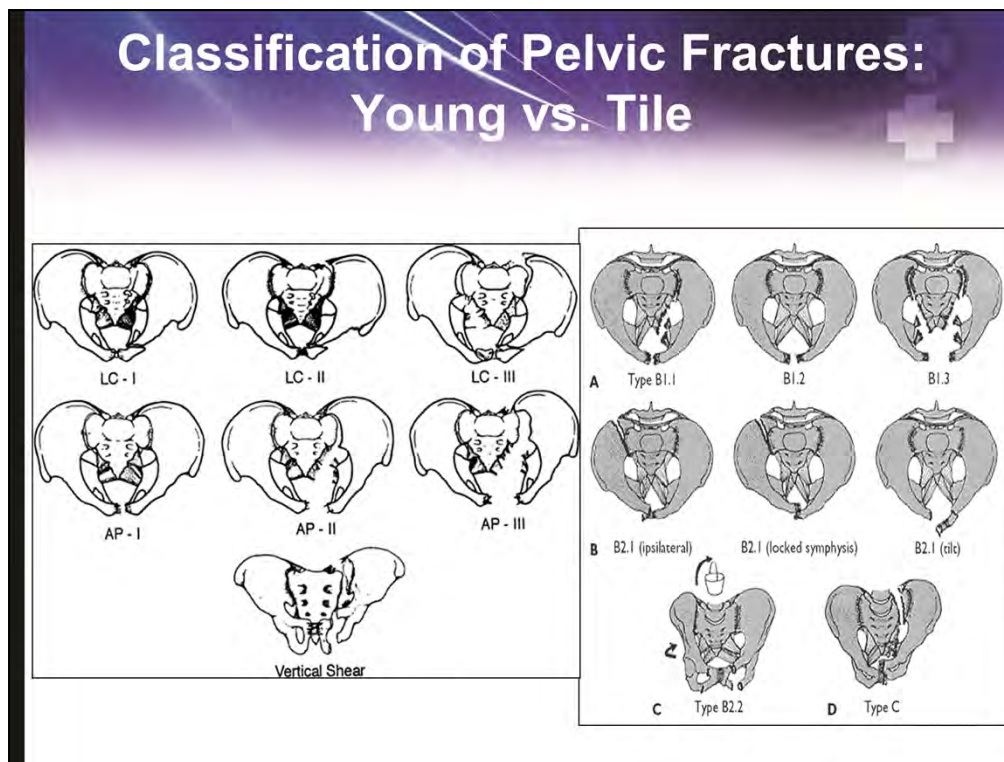


Pelvis fractures are often associated with massive hemorrhage. A pelvic injury can cause covert bleeding of up to 6 units of blood loss, e.g. “bleeding to death”. Since each unit of blood is approximately 473 ml’s, if the patient loses 3 liters of blood, that is half the amount of blood in the human body.

Each unit of blood is a pint or 473ml.

Human body holds 80 ml/kg of blood ≈ 5.5 liters

Approximately 2 liters of blood loss (1/3 of total blood) may still show a systolic blood pressure of 100 mmHG



The bony pelvis consists of the ilium, ischium, and pubis, which form a ring with the sacrum. Disrupting this ring requires significant energy. Because of the extreme force, pelvic fractures frequently involve injury to organs contained within the bony pelvis and even outside yet close to the pelvis. Pelvic fractures cause severe hemorrhage due to the extensive blood supply to the region.

Classification: Pelvic fractures are commonly described using one of two classification systems.

Young classification system is based on mechanism of injury: lateral compression, anteroposterior compression, vertical shear, or a combination of forces.

Grade I - sacral compression on side of impact

Grade II - posterior iliac, or crescent fracture on side of impact

Grade III - contralateral sacroiliac joint injury

Open book fracture is the result from a heavy impact to the groin, e.g.; pubis. With an open book pelvic fracture the left and right halves of the pelvis are separated at front and rear, the front opening more than the rear, as in an open book, and may require surgical reconstruction.

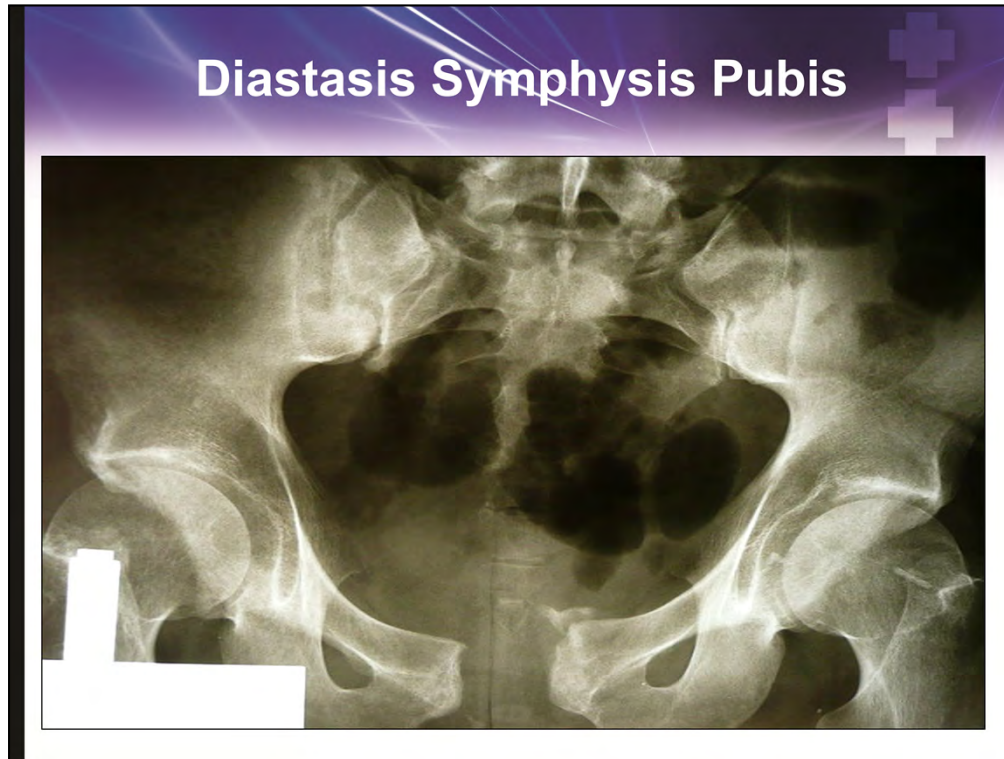
Severe pelvis fractures may require months or years of rehabilitation.

Tile Classification System is based on the integrity of the posterior sacroiliac complex.

Type A- sacroiliac is intact. Nonoperative intervention

Type B- partial disruption from rotation injuries



Type C- complete disruption and unstable. From great force, e.g.; car crash, fall from height



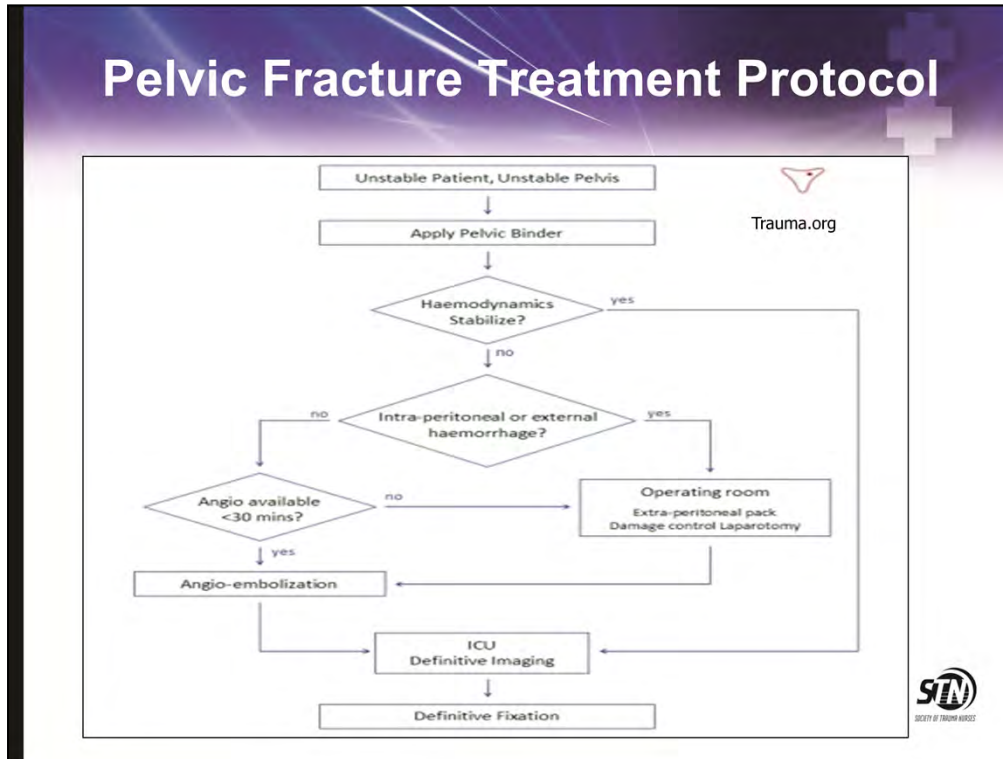
Diastasis symphysis pubis is the separation of pubic bones, as in displaced bones without a fracture.

