Initial Assessment and Management of the Multiply Injured Patient

John C. Weinlein, MD

Assistant Professor

University of Tennessee-Campbell Clinic

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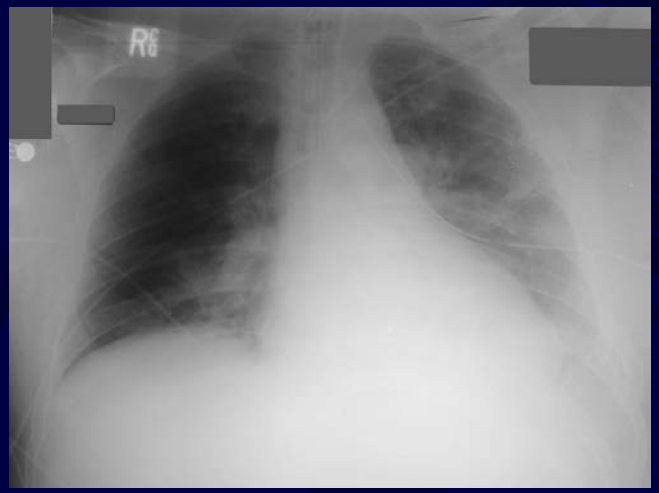
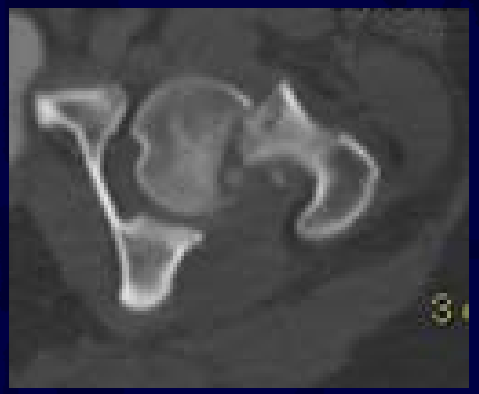
The issues…





Outline

- Evaluation of the polytrauma patient
- Scoring Systems important to polytrauma
- Urgencies and Emergencies
- MOF, ARDS
- Physiologic responses to trauma
- Definition of *Damage Control Orthopaedics*, (DCO)
- History of DCO and *Early Total Care*, (ETC)
- Evidence for DCO
- Occult Hypoperfusion and Resuscitation
- Modes of DCO
- Timing of definitive fixation in DCO

Evaluation of the polytrauma patient

- ATLS
- Primary Survey
  - Airway
  - Breathing
  - Circulation
  - Disability
  - Exposure/Environmental Control
- Secondary Survey
- Tertiary Survey

Evaluation of the polytrauma patient

- Primary Survey
  - Airway
    - Establishment of an airway with regard for associated cervical spine injury
    - Clinical evaluation for obstruction
      - Facial fractures, mandible fractures, laryngeal or tracheal injury, aspiration, foreign body

Evaluation of the polytrauma patient

- Primary Survey
  - Breathing
    - Clinical and radiographic (CXR) evaluation
    - ABG
    - Common causes of hypoxemia:
      - Flail chest with contusion, tension pneumothorax, open pneumothorax

Evaluation of the polytrauma patient

- Primary Survey
  - Circulation
    - Clinical and radiographic (CXR, pelvic XRay evaluation)
    - Application of circumferential sheet or binder where indicated
    - Application of direct pressure to areas of obvious hemorrhage
    - Initiation of resuscitation

Evaluation of the polytrauma patient

- Primary Survey
  - Disability
    - Neuro evaluation

Evaluation of the polytrauma patient

- Primary Survey
  - Exposure/Environmental Control
    - Clinical evaluation to identify occult injuries
    - Rewarming of patients

Evaluation of the polytrauma patient

- Must differentiate hemorrhagic shock from shock secondary to other etiologies:
  - Neurogenic
  - Cardiogenic

Evaluation of the polytrauma patient

- Initiation of Resuscitation
- Anticipated needs based on degree (“*Class*”) of hemorrhage at presentation
  - Crystalloid
    - 1-2 L crystalloid
  - Assess response
    - Rapid, transient, or minimal/none

Class of Hemorrhage

- Class I:
  - up to 15% (750cc) blood volume loss
- Class II:
  - 15-30% (750-1500cc) blood volume loss
- Class III:
  - 30-40% (1500-2000cc) blood volume loss
- Class IV:
  - >40% (>2000cc) blood volume loss

Class of Hemorrhage

	Class 1	**Class 2**	**Class 3**	**Class 4**
Blood loss (mL)	Up to 750	750-1500	1500-2000	>2000
Blood loss (% of volume)	Up to 15%	15-30%	30-40%	>40%
Heart rate	<100	100-120	120-140	>140
Blood pressure	Normal	Normal	Decreased	Decreased
Pulse pressure (mmHg)	Normal	Decreased	Decreased	Decreased
Respiratory rate	14-20	20-30	30-40	>35
Urine output (mL/hr)	>30	20-30	5-15	Negligible
Mental status	Slightly anxious	Mildly anxious	Confused	Lethargic

Blood Transfusion

- Transient or nonresponders to crystalloid (Class III/IV hemorrhage) will require transfusion
- Cross-matched, Type-specific, or Type O blood given based upon timing of need

Massive Transfusion

- Greater emphasis on more balanced product administration
- *Damage control resuscitation*
  - 1:1:1 ratio of pRBC:plasma:platelets

Evaluation of the polytrauma patient

- Further Imaging
  - FAST
  - CT

Evaluation of the polytrauma patient

- FAST (focused assessment with sonography for trauma)
  - Intraabdominal free fluid
  - Pericardial effusion
  - Solid organ injury (limited sensitivity)

Nural MS, Yardan T, Guven H, et al. Diagnostic value of ultrasound in the evaluation of blunt abdominal trauma. *Diagn Interv Radiol*. 2005;11:41-44.

Evaluation of the polytrauma patient

- Secondary Survey
  - Complete physical exam with updating of patient's history
  - Incorporates information from ongoing studies (FAST, CT, extremity XRays, etc.)
  - Usually within first 12-24 hours after injury

Evaluation of the polytrauma patient

- Tertiary Survey
  - Repeat physical exam with review of any additional labs and radiographs
  - 12% of injuries in polytrauma patients are missed in first 24 hours
  - Standardized tertiary survey has shown to decrease missed injuries by 36%

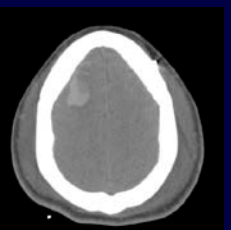
Chan RN, Ainscow D, Sikorski JM. Diagnostic failures in the multiple injured. *J Trauma*. 1980;20:684-687.
Biffl WL, Harrington DT, Cioffi WG. Implementation of a tertiary survey decreases missed injuries. *J Trauma*. 2003;54:38-43.

Scoring Systems

- Glasgow Coma Scale
- Abbreviated Injury Scale
- Injury Severity Score
- New Injury Severity Score

Glasgow Coma Scale

- Summation of **best** motor, verbal , eye response
- Observer dependant
- Predictive of mortality (admission > field)
- Affected by pharmacological agents, level of resuscitation



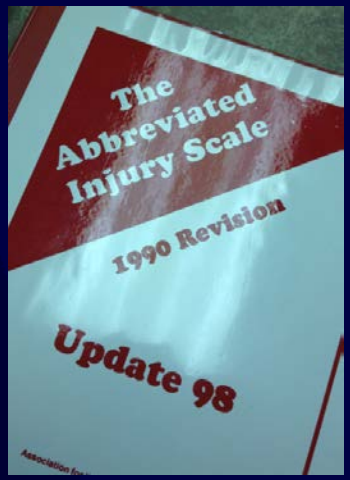
- Eye Opening
  - Spontaneous 4
  - To voice 3
  - To pain 2
  - None 1
- Verbal Response
  - Oriented 5
  - Confused 4
  - Inappropriate words 3
  - Incomprehensible sounds 2
  - None 1
- Motor Response
  - Obeys commands 6
  - Localized pain 5
  - Withdraw to pain 4
  - Flexion to pain 3
  - Extension to pain 2
  - None 1

Abbreviated Injury Scale (AIS)

- 9 anatomic areas:
  - Head
  - Face
  - Neck
  - Thorax
  - Abdomen
  - Spine
  - Upper Extremity
  - Lower Extremity
  - External

Abbreviated Injury Scale (AIS)

- Each area scored from 0 to 6
- Values are consensus driven
- Values found in “dictionary”



0 None
1 Minor
2 Moderate
3 Serious
4 Severe
5 Critical
6 Not survivable

Abbreviated Injury Scale

- Examples:
  - Femur fracture → serious, AIS=3
  - Pulmonary contusion → serious, AIS=3
  - Flail chest→ severe, AIS=4

Injury Severity Score (ISS)

- Calculated from AIS
- Highest AIS value from each individual anatomic area (6)
  - Head/ neck
  - Face
  - Chest
  - Abdomen
  - Extremities including pelvis
  - External
- Three highest AIS values (from different anatomic areas)
  - → squared
  - → summed

$$AIS^2 + AIS^2 + AIS^2$$

Injury Severity Score (ISS)

- Highest Score: 75 (not survivable)
  - AIS of 5 in three anatomic areas
  - AIS of 6 in any anatomic area

Injury Severity Score (ISS)

- Defines polytrauma
  - ISS $\geq$ 18
- Correlates with:
  - Morbidity
  - Mortality
  - Length of hospital stay

Injury Severity Score (ISS)

- A problem with ISS…

Injury Severity Score (ISS)

- A problem with ISS… injuries within the same anatomic system are only counted once

ISS and Bilateral Femur Fractures

Unilateral Femur fracture ≠ Bilateral Femur fractures

≠

Bilateral Femur Fractures

- Historical mortality rates ~40%

Bilateral Femur Fractures

- Independent risk factor for ARDS

Kobbe P, Micansky F, Lichte P et al. Increased morbidity and mortality after bilateral femoral shaft fractures: myth or reality in the era of damage control? *Injury*. 2013;44:221-225.

Bilateral Femur Fractures Contemporary Results

- 5.6% mortality
- Treated with retrograde IMN at same setting

Cannada LK, Taghizadeh S, Murali J, et al. Retrograde intramedullary nailing in treatment of bilateral femur fractures. *J Orthop Trauma*. 2008;22:530-534.

Bilateral Femur Fractures Contemporary Results

- 6.9% overall mortality
- 60/72 patients treated definitively <24hours (2 patients died before fixation)
- 2 patients treated with external fixation
- Results:
  - 0% ARDS; 2.9% MOF
  - 3 deaths after fixation
    - 2/3 → MOF (s/p IMN <24hr)
  - "not possible to determine which patients may be safely treated with early definitive fixation"

Lane MK, Nahm NJ, Vallier HA. Morbidity and mortality of bilateral femur fractures. *Orthopedics*. 2015;38:588-592.

New Injury Severity Score (NISS)

- Three highest AIS values **regardless** of anatomic region are utilized
- May be a better predictor of morbidity and mortality

Life > Limb
in the initial treatment of polytrauma patient

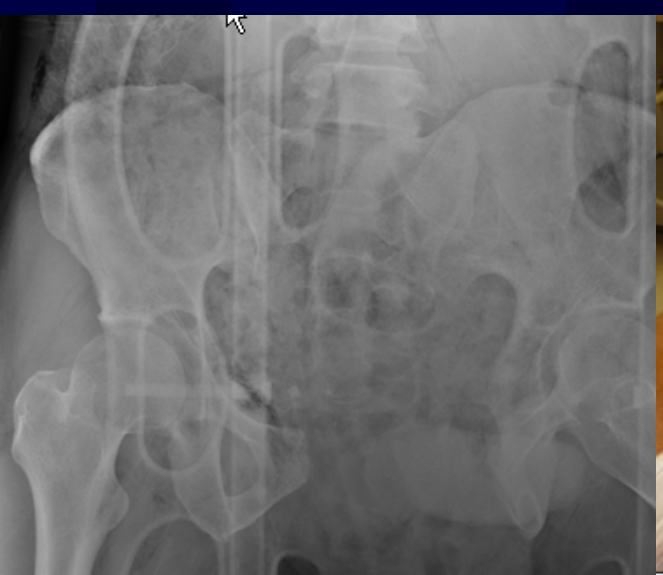
- However, care of the orthopaedic injuries does impact mortality
- Orthopaedic urgencies and emergencies must be treated within overall context of polytraumatized patient's condition

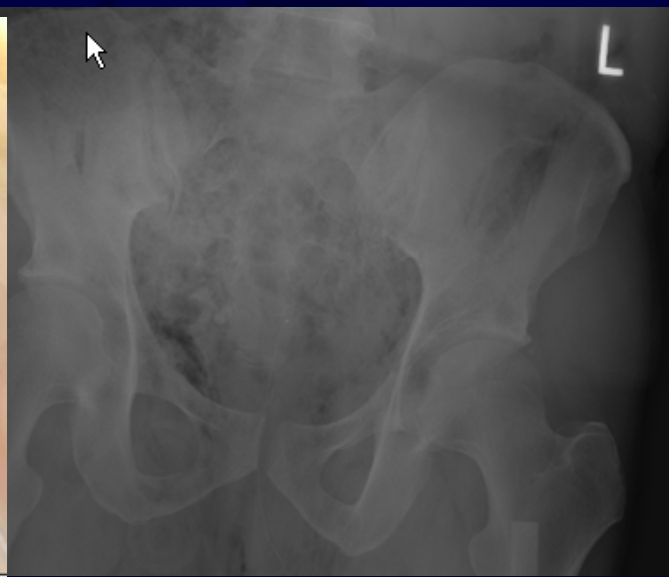
Orthopaedic Urgencies and Emergencies

- Unstable pelvic fractures
- Fractures or dislocations with associated vascular injuries
- Acute compartment syndrome (ACS)
- Spine injury with deficit
- Joint dislocations or fracture/dislocations with neurologic or potential neurologic sequelae
- Joint dislocations associated with avascular necrosis
- Fractures or dislocations with associated soft tissue compromise
- Open fractures

Urgencies and Emergencies

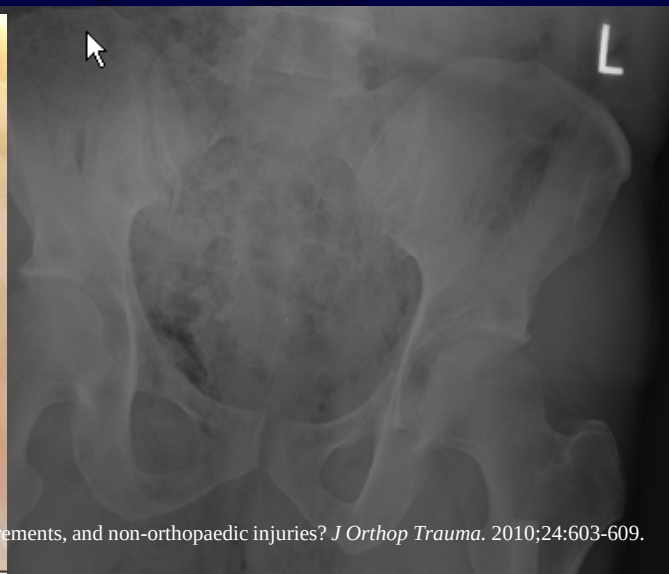
- Unstable pelvic fractures





Urgencies and Emergencies

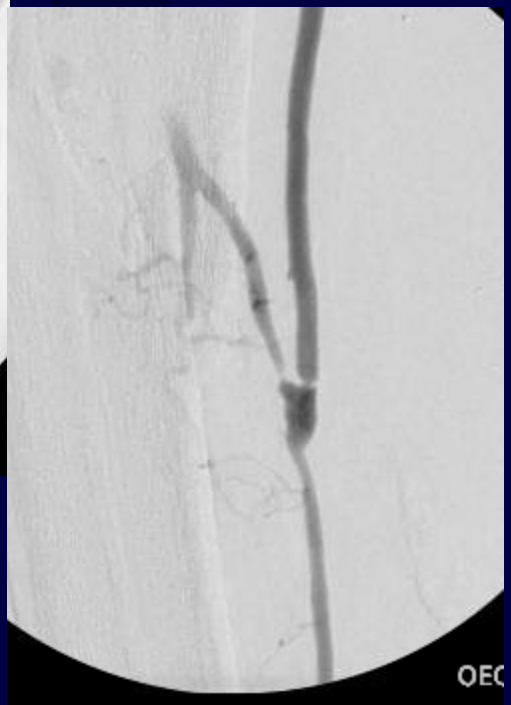
- Unstable pelvic fractures
  - Associated with significant transfusion requirements
  - Initial Treatment:
    - Mechanical stabilization
    - Assessment of response to resuscitation
      - Angiography
      - Pelvic Packing



Manson T, O'Toole RV, Whitney A, et al. Young-Burgess classification of pelvic ring fractures: does it predict mortality, transfusion requirements, and non-orthopaedic injuries? *J Orthop Trauma.* 2010;24:603-609.

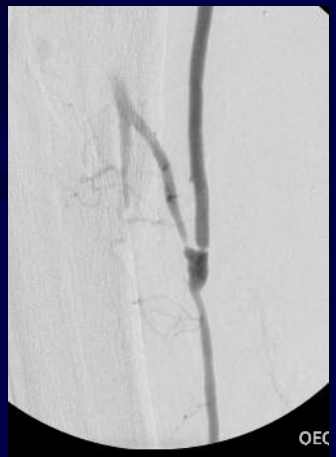
Urgencies and Emergencies

- Fractures or dislocations with associated vascular injuries



Urgencies and Emergencies

- Fractures or dislocations with associated vascular injuries
  - Initial Treatment:
    - Control hemorrhage (direct pressure)
    - Realign limb
    - Splint
    - Further evaluation (intraop arteriogram, etc.)
    - Vascular repair +/- skeletal stabilization

Urgencies and Emergencies

- Acute compartment syndrome (ACS)

Clinical Photo Courtesy L. Cannada

Urgencies and Emergencies

- Acute compartment syndrome (ACS)
  - Initial treatment:
    - Remove splint or dressing
    - Place extremity at level of heart
    - Emergent fasciotomy