## Associated Injuries in Order of Frequency

- Closed head injury
- Long bone fractures
- Peripheral nerve injury
- Thoracic injury
- Bladder
- Spleen
- Liver
- GI tract
- Kidney, Urethra, Mesentery, Diaphragm



The term polytrauma can be synonymous with pelvic injuries because more often than not, organs in and in close proximity to the pelvis have sustained injury as well.



Patient with an unstable pelvis will likely have other injuries; vascular, abdominal, GU or spinal cord.

A protocolized approach as seen in the slide is used to treat.

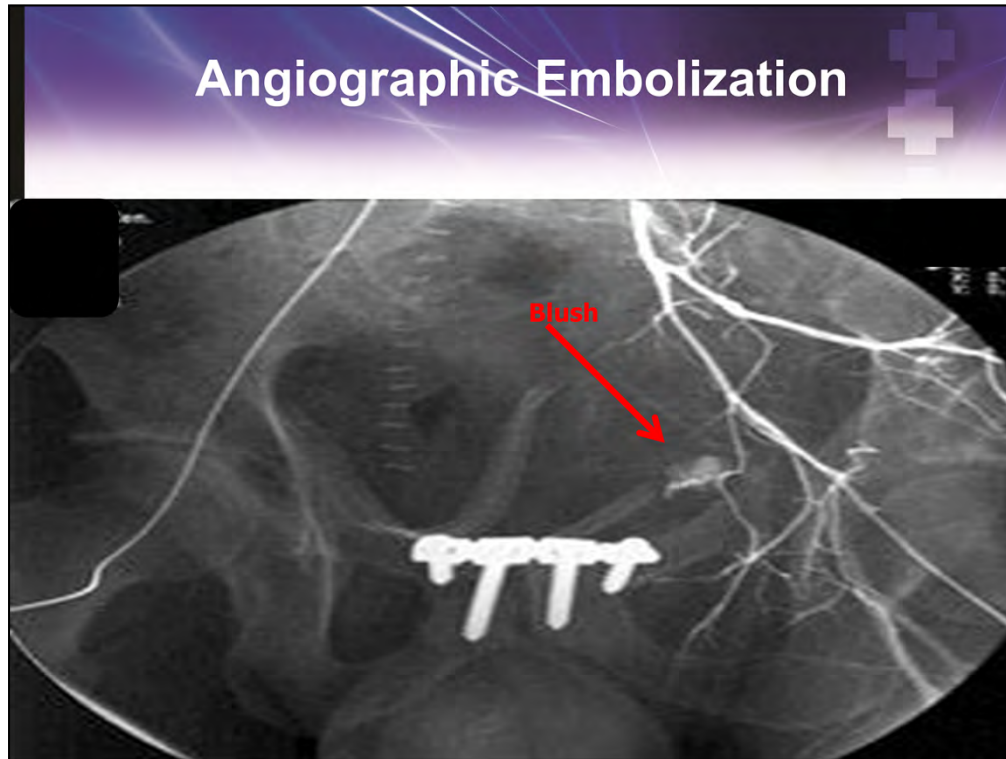
If massive transfusion is required, remember to keep fluids and patient warm to prevent hypothermia, thus preventing acidosis, and coagulopathy-the Trauma Triad of Death.

**Do you have a pelvic fracture treatment protocol?**

**Do you know how to find a pelvic binder?**

**Do you know how to assess if pelvic binder is in correct position?**

**How do you assess the skin under a pelvic binder? Or do you?**



#### Angiographic-embolization

Patient with extensive hemorrhaging off the branches of the internal iliac artery caused by a pelvic fracture should undergo angiography for endovascular control. When an injured pelvis falls in a high index of suspicion the patient is transferred immediately to angiography.

In the unstable Pelvis, up to 40% of hemorrhagic bleeding is caused by injury to the anterior branch of the iliac artery, e.g.; the Obturator or Pudendal arteries so good rule of thumb is to evaluate if the patient responds hemodynamically to a bolus of 250-500 ml fluid. If so, they are most likely not actively bleeding and can be safely transported to CT scan for imaging. But if they remain unstable, angiography for immediate embolization to control hemorrhage should be considered. If there are additional injuries perhaps the operating room to control multiple sites of bleeding is more appropriate.



## Complex Open Fractures

- Gustilo I : <1 cm wound over Fx
- Gustilo II: >1cm wound over Fx
- Gustilo III:
  - A) Extensive soft tissue injury
  - B) Periosteal stripping
  - C) Arterial injury needing repair



The Gustilo system of classification of open tibial fractures is the most common classification system for open fractures (Fx).



Open Type I is a wound with  $<1$  cm dimensions

Type II is a wound with  $> 1$  cm dimensions

<b>Mangled Extremity Severity Score (MESS)</b>			
Type	Characteristics	Injury	Points
1	Low energy	stab wound, simple closed fx, small-caliber GSW	1
2	Medium energy	Open/multilevel fx, dislocation, moderate crush	2
3	High energy	shotgun, high-velocity GSW	3
4	Massive crush	Logging, railroad, oil rig accidents	4
<b>Shock Group</b>			
1	Normotensive	BP stable	0
2	Transiently hypotensive	BP unstable in field but responsive to fluid	1
3	Prolonged hypotension	SBP <90mmHg in field and responsive to IV fluids in OR	2
<b>Ischemia Group</b>			
1	None	Pulsatile, no signs of ischemia	1
2	Mild	Diminished pulses without signs of ischemia	2
3	Moderate	No dopplerable pulse, sluggish cap refill, paresthesia, diminished motor activity	3
4	Advanced	Pulseless, cool, paralyzed, numb without cap refill	4
<b>Age Group</b>			
1	<30y/o		0
2	>30 <50		1
<b>MESS score: six or less consistent with a salvageable limb. Seven or greater amputation generally the eventual result.</b>			
From Helfet DL, Clin Orthop 1990 256:80			

### Mangled Extremity Severity Score (MESS)

- Used when considering limb salvage
- A tool to help predict outcome

#### Skeletal soft-tissue injury

Low energy: stab, simple fracture, pistol gunshot wound= 1

Medium energy: open or multiple fractures, dislocations= 2

High energy: high speed MVA or rifle blast= 3

Very high energy: high speed trauma= 4

#### Limb ischemia:

Pulse weak or absent with normal perfusion= 1/ Pulseless; parenthesis, or diminished capillary refill= 2/ Cool, paralyzed, numb= 3