Clinical Photo Courtesy L. Cannada

Urgencies and Emergencies

- Spine injury with deficit

Urgencies and Emergencies

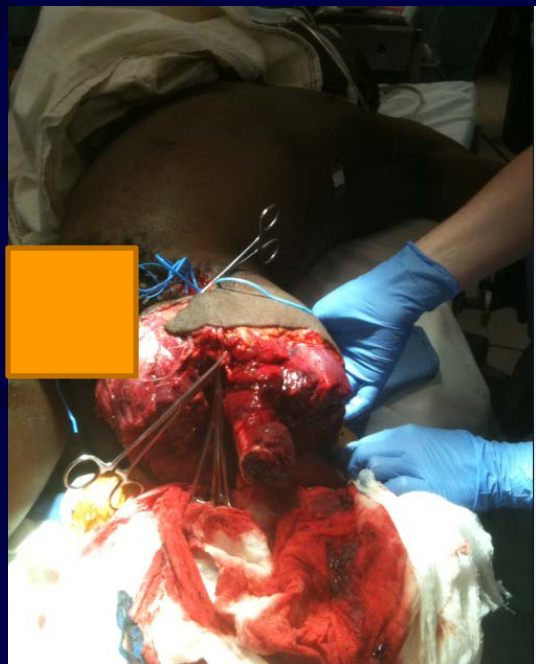
- Spine injury with deficit
  - Initial treatment:
    - Immobilization to prevent further neurologic insult
    - Further treatment depends upon injury (consider reduction when appropriate)

Urgencies and Emergencies

- Traumatic amputations

Urgencies and Emergencies

- Traumatic amputations
  - Control of bleeding (tourniquets or direct pressure)
  - Obtain definitive proximal control of bleeding
  - Situation will dictate whether *urgency* or *emergency*



Urgencies and Emergencies

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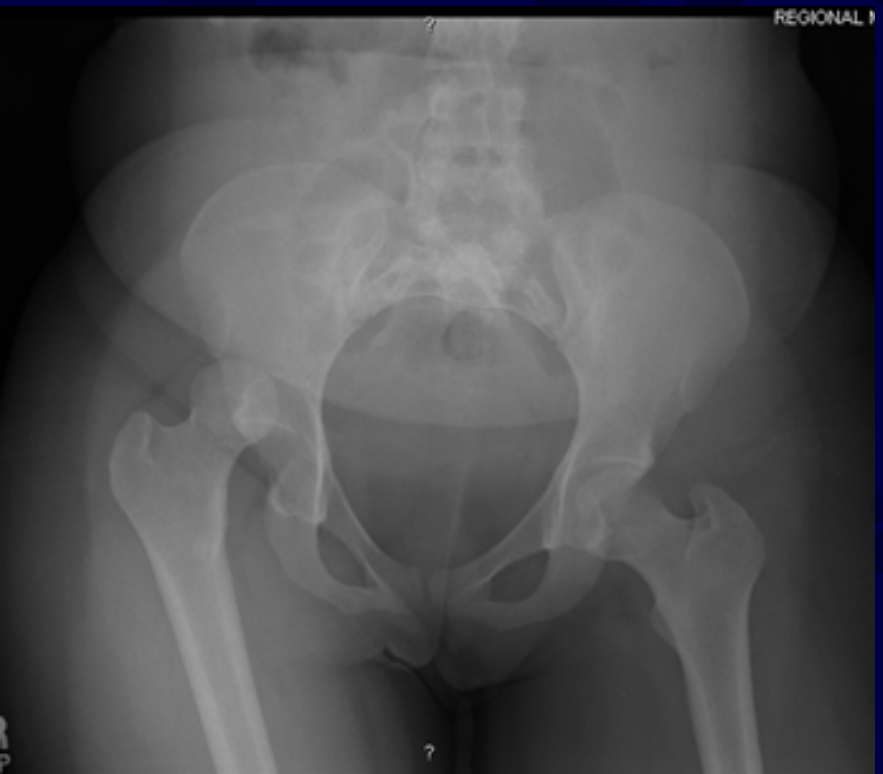
Urgencies and Emergencies

- Joint dislocations or fracture/dislocations with neurologic or potential neurologic sequelae
- Initial treatment:
  - Emergent Reduction
  - Assessment of vascularity
    - Physical Exam
    - Ankle Brachial Index (ABI)
    - Arteriogram

Urgencies and Emergencies

- Joint dislocations associated with avascular necrosis



Urgencies and Emergencies

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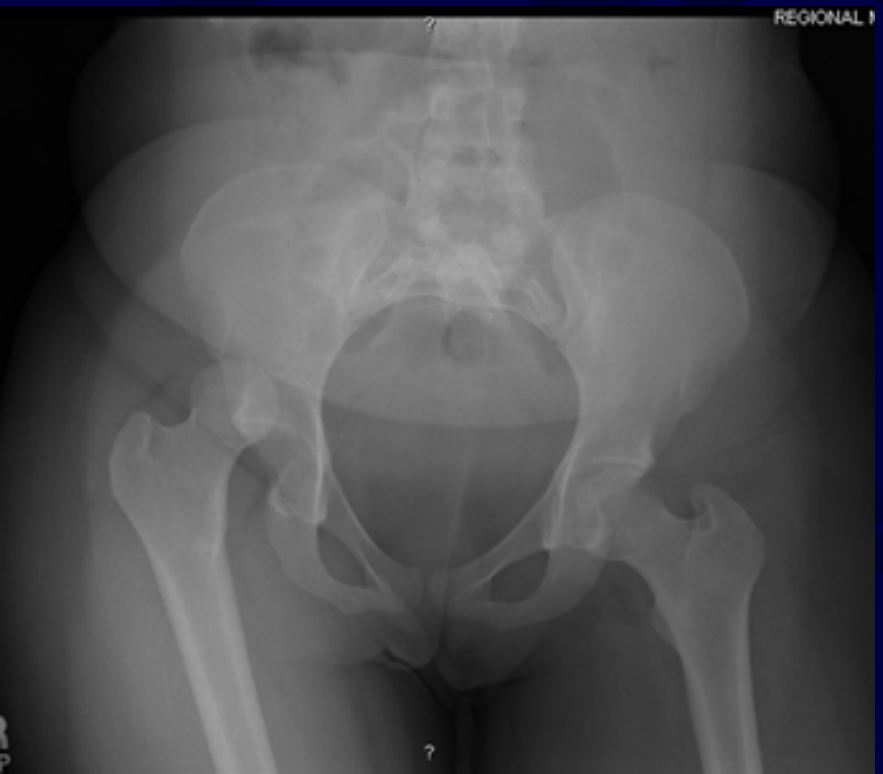

Urgencies and Emergencies

- Fractures or dislocations with associated soft tissue compromise

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- Fractures or dislocations with associated soft tissue compromise
  - Initial treatment:
    - Emergent Reduction

Urgencies and Emergencies

- Open fractures

Urgencies and Emergencies

- Open fractures
  - Initial treatment:
    - Sterile dressing, restore alignment/stabilize limb
    - **Antibiotics**
    - Tetanus
  - Timing of debridement generally has NOT been associated with infection
  - Patients should be taken OR ***as soon as possible*** after life threatening conditions have been treated and stabilized
  - **Early administration of antibiotics→ decreased rates of infection**

Lack WD, Karunakar MA, Angerame MR, et al. Type III open tibia fractures: immediate antibiotic prophylaxis minimizes infection. *J Orthop Trauma.* 2015;29:1-6.
Patzakis MJ, Wilkins J. Factors influencing infection rate in open fracture wounds. *Clin Orthop Relat Res.* 1989;246:36-40.

What are we trying to avoid in care of polytrauma patient?

What are we trying to avoid in care of polytrauma patient?

- MOF
- ARDS

Multiorgan Failure (MOF)

- Multiorgan Dysfunction Syndrome
- Affects multiple organ systems
- Many theories re: etiology
- High incidence of mortality

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- High incidence of mortality
- May be related to **imbalance between proinflammatory and antiinflammatory mediators**

Acute Respiratory Distress Syndrome

- ARDS
- Acute onset
- Bilateral infiltrates on CXR
- PaO2/FiO2 < **200**
- High incidence of mortality

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Physiologic Response to Trauma

- Systemic Inflammatory Response (SIRS)
- Compensatory Anti-inflammatory Response (CARS)

Systemic Inflammatory Response

- “First hit” phenomena
- Proinflammatory cytokine response (IL-6, IL-8, etc.)

Clinical Manifestations of the Systemic Inflammatory Response

- Fever
- Tachycardia
- Hyperventilation
- Leukocytosis

Quantifying the Systemic Inflammatory Response

- SIRS Score
- Four variables, each scored 0 or 1
  - HR > 90
  - WBC <4,000 or >12,000
  - RR > 20 (or PaCO2<33mmHg)
  - Temperature <34 or >38 (100.4 degrees Fahrenheit)
- Total Score= sum of four variables (0 to 4)
- Score > 1 indicative of *Systemic Inflammatory Response Syndrome*

Systemic Inflammatory Response Syndrome (SIRS)

- Predictive of:
  - ARDS
  - DIC
  - ARF
  - Shock

Inflammatory Mediators

- CRP
- Lipopolysaccharide-binding protein
- Procalcitonin
- Tumor necrosis factor
- IL-1, **IL-6**, IL-8, IL-10, IL-18
- Cytokine receptors
- Adhesion molecules
- Elastase
- Human leukocyte antigens
- DNA

Bosse MJ, Kellam JF. Damage Control Orthopaedic Surgery: A Strategy for the Orthopaedic Care of the Critically Injured Patient. In Browner BD, Jupiter JB, Levine AM et al. (Eds.), *Skeletal Trauma*, 4th Edition. 2009.
Pape HC, Giannnoudis PV. Management of the Multiply Injured Patient. In Court-Brown C, Heckman JD, McQueen MM, et al (Eds.), *Rockwood and Green's Fractures in Adults*, 8th Edition. 2015.

IL-6

- Produced by T- and B-cells, and endothelial cells
- Correlates with:
  - soft tissue trauma, chest trauma, ISS, MODS, ARDS, sepsis, and overall outcome

Definition of Damage Control Orthopaedics

- Approach to treating polytrauma patients with the goal of minimizing the impact of the "second hit"

Definition of Damage Control Orthopaedics

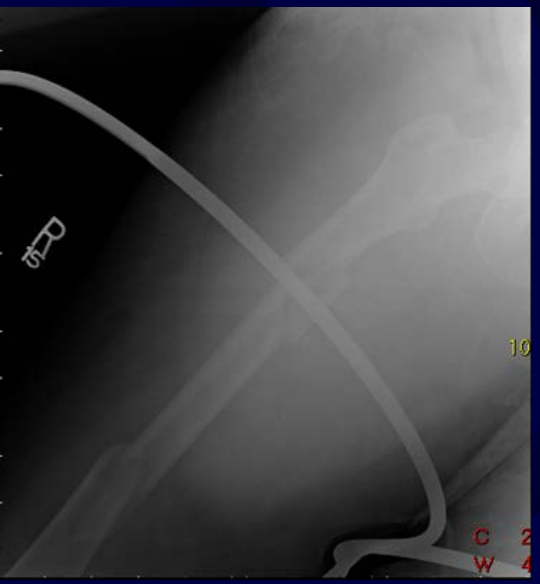
- Initial priorities→
  - Hemorrhage control
  - Soft tissue management
  - Provisional fracture stabilization

Definition of Damage Control Orthopaedics

- Definitive treatment delayed until physiology improved

History of DCO

- Before 1950's, "too sick to operate on"



History of DCO

- Late 1980's, "too sick **not** to operate on"

History of DCO

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→ **Early Total Care (ETC)**

Bone LB, Johnson KD, Weigelt J, et al. Early versus delayed stabilization of femoral fractures. A prospective randomized study. *J Bone Joint Surg Am.* 1989;71:336-340.

History of DCO

- Bone et al JBJS 1989→ ***Early Total Care***
- Prospective randomized study:
  - Femur fractures treated < 24 hours

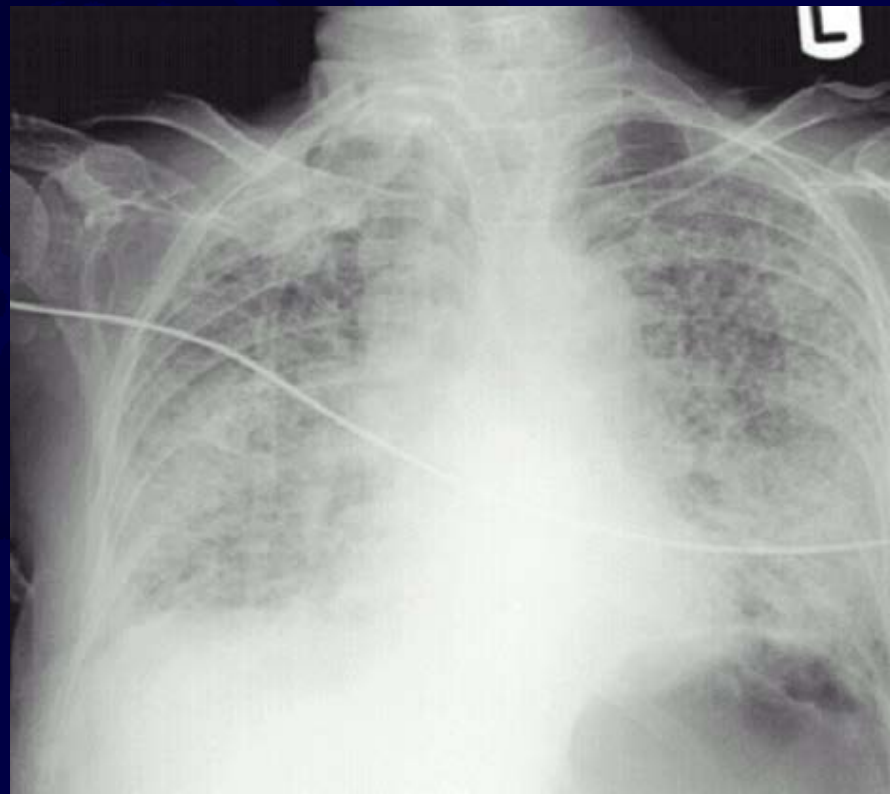
    vs
  - Femur fractures treated > 48 hours

- Early fixation in patients with an ***ISS ≥ 18*** →decreased:
  - Pulmonary complications
  - ICU LOS
  - Hospital LOS

Bone LB, Johnson KD, Weigelt J, et al. Early versus delayed stabilization of femoral fractures. A prospective randomized study. *J Bone Joint Surg Am.* 1989;71:336-340.

History of DCO

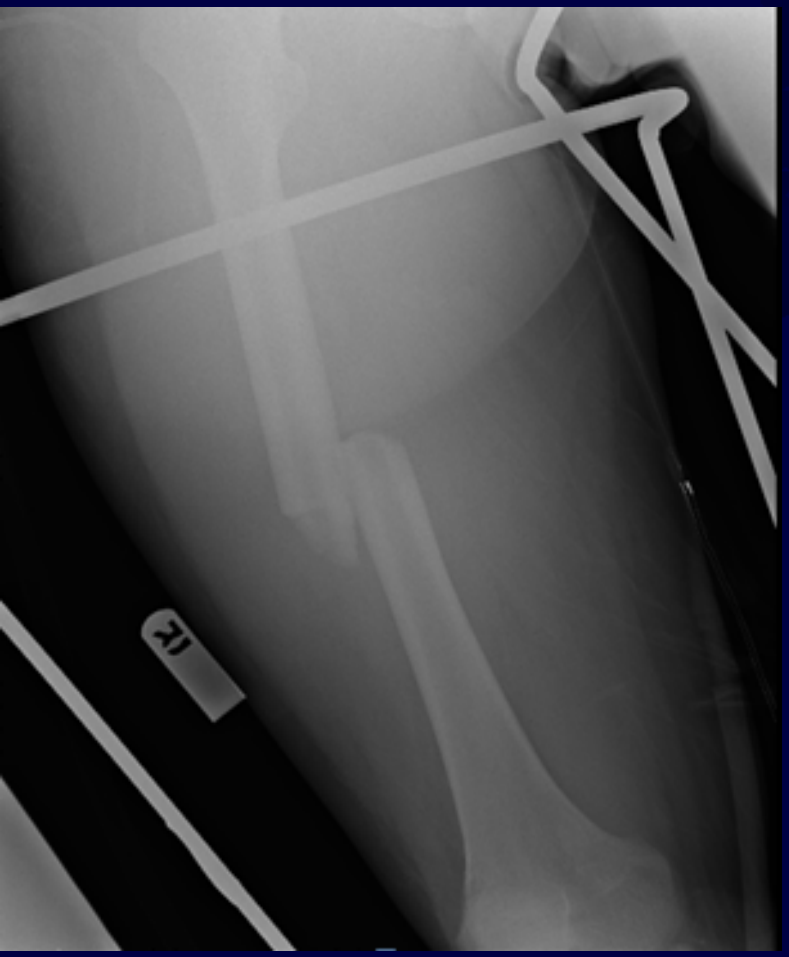
- Early 1990's, complications associated with ETC begin to be described
  - ARDS
  - MOF



History of DCO

- Pape and others have done extensive work in identifying patients in whom ETC **may not** be appropriate leading to an alternative treatment strategy→

"Damage Control Orthopaedics"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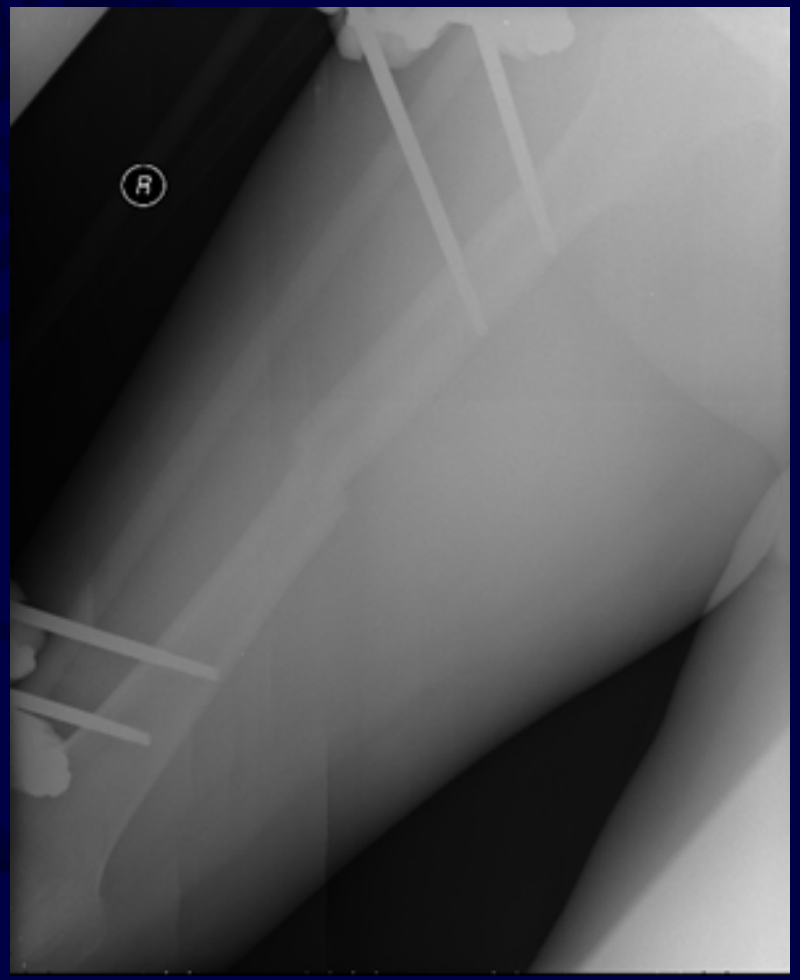
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Certain patients who do not tolerate ETC?