#### Shock:

Systolic BP > 90 mm Hg= 0

Hypotensive = 1

Persistent hypotension= 2

#### Age (years)

< 30= 0

30-50= 1

> 50= 2

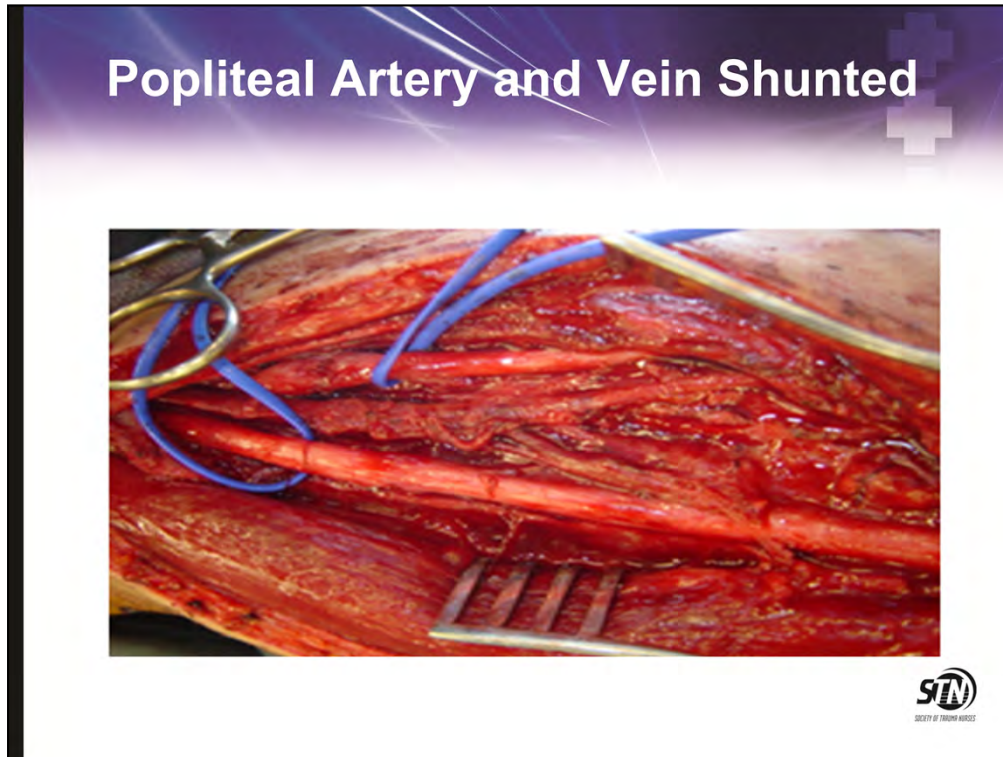
Score is doubled for ischemia > 6 hours



A mangled extremity almost always includes neurovascular damage.

Shredded muscles and transected nerves, or > 6 hours of arterial occlusion meet criteria for immediate amputation.

**What do you think the MESS Score on this limb is?**

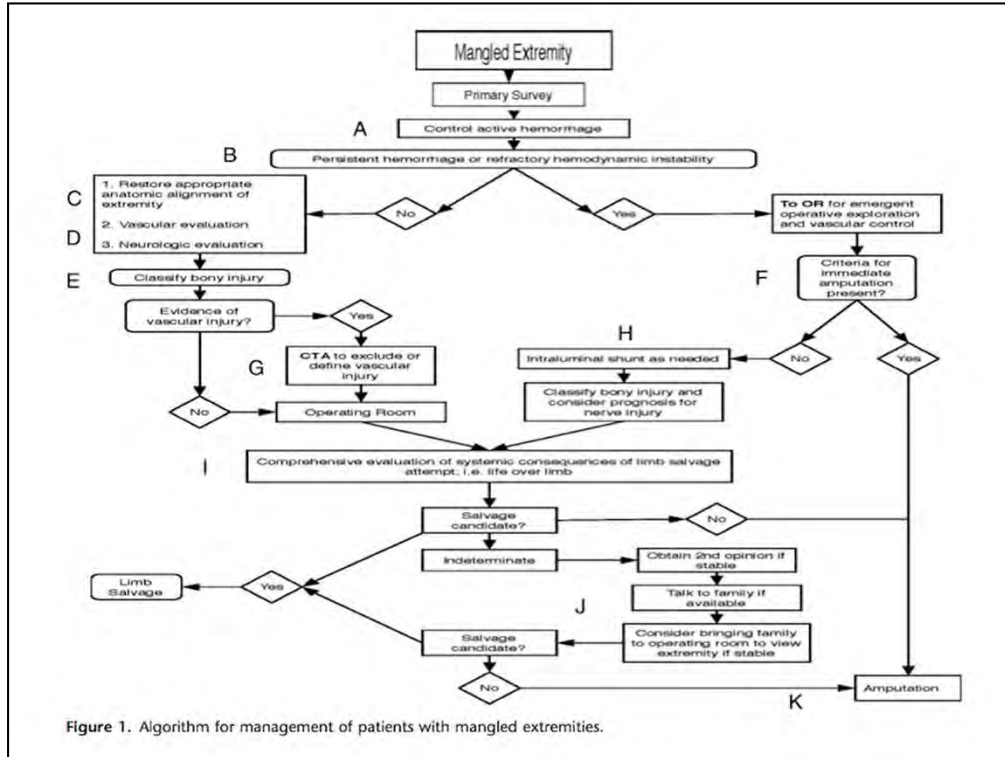


Managing the mangled extremity requires prompt decision-making considerations. If the patient's life is in danger from the injury, the limb must be amputated. If the limb can be salvaged, bleeding must be controlled with the use of direct pressure, and/or a tourniquet. Broad spectrum antibiotics must be administered prior to the operating room. Diagnostic evaluations prior to limb salvage in the operating may be done using a FAST (ultrasound, CT, or MRI). Continued resuscitation must be ongoing, and assessment sensory and motor function to establish a baseline is essential prior to intubation. If there remains a consideration for limb salvage in the absence of arterial blood flow, than intraluminal shunts must be placed into the injured artery and vein.

Severe trauma with persistent hypothermia, acidosis and coagulopathies will indicate life over limb amputation.



Extensive soft tissue injury to a mangled extremity



The algorithm is a guide for physicians to consider as they manage the difficult mangled extremity. Yet vascular and neurologic status is the priority over limb salvage.

**Will need to point to and summarize the decision points in this algorithm.**



The zone of injury is often not noted until the operative period, and consists of the extent of damage to the surrounding soft tissue. Radiographic studies may not reveal the extent of damage, thus ongoing clinical assessment to areas proximal and distal to the injury site are important.



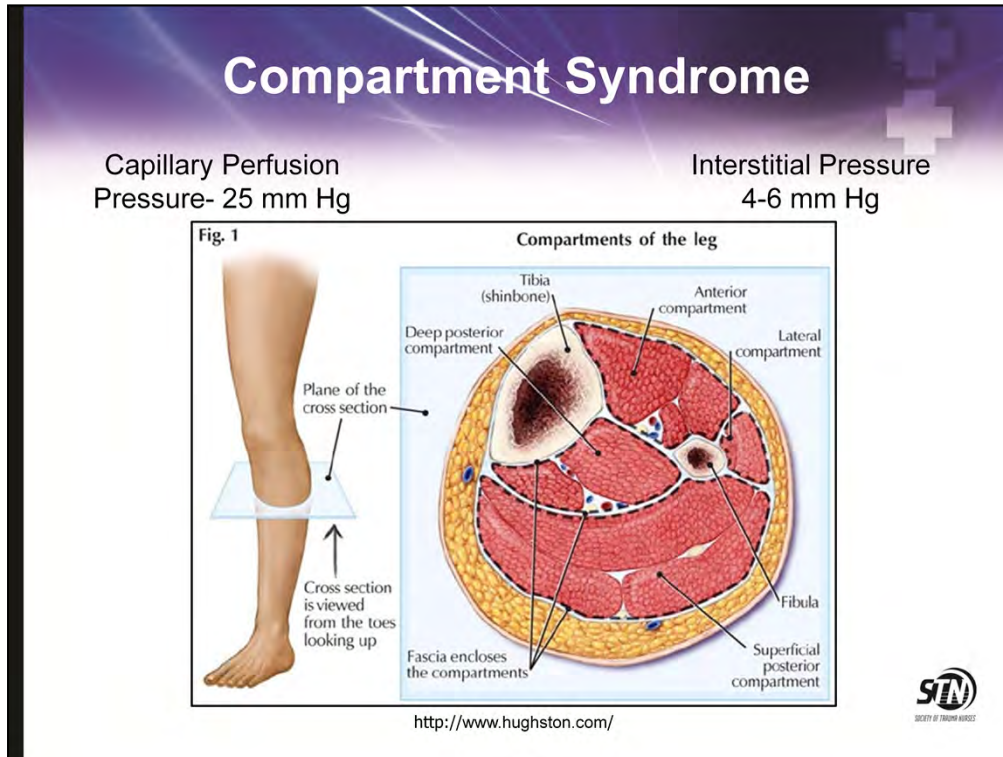


Dr. Richard von Volkmann (1830-1889), the 19<sup>th</sup> century German physician, first identified CS while analyzing the cause of forearm contractures from tight bandages, and speculated that nerve etiology was not the cause.