- Retrospective
- Polytrauma patients with femur fracture treated with IMN
- Analyzed patients based upon
  - chest injury (AIS thorax <2 versus AIS thorax ≥2)
  - timing of fixation (<24hrs vs >24hrs)
- **Trend** towards higher ARDS (33% vs 7.7%) in patients with severe chest injury managed acutely with IMN

Pape HC, Aufm'Kolk M, Paffrath T, et al. *J Trauma*. 1993;34:540-547.

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  (did **not** reach statistical significance)

Pape HC, Aufm'Kolk M, Paffrath T, et al. *J Trauma*. 1993;34:540-547.

DCO

- Hannover Data, Pape et al J Trauma 2002
  - Reduction in rates of ARDS and MOF over time with increased usage of DCO

Pape HC, Hildebrand F, Pertschy S, et al. Changes in the management of femoral shaft fractures in polytrauma patients: from early total care to damage control orthopedic surgery. *J Trauma*;200253:452-462.

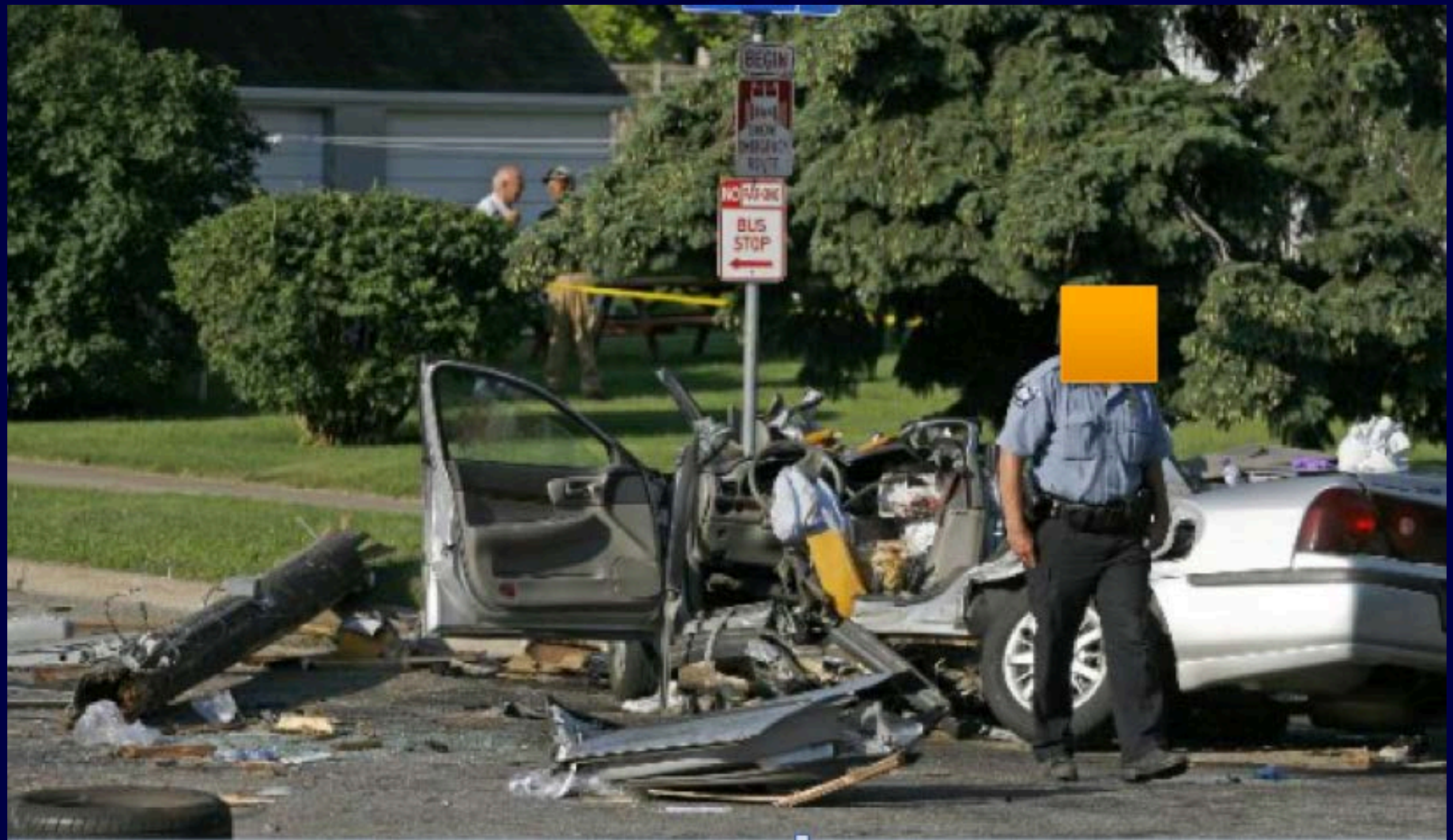
DCO

- Hannover Data, Pape et al J Trauma 2002
  - Reduction in rates of ARDS and MOF over time with increased usage of DCO

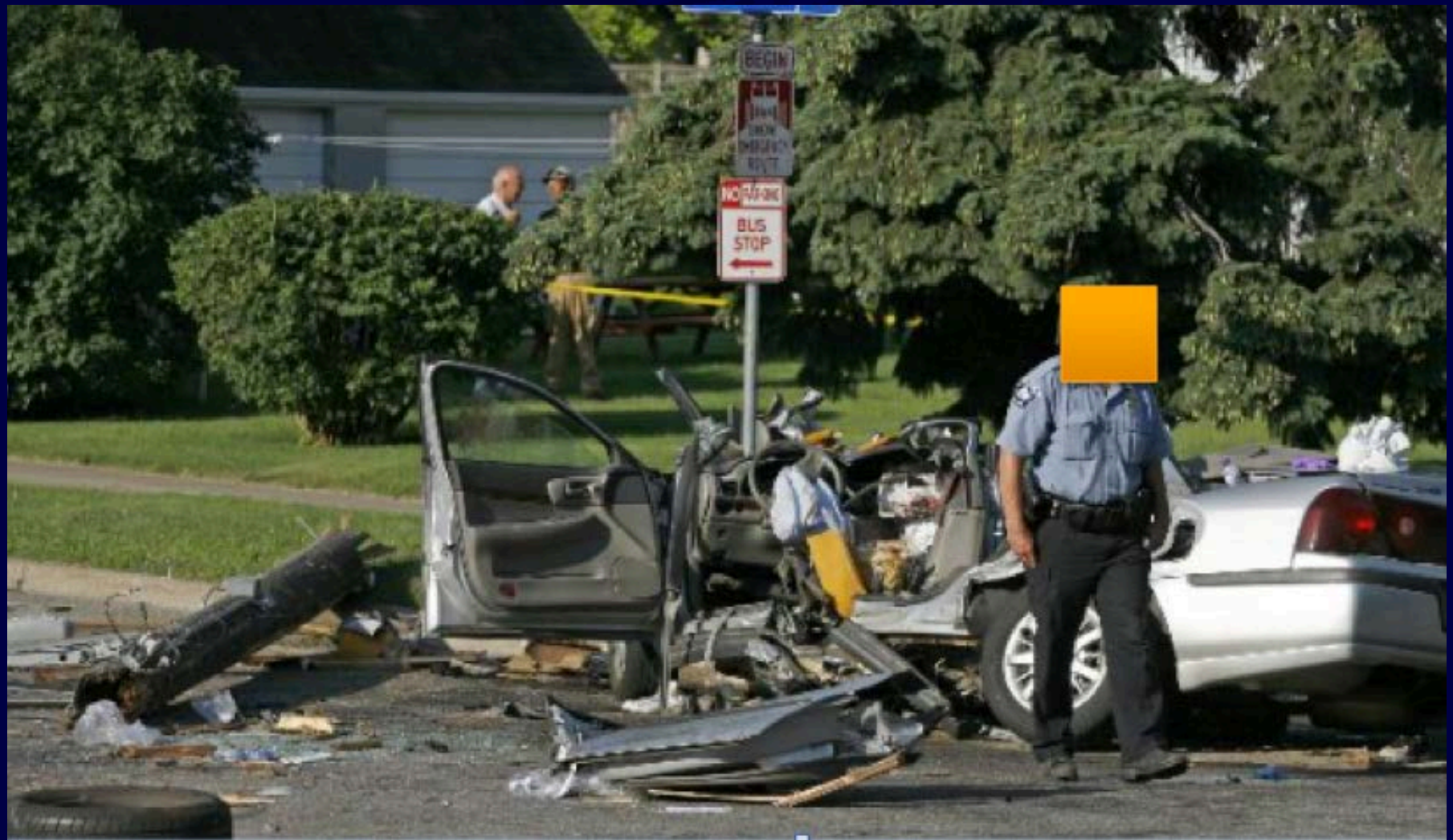
- *"a long bone fracture is classified as an **emergency** that has to be stabilized acutely (at least < 8hrs)"*

Pape HC, Hildebrand F, Pertschy S, et al. Changes in the management of femoral shaft fractures in polytrauma patients: from early total care to damage control orthopedic surgery. *J Trauma*;200253:452-462.

“First Hit”



“First Hit” → Systemic Inflammatory Response



Systemic Inflammatory Response

- ⇧ proinflammatory cytokines → “primed” PMNs
- “primed” PMNs likely involved in secondary tissue injury (secondary lung injury)

“Second Hit”

- Surgery may represent “second hit”
- May exacerbate systemic inflammatory response
- May lead to secondary lung injury

Intramedullary Nailing, not without physiologic effects…

- Blood loss
- Fluid loss
- Fat embolization
- Production cytokines
- Activation coagulation system

“First Hit”

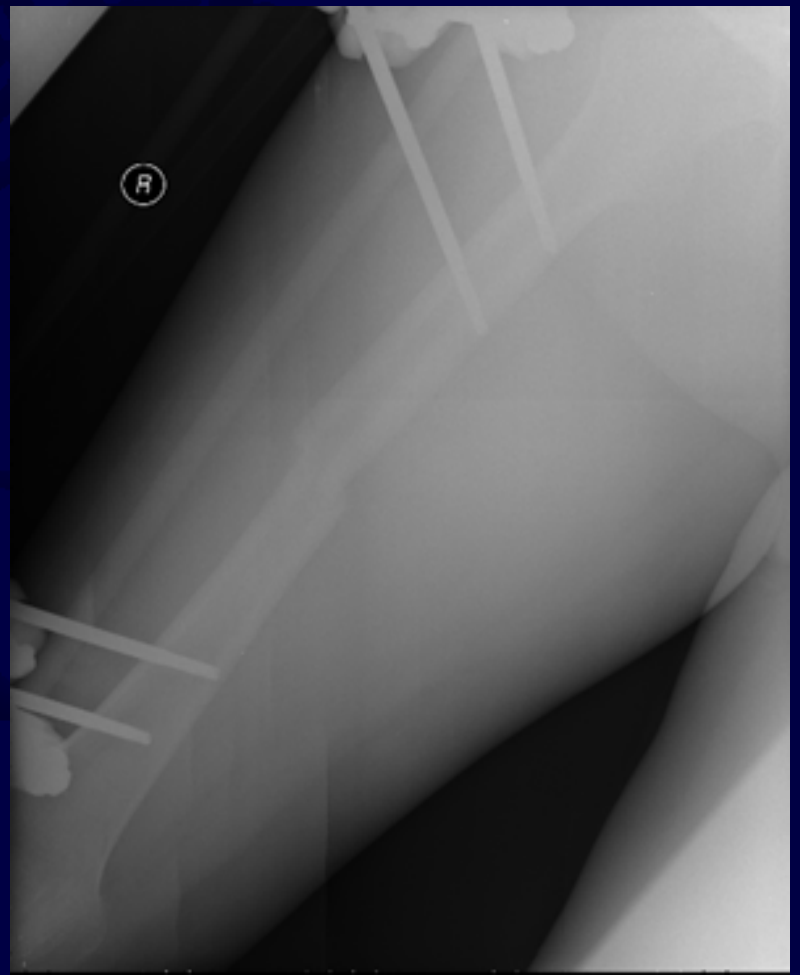
We as surgeons have **no** control…

“Second Hit”

We as surgeons **have** control…

When do we fix the fracture in the polytrauma patient?

ETC vs DCO



Impact of timing of the "second hit"

- An inappropriately timed secondary intervention may result in crossing threshold resulting in ARDS or MOF

The “Second Hit”

- Which patient’s are affected?

Patient risk stratification

- **Stable**
- **Borderline**
- **Unstable**
- **In extremis**

Patient risk stratification

TABLE 9-5 Classification Systems for Clinical Patient Assessment

	Parameter	Stable (Grade I)	Borderline (Grade II)	Unstable (Grade III)	In Extremis (Grade IV)
Shock	Blood pressure (mm Hg)	100 or more	80–100	60–90	<50–60
	Blood units (2 h)	0–2	2–8	5–15	>15
	Lactate levels	Normal range	Around 2.5	>2.5	Severe acidosis
	Base deficit (mmol/L)	Normal range	No data	No data	>6–8
	ATLS classification	I	II–III	III–IV	IV
Coagulation	Platelet count (µg/mL)	>110	90–110	<70–90	<70
	Factor II and V (%)	90–100	70–80	50–70	<50
	Fibrinogen (g/dL)	1	Around 1	<1	DIC
	D-dimer	Normal range	Abnormal	Abnormal	DIC
Temperature		<33°C	33–35°C	30–32°C	30°C or less
Soft Tissue Injuries	Lung function; PaO_2/FiO_2	350–400	300–350	200–300	<200
	Chest trauma scores; AIS	AIS 1 or 2	AIS 2 or more	AIS 2 or more	AIS 3 or more
	Chest trauma score; TTS	0	I–II	II–III	IV
	Abdominal trauma (Moore)	< or = II	< or = III	III	III or > III
	Pelvic trauma (AO class.)	A type (AO)	B or C	C	C (crush, rollover abd.)
	Extremities	AIS I–II	AIS II–III	AIS III–IV	Crush, rollover extrem.

Pape HC, Giannnoudis PV. Management of the Multiply Injured Patient. In Court-Brown C, Heckman JD, McQueen MM, et al (Eds.), *Rockwood and Green's Fractures in Adults*, 8th Edition. 2015.

Patient risk stratification

- Some controversy exists re: acute treatment of “borderline” patients

TABLE 9-5 Classification Systems for Clinical Patie

	Parameter	Stable (Grade	Borderline (Grade II)	Unstable (Grade III)	In Extremis (Grade IV)
Shock	Blood pressure (mm Hg)	100 or more	80–100	60–90	<50–60
	Blood units (2 h)	0–2	2–8	5–15	>15
	Lactate levels	Normal range	Around 2.5	>2.5	Severe acidosis
	Base deficit (mmol/L)	Normal range	No data	No data	>6–8
	ATLS classification	I	II–III	III–IV	IV
Coagulation	Platelet count (µg/mL)	>110	90–110	<70–90	<70
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Pape HC, Giannnoudis PV. Management of the Multiply Injured Patient. In Court-Brown C, Heckman JD, McQueen MM, et al (Eds.), *Rockwood and Green’s Fractures in Adults*, 8th Edition. 2015.

Potential issues with overutilization of DCO

- Unnecessary delay in definitive treatment
- Longer ICU stays
- Longer time on ventilator
- Longer hospital stays
- Increased cost

Borderline Patients

- ISS>20 + thoracic injury
- Shock (SBP <90)
- ISS>40
- Bilateral pulmonary contusion
- Elevated pulmonary arterial pressure >24mmHg
- Pulmonary arterial pressure increase of 6mmHg during procedure
- Hypothermia
- ?Severe abdominal injury
  (AIS abdomen ≥ 3)
- ?Bilateral femur fractures
- ?Head injured patient

Borderline Patients

- ISS>20 + thoracic injury
- Shock (SBP <90)
- ISS>40
- Bilateral pulmonary contusion
- Elevated pulmonary arterial pressure >24mmHg
- Pulmonary arterial pressure increase of 6mmHg during procedure
- Hypothermia
- ?Severe abdominal injury (AIS abdomen ≥ 3)
- ?Bilateral femur fractures
- ?Head injured patient

Borderline Patients

- Severe abdominal injury (AIS abdomen ≥ 3)

  Retrospective review of 3069 polytrauma patients treated for femur fracture with internal fixation

  ~50% relative risk reduction in mortality in patients treated after 12 hours

Morshed S, Miclau T, Bembom O, et al. *J Bone Joint Surg Am.* 2009;91:3-13.

Borderline Patients

- Severe abdominal injury (AIS abdomen ≥ 3)

  Retrospective review of 3069 polytrauma patients treated for femur fracture with internal fixation

Patients with significant abdominal injury benefitted most from delay

Morshed S, Miclau T, Bembom O, et al. *J Bone Joint Surg Am.* 2009;91:3-13.

Level I Data?

- RCT comparing IMN vs DCO in stable and borderline patients

Pape HC, Rixen D, Husebye EE, et al. *Ann Surg*. 2007;246:491-499.

Level I Data?

- RCT comparing IMN vs DCO in stable and borderline patients

Exclusion criteria included: AIS thorax >2; Body weight > 250 lbs.

Pape HC, Rixen D, Husebye EE, et al. *Ann Surg*. 2007;246:491-499.

Level I Data?

- Stable Patients
- →acute IMN associated with decreased ventilator time

Pape HC, Rixen D, Husebye EE, et al. *Ann Surg*. 2007;246:491-499.

Level I Data?

- Borderline Patients
- →acute IMN associated with increased *acute lung injury (ALI)*
  - 6.69x greater chance of developing ALI, s/p acute IMN

Pape HC, Rixen D, Husebye EE, et al. *Ann Surg*. 2007;246:491-499.

Level I Data?

- Borderline Patients
- →acute IMN associated with increased *acute lung injury (ALI)*
  - 6.69x greater chance of developing ALI, s/p acute IMN (CI = 1.01-44.08)

Level I Data?