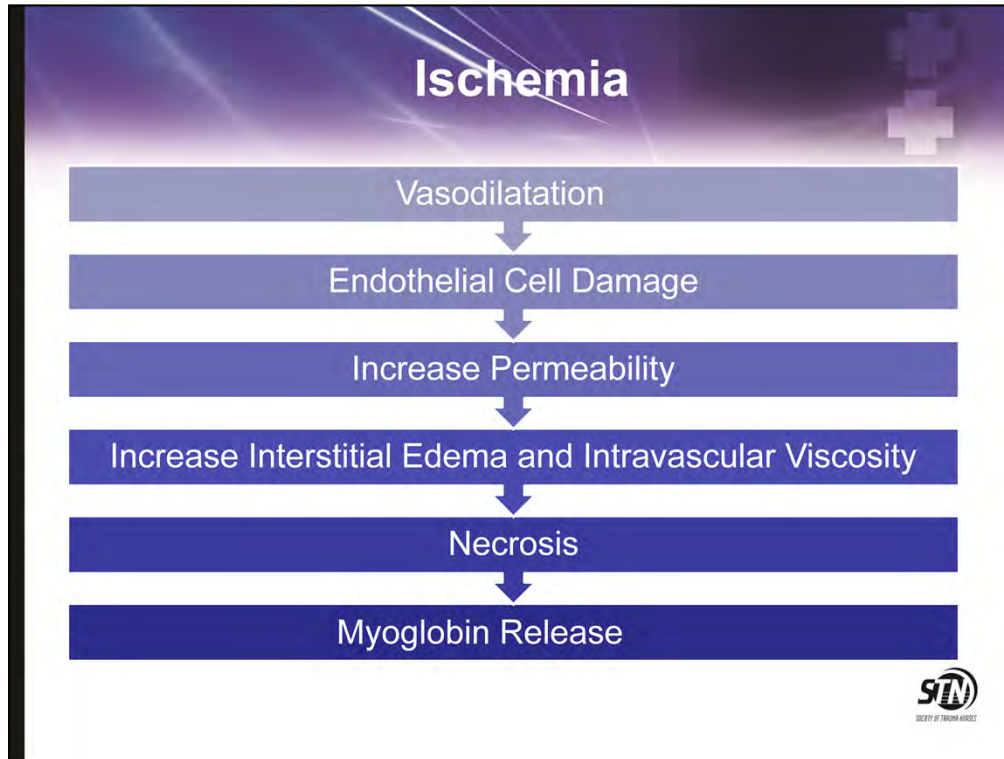
Patients with a burning pain, increasing severity of pain, and movement of the limb as in dorsiflexion of the foot that causes pain to the gastrocnemius muscle. Arterial pulses may be present because compartment pressure is usually less than systolic blood pressure, but the soft tissues are swollen, and the limb has a hard and warm feel to it. Blisters also suggest CS.

Paresthesias and paralysis are late findings.

Of course with unconscious patients, a more detailed evaluation upon suspicion must occur.



Fascia separates muscle and inside each fascia is a “compartment”. Every compartment includes muscles, nerves, and blood vessels. The fascia does not have the capability to expand, and blood flow will cease once the compartment is blocked by high pressures. Eventually, if left untreated, the muscles and nerves within the compartment will die and the limb will need to be amputated.





The mechanism of ischemic injury include biochemical and physiologic changes as a result of a change in circulation. Mechanisms include a decrease of high energy metabolism, a “no flow” state interrupted by swelling, and the change from aerobic to anaerobic metabolism that results in acidosis.

High energy phosphate decrease, which causes ATP depletion, and cellular electrolyte disturbances begin. Potassium begins to leak from the cell while sodium and calcium begin to infiltrate the cell. And it is the sodium influx into the cell that increases water inside the cell to cause cellular “flooding”.

## Etiology

Increased Fluid Content in Interstitial Space

Decreased Compartment Size



The slide features a purple gradient background with the word 'Etiology' in white. Two blue rounded rectangular boxes contain the text 'Increased Fluid Content in Interstitial Space' and 'Decreased Compartment Size'. To the right is a photograph of a person lying on a staircase. In the bottom right corner is the STN logo with the tagline 'SOCIETY OF TRAUMA NURSES'.

Increased fluid content in interstitial space (swelling) is in traumatic fractures and soft tissue injuries, crush injuries and surgery.

Decreased compartment size from cast, fall at home and not found for many hours!

## Signs and Symptoms



- Pain disproportionate to injury!
- Pain with passive stretching
- Neuro compromise
- Tenseness
- Unilateral size increase

Wiki.org




Signs and symptoms are included in the nursing assessment and must be ongoing throughout the course of the injury. Pain and neurovascular changes must be carefully monitored as well as an increase in size of the affected extremity



CS often affects the lower limbs and is often seen in Tibia-Fibula fractures. High level of suspicion for compartment syndrome in high risk patients.

## Interventions

- Supplemental O<sub>2</sub>
- Level extremity
- Routine trauma resuscitation
- Extra vigilance in some patients
- Hydration
- Diuresis
- Alkalinization of urine



Timing is everything when diagnosing and treating compartment syndrome (CS). Irreversible nerve damage begins after 6 hours of hypertension inside the compartment. Treatment for CS

Identify it early. If there are long extrication times-expect it. If the patient complains of pain or a “tight feeling” in the extremity, anticipate CS and begin treatment early.

1. Splint the limb at heart level. Do not elevate the affected extremity as this will decrease the Mean Arterial Pressure (MAP). When the limb is kept at heart level, swelling is decreased and (MAP) is maintained. The MAP (normal is 70-110 mmHG) is considered the perfusion pressure for organs in the body. A MAP of 60 mmHG will allow organs to receive blood flow, and hence, oxygen. If the number falls below 60 mmHG, organ ischemia will develop.
2. Initiate oxygen to promote oxygen to the tissues. Oxygen may raise the partial pressure of Oxygen (PO<sub>2</sub>) to support oxygen to the tissues.
3. Hydrate the patient with Normal Saline (isotonic) because Saline does not have Potassium. There may be a relative hypovolemia if metabolic acidosis has started, and hypovolemia makes ischemia worse.
4. Measure intracompartmental pressures and ensure the pressure is not above 30 mmHG. Pressures higher than 35-45 will require surgery.
5. Often measurements are done using the Delta-P (diastolic blood pressure {DBP} minus the compartment pressure {CP}). Delta-P's of < 30 mmHG will be indicative of a Fasciotomy (surgical procedure where a long cut is made into the Fascia to reduce the pressure inside the compartment) A Diastolic Blood Pressure of 65 mmHG and Compartment Pressure of 40 mmHG (DBP-CP= Delta-P) = 25 mmHG will require a Fasciotomy. Follow up surgery is necessary after 48-72 hours to close the Fasciotomy and a skin graft may be necessary.
6. Mannitol may assist with diuresis to eliminate urine acidity. Avoid Lasix as it adds to the acidity and worsens the condition. The area of the renal tubules that becomes obstructed with Myoglobin is below the Loop of Henle, so Mannitol, and not Lasix (which works at the loop) is indicated. Also, Mannitol can be given as a bolus of 1 gm/kg or added to the intravenous fluids as a continuous infusion.
7. Sodium Bicarbonate will reverse the metabolic acidosis, and keep the urine alkalotic and free of tubule obstruction. It will also reduce the hyperkalemia. Start at 1 mEq/kg and then as a continuous infusion at 50-100 mEq/L of Normal Saline at 150 ml/hr.
8. Hyperbaric Oxygen Therapy (HBO) maintains oxygen perfusion to tissues and organs and promotes wound healing. HBO also reduces amputation rates and surgical necessities.

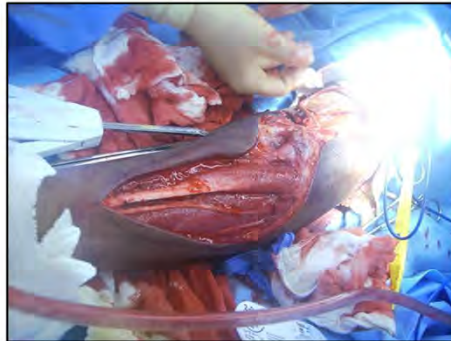


The Delta P, e.g.; the perfusion pressure inside the affected compartment is (diastolic pressure – compartment pressure) If the Delta P is < 30 mmHG, fasciotomies are often performed to prevent ischemia.