- Definition of ALI?
  - Bilateral pulmonary infiltrates
  - Pulmonary capillary wedge pressure <18
  - PaO2/FiO2 < 300

Level I Data?

- Definition of ALI?
  - Bilateral pulmonary infiltrates
  - Pulmonary capillary wedge pressure <18
  - PaO2/FiO2 < 300
  - Clinical Significance?

Morbid Obesity:  Systemic Complications with IMN

- Morbidly obese polytrauma patients with femur fracture found to have higher rates of ARDS and death

Weinlein JC, Deaderick S, Murphy, R. Morbid obesity increases risk for systemic complications in patients with femur fractures. *J Orthop Trauma*. 2015;29:91-95.

ETC/DCO data may not be applicable to obese or morbidly obese

Unreamed IMN less of a “second hit?”

Reamed vs Unreamed IMN

- RCT
- 322 femur fractures
- IMN within 24 hours

Canadian Orthopaedic Trauma Society. Reamed versus unreamed intramedullary nailing of the femur: comparison of the rate of ARDS in multiple injured patients. *J Trauma.* 2006;20:384-387.

Reamed vs Unreamed IMN

- Reamed IMN→ 3/63 ARDS
- Unreamed IMN→ 2/46 ARDS
- 2 deaths in each group
- No statistically significant difference
- 39,817 patients would be needed to appropriately power study

Canadian Orthopaedic Trauma Society. Reamed versus unreamed intramedullary nailing of the femur: comparison of the rate of ARDS in multiple injured patients. *J Trauma*. 2006;20:384-387.

Evaluating Response to Resuscitation

- Patients with Class 1 or 2 hemorrhage may present occultly secondary to compensatory mechanisms
- Vitals signs **not** sensitive indicators of shock or resuscitation
- pH, base deficit, lactate, serum bicarbonate helpful in monitoring resuscitation

Evaluating Response to Resuscitation

- *Compensated Shock*→
  - Brain and heart perfused at expense of other organs
  - Occult hypoperfusion exists

Occult Hypoperfusion

- Patients with an ISS ≥ 18 and a femur fracture stabilized (reamed IMN) within 24 hours of admission

- No patients had any clinical signs of shock:
  - Normotensive
  - Not Tachycardic
  - Adequate urine output

Crowl AC, Young JS, Kahler DM, et al. Occult hypoperfusion is associated with increased morbidity in patients undergoing early femur fracture fixation. *J Trauma*. 2000;48:260-267.

Occult Hypoperfusion

- Retrospectively divided into 2 groups based on lactate levels (normal and abnormal)
- The group with a lactate of > 2.5 had higher pulmonary and infectious complication rates

Crowl AC, Young JS, Kahler DM, et al. Occult hypoperfusion is associated with increased morbidity in patients undergoing early femur fracture fixation. *J Trauma.* 2000;48:260-267.

Occult Hypoperfusion

- Retrospective study
- N=72
- Femur fracture with ISS ≥ 15
- Serum bicarbonate (SB) values analyzed based on quoted thresholds of metabolic acidosis:
  - BD of 6mmol/L→ 24.7mequiv/L
  - BD of 5mmol/L→ 26.4 mequiv/L

Morshed A, Corrales LA, Lin K, et al. Femoral nailing during serum bicarbonate-defined hypo-perfusion predicts pulmonary organ dysfunction in multi-system trauma patients. *Injury*. 2011;42:643-649.

Occult Hypoperfusion

- SB<24.7 within 6 hours of surgery → **12.2X** odds of developing POD (pulmonary organ dysfunction)
- SB<26.4 within 6 hours of surgery → **10.9X** odds of developing POD

Morshed A, Corrales LA, Lin K, et al. Femoral nailing during serum bicarbonate-defined hypo-perfusion predicts pulmonary organ dysfunction in multi-system trauma patients. *Injury*. 2011;42:643-649.

Occult Hypoperfusion

- “appropriate damage-control measures and aggressive resuscitation prior to definitive fracture care are advised…”

Morshed A, Corrales LA, Lin K, et al. Femoral nailing during serum bicarbonate-defined hypo-perfusion predicts pulmonary organ dysfunction in multi-system trauma patients. *Injury*. 2011;42:643-649.

Resuscitation and *Early Appropriate Care*

- pH, base excess, lactate utilized to determine when patient's physiology appropriate for definitive care
- pH ≥7.25
- Base excess ≥-5.5
- Lactate <4.0
- Definitive care would proceed when any one of three criteria has been achieved

Vallier HA, Wang X, Moore TA et al. Timing of orthopaedic surgery in multiple trauma patients: development of a protocol for early appropriate care. *J Orthop Trauma*. 2013; 27:543-551.
Nahm NJ, Moore TA, Vallier HA. Use of two grading systems in determining risks associated with timing of fracture fixation. *J Trauma Acute Care Surg*. 2014; 77:268-279.

Resuscitation and *Early Appropriate Care*

- Includes femur fractures and also other axially unstable injuries (fractures of pelvis, acetabulum, spine)
- Patients treated with EAC within 36 hours:
  - 1.5% ARDS
  - 0.37% MOF
  - 1.5% Mortality
  - Shorter ICU and total LOS, ventilation time

Vallier HA, Moore TA, et al. Complications are reduced with a protocol to standardize timing of fixation based on response to resuscitation. *J Orthop Surg Res*. 2015;10:155.

Resuscitation and “normalizing lactate”

- Retrospective review of protocol for treatment of femur fractures in polytrauma patients
- N=229; ISS≥17
- 88% patients treated with reamed IM nailing and 12% treated with DCO (External fixation)
- “Normalizing lactate” →parameter used to demonstrate adequate resuscitation
- Mean time btwn admission and IM nailing: ~14hours

O’Toole RV, O’Brien M, Scalea T, et al. Resuscitation before stabilization of femoral fractures limits acute respiratory distress syndrome in patients with multiple traumatic injuries despite low use of damage control orthopedics. *J Trauma.* 2009;67:1013-1021.

Resuscitation and “normalizing lactate”

- Results:
  - ARDS (overall): 1.5%
  - ARDS (pulmonary injured patients): 2.0%
  - ARDS (pulm. injured patients with ISS>28): 3.3%

O’Toole RV, O’Brien M, Scalea T, et al. Resuscitation before stabilization of femoral fractures limits acute respiratory distress syndrome in patients with multiple traumatic injuries despite low use of damage control orthopedics. *J Trauma.* 2009;67:1013-1021.

Resuscitation and “normalizing lactate”

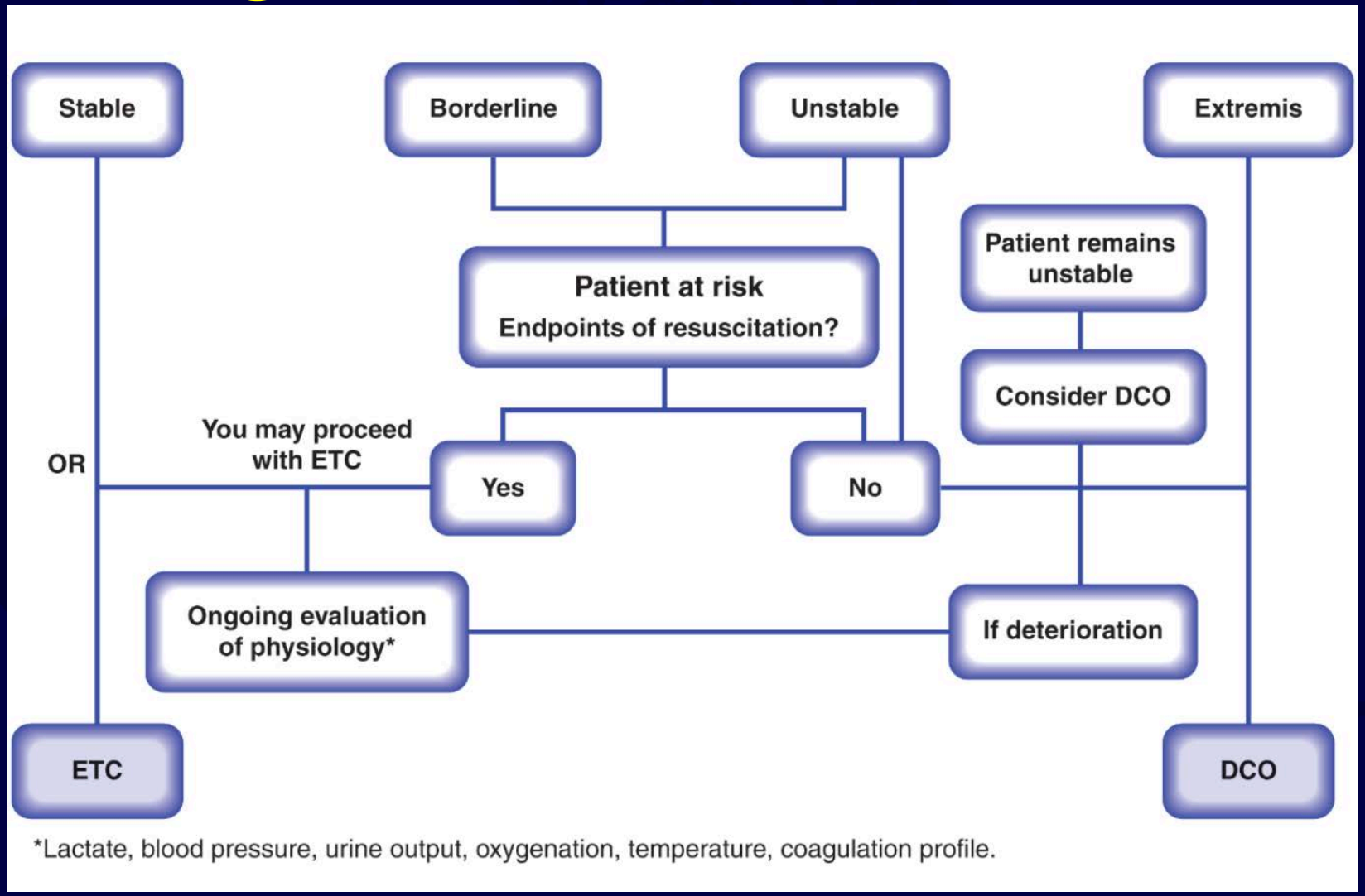
- Simple measures of resuscitation reasonable indicators as to when a patient can physiologically tolerate intramedullary nailing

O’Toole RV, O’Brien M, Scalea T, et al. Resuscitation before stabilization of femoral fractures limits acute respiratory distress syndrome in patients with multiple traumatic injuries despite low use of damage control orthopedics. *J Trauma*. 2009;67:1013-1021.