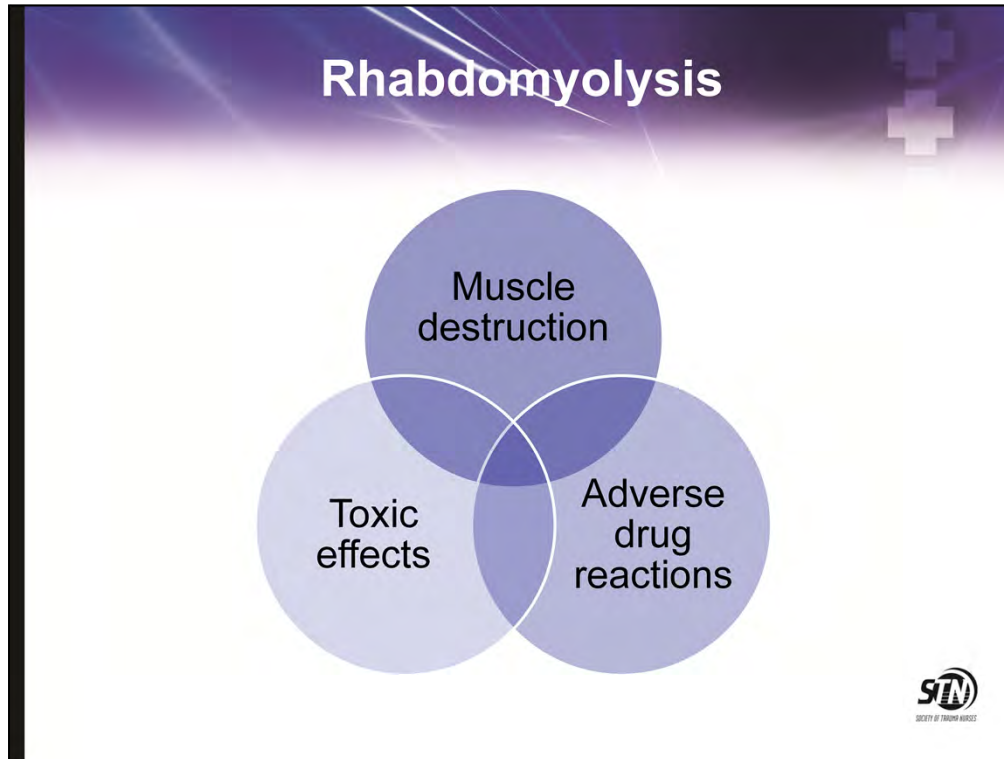


## Fasciotomy

- Definitive Treatment with limb saving results
- Extends hospital length of stay as it turns a closed injury into an open injury
- Threshold for compartment pressure remains ~ 30 mmHg



There is some literature to state that pressures up to 45 mmHG are also satisfactory. Yet others explain that a “prophylactic” fasciotomy prevents from CS from developing.



Rhabdomyolysis was first noticed in crush injuries in the 1940's and is caused by the breakdown of muscle fibers and leaking of toxic substances (myoglobin) into the bloodstream. It may also be caused by adverse drug reactions to certain medications.

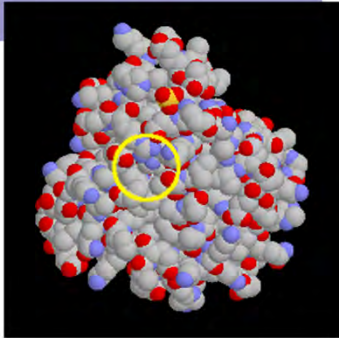
It causes a cascade of problems that include Hypovolemia, Hyperkalemia, Metabolic Acidosis, Acute Renal Failure, and Disseminated Intravascular Coagulation (DIC).

Rhabdomyolysis is responsible for 15% of Acute Renal Failure cases. The mortality rate for patients is about 5%, and in patients with pre existing comorbidities, that rate may be higher.

## What is Myoglobin

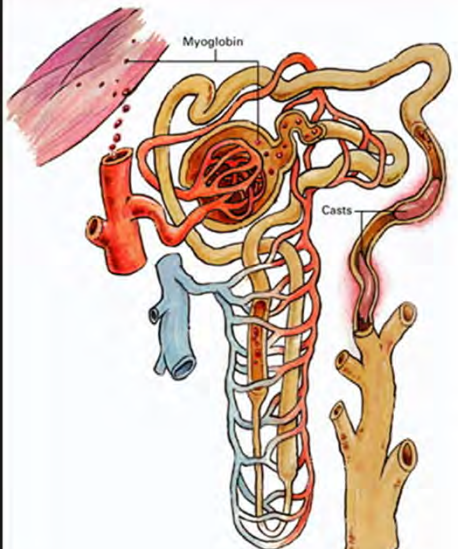
Iron containing pigment found in skeletal muscle

Especially in those specialized for sustained contraction




Skeletal muscle is the largest type of muscle in the body. It relies heavily on Adenosine triphosphate (ATP) for its energy in the cell membrane. When ATP is functioning properly, potassium and calcium flow inside, and sodium flows out. Myoglobin, a protein, is also found in skeletal muscle, and supplies the muscle with oxygen. With a crush injury- the pump is not effective, and Calcium and Sodium rush in, while Potassium and Myoglobin leak out. Eventually these leak into the bloodstream by way of the capillary network, causing Rhabdomyolysis.

## Pathophysiology



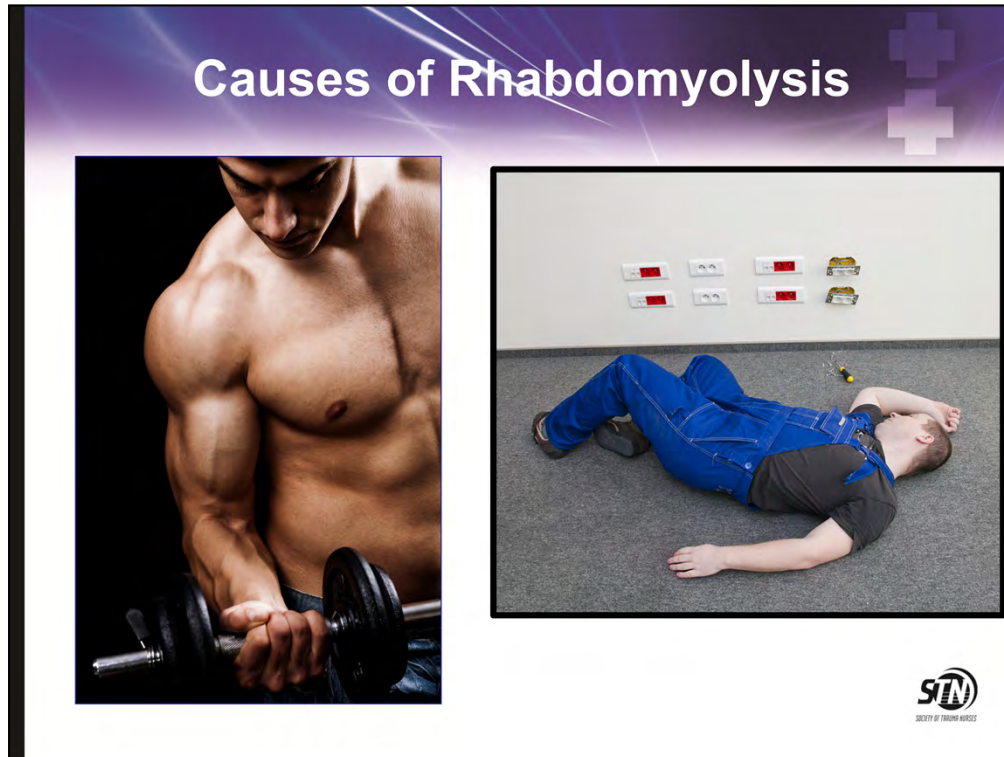
- Direct toxicity
- Cast formation
- Mechanical obstruction
- Acid urine causes myoglobin to form a gel
- Hypoperfusion from hemorrhage and fluid shifts
- Reperfusion fluid shifts
- Further hypoperfusion



Once the body experiences trauma to muscle cells, and cellular byproducts are released into the bloodstream, mainly potassium and myoglobin, the condition causes toxic consequences.

Intracellular free ionized calcium is released early as a dysfunction of direct membrane rupture and depleted cellular energy. The free ionized calcium release activates protease, increases skeletal muscle contractility, stimulates mitochondrial dysfunction, and eventually cell death.

The high levels of myoglobin and Creatine Phosphokinase are hallmark signs.