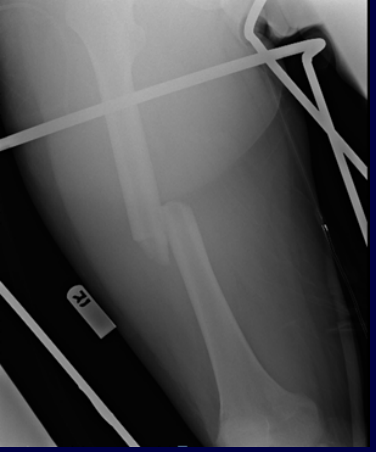
“Resuscitated”

- Stable hemodynamics
- No hypoxemia
- Lactate
  - < **2.5** mmol/L (Crowl et al)
  - < **4.0** mmol/L (Vallier et al)
  - “normalizing,” or trending toward 2.5 mmol/L (O’Toole)
- Base Deficit
  - <5.5 (Vallier et al), <5, <6
- Serum Bicarbonate
  - SB>24.7; SB>26.4 (Morshed et al)
- pH > 7.25 (Vallier et al)
- Normal coags
- Normothermia
- Normal U/O (>1cc/kg/hr)

Algorithm for ETC vs DCO



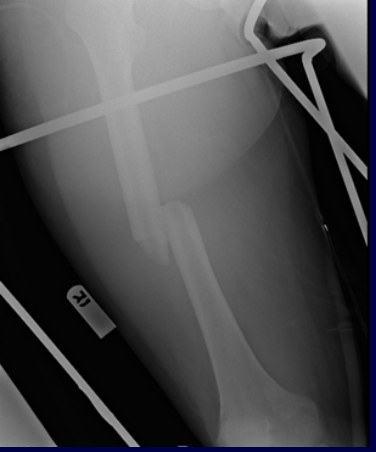
Pape HC, Giannnoudis PV. Management of the Multiply Injured Patient. In Court-Brown C, Heckman JD, McQueen MM, et al (Eds.), *Rockwood and Green's Fractures in Adults*, 8th Edition. 2015.



Modes of DCO

- Retrospective review of protocol for treatment of polytrauma patients with sub analysis of patients undergoing DCO
- Overall rate of ARDS: 4.4%
- 39% of patients underwent DCO
- 60 patients→ skeletal traction
- 19 patients→ external fixation

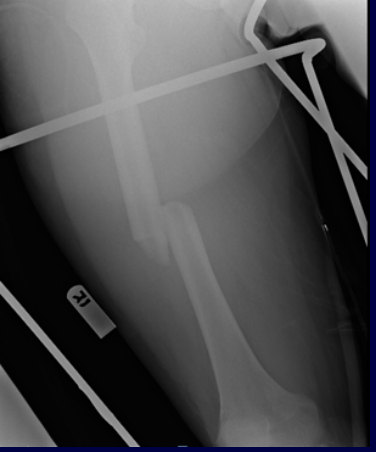
Scannell BP, Waldrop NE, Sasser HC, et al. Skeletal traction versus external fixation in the initial temporization of femoral shaft fractures in severely injured patients. *J Trauma*. 2010;68:633-640.



Modes of DCO

- Results:
  - No significant differences between external fixation and skeletal traction in rates of:
    - ARDS
    - MOF
    - Pneumonia

Scannell BP, Waldrop NE, Sasser HC, et al. Skeletal traction versus external fixation in the initial temporization of femoral shaft fractures in severely injured patients. *J Trauma.* 2010;68:633-640.

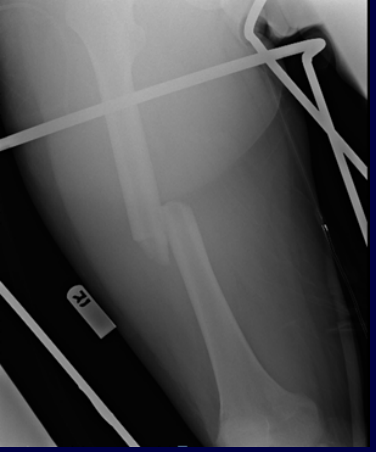


Modes of DCO

Authors' Conclusion:

- Unless patient is already in operating room, no significant advantage to external fixation vs skeletal traction

Scannell BP, Waldrop NE, Sasser HC, et al. Skeletal traction versus external fixation in the initial temporization of femoral shaft fractures in severely injured patients. *J Trauma*. 2010;68:633-640.

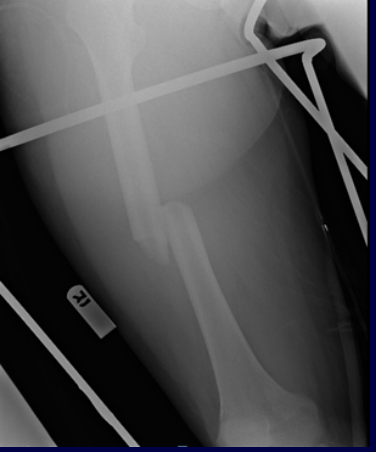


Modes of DCO

Problems with study:

- Small number of patients, particularly in external fixation group, raising possibility of Type II error

Scannell BP, Waldrop NE, Sasser HC, et al. Skeletal traction versus external fixation in the initial temporization of femoral shaft fractures in severely injured patients. *J Trauma*. 2010;68:633-640.



Modes of DCO

Theoretical concerns with traction:

- Difficulty with pulmonary toilet?
- Increased narcotic requirements secondary to increased pain with increased fracture instability?
- Increased risk of FES?

Timing of definitive treatment in DCO

- Polytrauma patients managed with initial DCO followed by later definitive fixation
- Patients who underwent conversion between 2 and 4 days were compared to those who underwent conversion between 5 and 8 days
- MODS 46% in early group versus 16% in late group

Pape HC, van Griensven M, Rice J, et al. Major secondary surgery in blunt trauma patients and perioperative cytokine liberation: determination of the clinical relevance of biochemical markers. *J Trauma*. 2001;50:989-1000.

Timing of definitive treatment in DCO

- Femoral shaft fractures and ISS >20
- Retrospective review
- Initial ex-fix vs early IMN
- 174 patients
- Ex fix group more severely injured
- SIRS score, modified Marshall multi-organ dysfunction score

Harwood JH, Giannoudis PV, van Griensven M, et al. Alterations in the systemic inflammatory response after early total care and damage control procedures for femoral shaft fracture in severely injured patients. *J Trauma.* 2005;58:446-454.

Timing of definitive treatment in DCO

- DCO patients converted from external fixator while SIRS score still elevated→ most pronounced post op inflammatory response and organ failure rate

Harwood JH, Giannoudis PV, van Griensven M, et al. Alterations in the systemic inflammatory response after early total care and damage control procedures for femoral shaft fracture in severely injured patients. *J Trauma*. 2005;58:446-454.

Timing of definitive treatment in DCO

- An Interpretation of Pape's Work→

  Majority of patients treated with DCO should probably wait until at least **post injury day 5** before definitive treatment

Timing of definitive treatment in DCO

- An Interpretation of Pape's Work→

  Majority of patients treated with DCO should probably wait until at least **post injury day 5** before definitive treatment

?

Timing of definitive treatment in DCO

- Utilization of the **SIRS Score** and possible serum measures of **proinflammatory markers may** allow more accurate assessment of patients (those that can be treated earlier with definitive surgery)

Summary

- Evaluation of polytrauma patient guided by algorithmic principles of ATLS.
- Identifying and treating orthopaedic urgencies and emergencies in the initial evaluation is critical in minimizing morbidity and mortality.
- Knowledge of certain scoring systems is necessary in managing polytrauma patients.

Summary

- Identifying patients with occult hypoperfusion is necessary to minimize morbidity and mortality.
- Knowledge of *Damage Control Orthopaedics* and when to implement methods of DCO is critical.

Summary

- Overwhelming majority of polytrauma patients with femur fractures **should** be treated and **benefit** from being treated within the first 24-36 hours.
- Further research will help clarify which patients can and can not tolerate acute intramedullary nailing and which patients should be treated with DCO.

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Thank you