Causes of Rhabdomyolysis include:

Muscle destruction (Burns, Crush, Musculoskeletal trauma, Exertion, Status epilepticus, Electrocution)

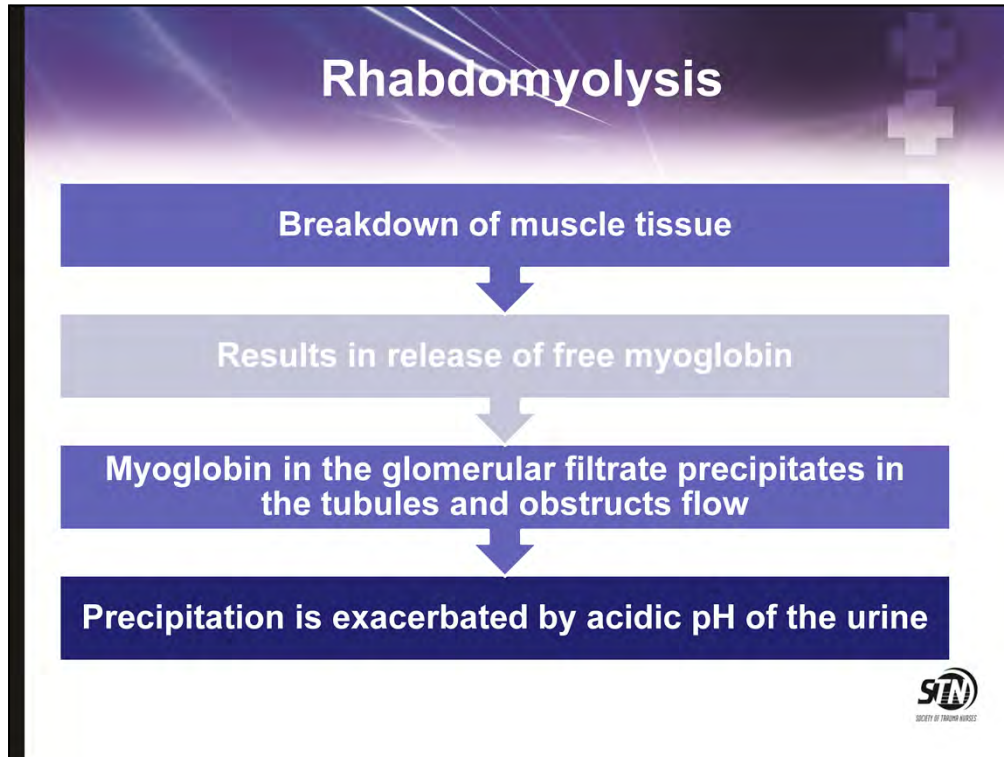
Adverse drug reactions (Statins, Amphotericin B)

Toxic effects (Propofol Infusion Syndrome, Amphetamines, cocaine, methanol)

Trauma and muscle compression are believed to cause rhabdomyolysis through direct injury to muscle, resulting in disruption of the sarcolemma and direct leakage of cell contents. Occlusion of muscular vessels due to thromboemboli, traumatic injury, or surgical clamping may lead to rhabdomyolysis if muscle tissue ischemia is prolonged. This is the leading cause of rhabdomyolysis in children aged 9-18 years, according to one review.

Orthopedic trauma, including compartment syndromes and fractures, may result in rhabdomyolysis. Such trauma commonly occurs in traffic and occupational accidents. Orthopedic injuries in natural disasters (e.g., earthquakes) are compounded by immobilization, hypovolemia, and significant rates of rhabdomyolysis.

**Key point: if you have an elderly patient who has fallen and has been found many hours later still lying in the same position, be sure to evaluate for rhabdomyolysis. They will probably be dehydrated too and if they are not well hydrated prior to and after contrast, they are at high risk for renal failure.**



Review the above process and discuss diagnosis.

Diagnostic Evaluation:

Laboratory values are the diagnostic tool most often used once a high index of clinical suspicion is assumed. The initial test is the Creatine Kinase assay (CK). If the laboratory value of Creatine Kinase (an enzyme that is released from damaged muscle) is 5 times the normal value, Rhabdomyolysis is suspected. It is not uncommon to see levels of 100,000 U/l in Rhabdomyolysis, yet values less than 20,000 generally do not place the patient at risk for kidney failure. A reddish-brown discoloration in the urine is often noted. CK levels continue to rise for 12 hours, and stay elevated for 1-3 days. Repeat CK assay every 6-12 hours in order to determine peak CK level and to evaluate success of treatment.

(LDH) Aldolase, lactate dehydrogenase, (SGOT) and serum glutamic-oxaloacetic transaminase are nonspecific enzymes that are elevated in rhabdomyolysis.

PT/PTT must be evaluated as well because Thromboplastin is released from injured myocytes in Rhabdomyolysis which can cause DIC.


Potassium that is released from injured cells can cause life-threatening dysrhythmias and death. Closely monitor serum potassium levels.

MRI is the imaging modality of choice to evaluate the distribution and extent of injury of affected muscles, especially when fasciotomy or involvement of deep compartments is considered

Obtain an electrocardiogram (ECG) if potassium levels are above normal. ECG may show results of hyperkalemia, including peaked T waves, prolonged PR and QRS intervals, and loss of the P wave or sine wave.

## Treatment of the *Effect* of Rhabdomyolysis

- Prevent Acute Renal Failure from the effects of myoglobinuria
  - Monitor CPK, serum and urine myoglobinuria
  - Ensure fluid resuscitation
  - Ensure hyperdynamic urine output
  - Ensure alkaline urine
  - May diurese for mechanical lavage
  - Carbonic anhydrase inhibitor



If compartment syndrome is suspected as the cause of the rhabdomyolysis measure compartment pressures and if compartment pressures are sustained in excess of 25-30 mm Hg- perform a fasciotomy.

The keystone of treatment for rhabdomyolysis is **aggressive hydration** to maintain good kidney function. The myoglobin resulting from the breakdown of muscle is eliminated as the kidneys are flushed of these huge molecules. It may take up to a liter of fluid an hour to maintain urine output of at least 200 ml per hour. The patient may look like the “Michelin man” and his intake may far surpass his output, but this is necessary until CPK goes down and myoglobin in urine is within normal limits.

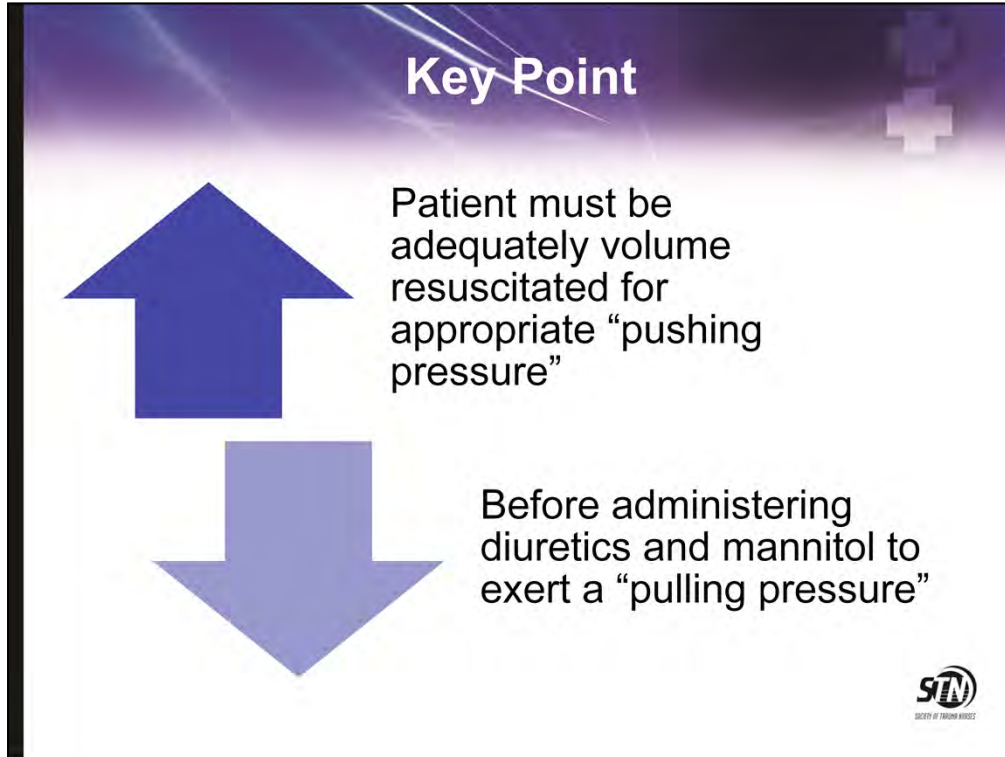
Diuretics such as Mannitol and Lasix may be used to assist in flushing the iron pigments from the kidneys, but **ONLY** if urine output is already 200 ml and hour. Data is not strong to support diuretics.

A Sodium Bicarbonate drip may also used to prevent Myoglobin from breaking down into toxic substances inside the kidneys.

The cascade of Myoglobin and uric acid crystals in the tubules, a decreased GFR (glomerular filtration rate), and the nephrotoxicity which may be caused by the breaking down of Myoglobin, all lead to renal failure. If Sodium Bicarbonate is used, mix one amp of the Na Bicarb in a liter of NS and run at 100 ml/h to maintain urine pH higher than 6.5 or 7. Data is not strong for alkalinizing urine either.

Acute hemodialysis may be indicated to clear the toxins.

**Key Point**



Patient must be adequately volume resuscitated for appropriate “pushing pressure”


Before administering diuretics and mannitol to exert a “pulling pressure”

**STN**  
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## Propofol Infusion Syndrome (PRIS)

- Adverse drug event with high doses
- Not recommended for infusions > 48 hrs
- Signs of PRIS: hyperkalemia, metabolic acidosis, lipemia, renal failure, cardiovascular collapse, hepatomegaly, rhabdomyolysis



Propofol infusion syndrome may also be a cause of Rhabdomyolysis. Monitor patients triglycerides every two days when they are on a propofol drip.

Triggers that may cause this syndrome include glucocorticoids, catecholamine's, and high doses of Propofol > 4 mg/kg/hr

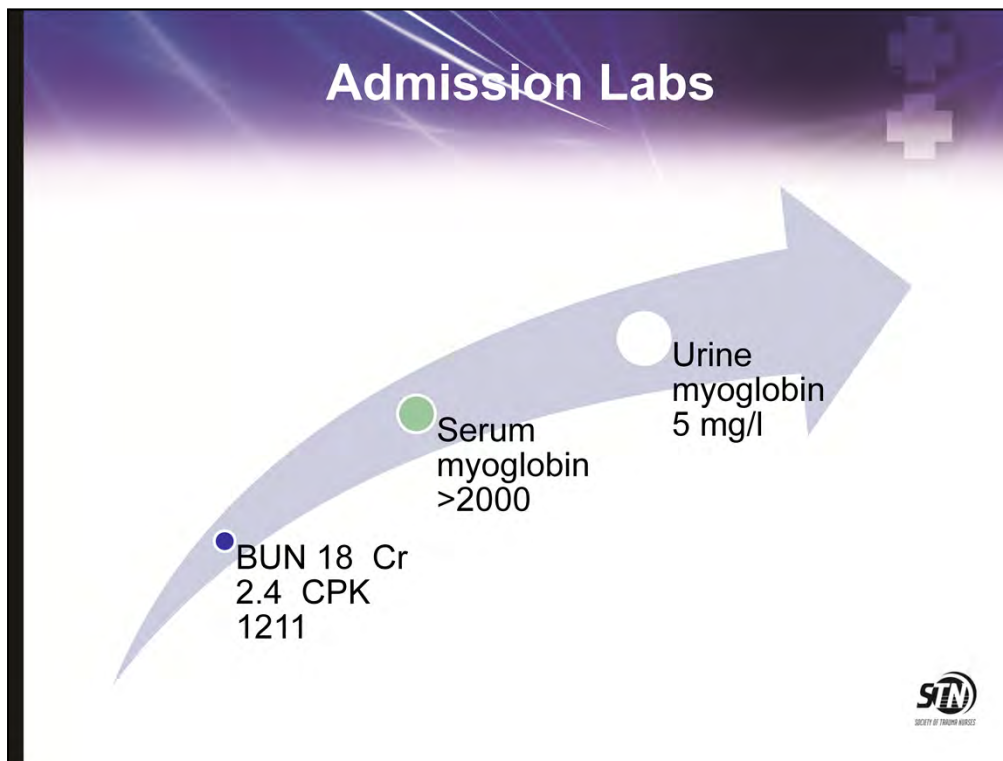
Propofol impairs utilization of free fatty acids which is the fuel for cardiac and skeletal muscle. Catabolism occurs and leads to cardiac collapse and rhabdomyolysis

Elevated serum creatine kinase, troponin I and myoglobin should prompt clinical suspicion of Propofol infusion syndrome.

## Case Study

- 18 year old dirt bike vs. car crash
- Previous MVC 12 months ago
  - SVC filter and ORIF left femur
  - On Coumadin, nephrogenic DI
  - Hypertrophied bladder, frequent UTI and chronic renal failure
- This admission has fx right femur and bladder rupture along with left ankle injury and closed head injury





The Bun is normal, yet the serum myoglobin and CPK are “climbing”.

## Diagnosis

- Precipitating Factor
- Serum myoglobin
- Urine myoglobin >15 mg/l
- +heme in absence of RBC in yellow urine
- CPK >5000 u/l incidence of ARF becomes significant

**STN**  
SOCIETY OF TRAUMA NURSES

This patient's risks are:

Muscle injury

Ex Lap

Hypotension

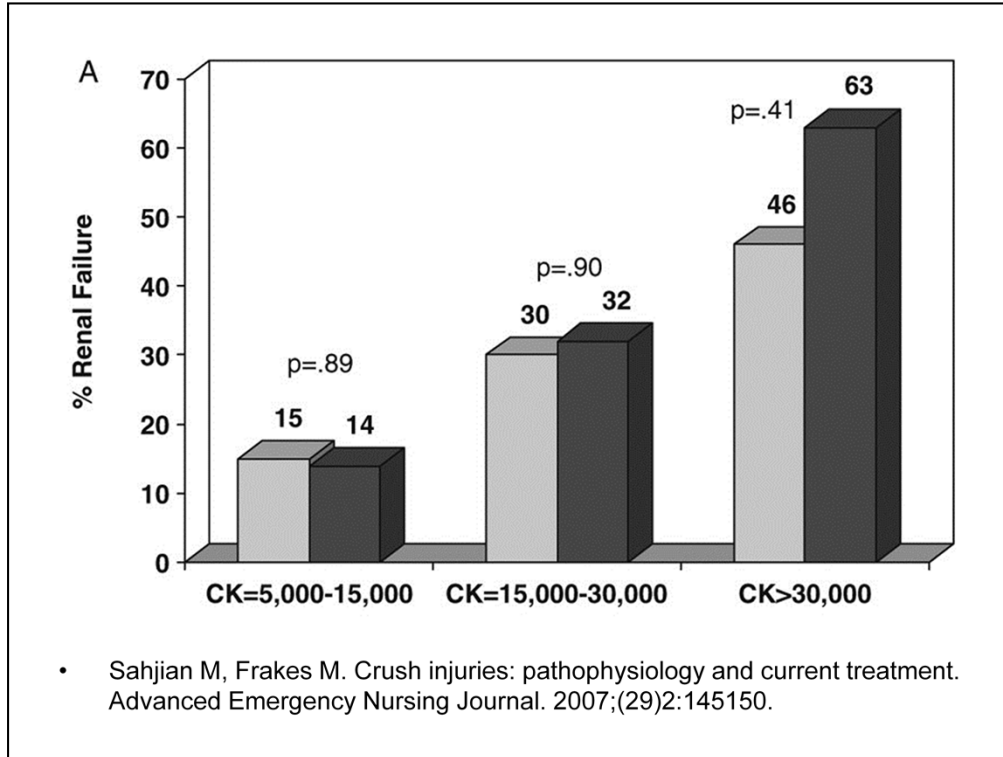
Contrast

ORIF femur

Chronic renal failure

Hyperkalemia is an immediate life threatening situation, yet occurs only in up to 40% of cases. More commonly, the Bun-creatinine ration may be reduced as the creatine to creatinine conversion of liberated muscle.


The Creatine Kinase (CK) is confirmative for Rhabdomyolysis. It is the most definitive indicative of muscle damage and will begin to rise within 12 hours and peak at 24-36 hours. If the CK levels to 15,000 U/L, renal failure is imminent.



CK levels 5 times the reference range is indicative of Rhabdomyolysis. Therefore CK levels must be repeated every 6-12 hours.

## Hospital Course



- PTD 2 BUN 29 Cr 4.5 CPK 5807
- Urine myoglobin 5
- Dialysis begins
- Dialyzed (RRT)
- By PTD 15 creatinine is 1.5
- Discharged on PTD 31



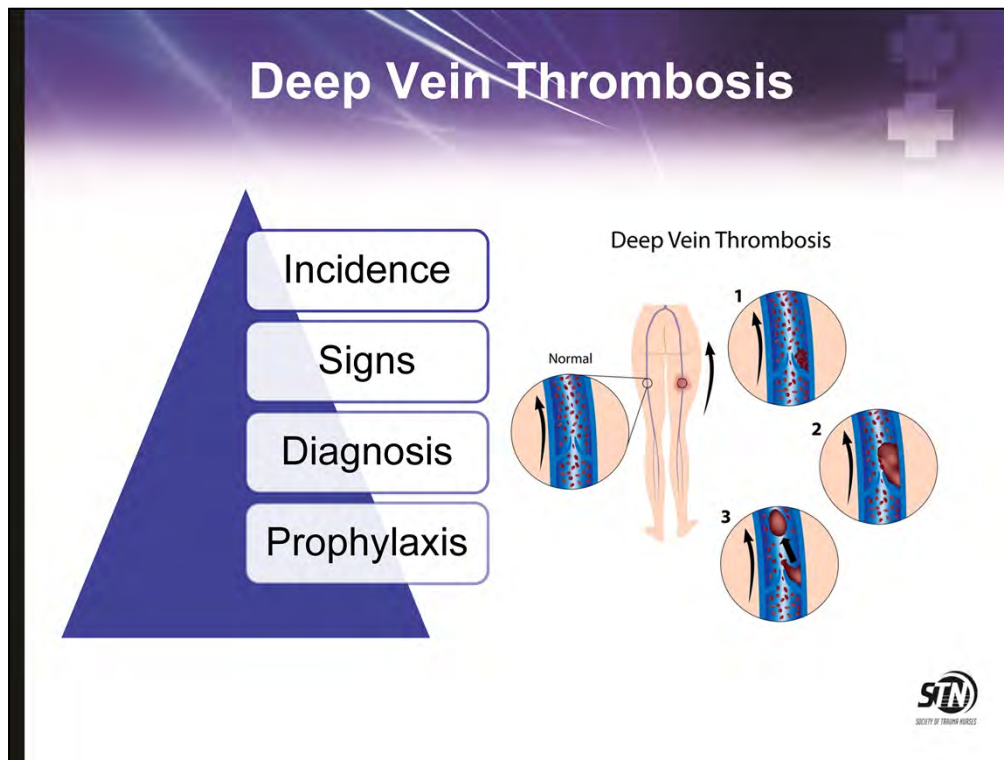
Labs to monitor will include CBC, H&H, BUN, Electrolytes, PT & aPTT, LDH, LFT, and CK

## Early Dialysis

- ARF pts who require RRT have increased morbidity and mortality
- Averting continued rises in creatinine might improve outcome in critically injured trauma patients



Kidney dysfunction develops 1-2 days after muscle damage. If fluid restoration is ineffective to support renal function, then Renal Replacement Therapy (RRT) must be initiated to remove excess acid, phosphate and potassium that will accumulate



30-50% of trauma patients with Pelvic and Femur fractures develop DVT's

Signs may include calf tenderness, swelling, fever, tachycardia

Magnetic Resonance Imaging is being used more and can detect pelvic DVT and DVT's from femur fractures. Any Tibia, long bone or pelvic fracture should be suspect for possible DVT risk.

There are no "gold standard" guidelines for DVT prophylaxis in the orthopedic trauma patient.

EAST guidelines for VTE prevention (1998) are on their web site and have been published in the Journal of Trauma Volume 53(1), July 2002, pp 142-164.

The American Academy of Orthopaedic Surgeons (AAOS) do not have a guideline for VTE prophylaxis in trauma patients.

<http://emedicine.medscape.com/article/1268573-overview> is link to DVT prophylaxis in orthopedic surgery (October 2012) and has a nice review of medications.

The 9<sup>th</sup> edition of the American College of Chest Physicians Antithrombotic Therapy and Prevention of Thrombosis Guidelines were published in February 2012,

All of the above indicate that the use of Low Molecular Weight Heparin seems to be more effective than Heparin for prophylaxis, but no class 1 evidence.

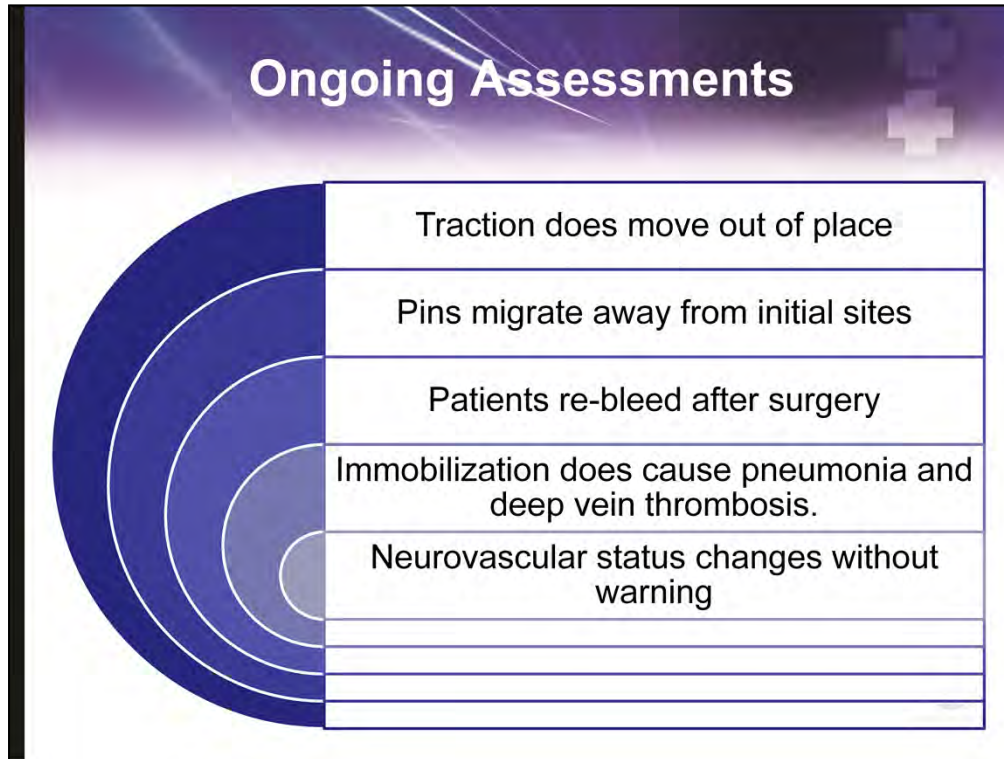
**What is your current pharmacologic and mechanical protocol for the simple or complex orthopedic injured patient?**

If the patient is going to be on prolonged bed rest, an Inferior Vena Cava (IVC) Filter is a viable option. The risk for DVT increases up to ½ the patients over 40 years of age.

The filters can remove up to 98% of emboli traveling to the pulmonary circulation, and last up to 1-2 years. Complications can include severe swelling after filter placement which may indicate a large embolus.

Indications for an IVC include age > 55, and ISS > 16, and any long bone or pelvic fracture that may require prolonged bed rest.





One of the most important ongoing assessments is the evaluation of the patient's neurovascular status. Blood flow and nerve function are vital for limb-salvage, homeostasis, and, cell rescue. The nurse can not leave to chance that once a procedure is completed, surgery was successful, and traction is now in place, the matter is done. The trauma nurse must stay aware of the risk of infection, over-sedation in pain management, loss of blood flow, sensation and movement (sensory and motor involvement) changes, and other pertinent clues. The assessment of musculoskeletal injury is ongoing.

## Summary

- Trauma care begins with standard process for care and destination protocol for pre-hospital personnel
- The initial management of the patient consists of a thorough assessment of the type and degree of injury, and the need for damage control surgery to maintain homeostasis
- Pain management is a critical aspect in the care of the patient with musculoskeletal injury



## Summary continued...

- The trauma nurse must be familiar with the types of radiographic studies performed and the need for follow studies in certain situations
- Multi-orthopedic injuries require different treatment strategies: traction, and open or closed reduction
- The nurse must identify limb-threatening compartment syndrome and patients at risk for rhabdomyolysis
- The nurse must protect the patient from infection, which may progress to osteomyelitis

