BOOM!!!!
Orthopaedic Trauma

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Orthopaedic Trauma Surgery
Resurgens Orthopaedics
Atlanta, Georgia

Conflict

• Consultant for Synthes Orthopaedics.
• Board of Directors of the OTA, GOS, ABOS and Resurgens Orthopaedics.
• AAOS Communications Cabinet Liaison to the Council on Advocacy.
Outcomes

• Comparative study concerning outcomes after “major fracture”.
• Surgeons more satisfied with outcomes than the patients were.

SF-36

• Multi-purpose, short health survey.
• 36 questions.
• Made available in standard form in 1990.
• Cited in 4000 publications.

• Scales:
  - Physical Functioning
  - Role-Physical
  - Bodily Pain
  - General Health
  - Vitality
  - Social Functioning
  - Role-Emotional
  - Mental Health
Trauma patients with fractures

- SF-36 scores:
  - Bodily pain, Physical function, Role-physical, Mental health, Role-emotional, Social function (p < 0.05).
- “Patients with orthopaedic injuries have relatively worse functional recovery than trauma patients without orthopaedic injuries, and this worsens with time”.

Psychological effects

- “Psychological distress is strongly associated with patient outcome--including functional outcome--following trauma.”
- “Psychological distress after trauma, with its large impact on trauma outcomes, remains a substantial problem that is usually ignored and untreated.”
The Big Bad Five...

- Tibial plafond
- Talar neck
- Calcaneus
- Unstable pelvis
- Femoral neck in young people

High mechanism injuries

- Falls
- MVC
Tibial Plafond Fractures

• Plafond = “roof”.
• Difficult surgery.
• Prolonged recovery.
• Nonunion and pain is common.
• Takes up to two years to see what the outcome will be.

Tibial plafond outcomes

• “Tibial plafond fractures are difficult to manage and may have serious complications”.
• “Loss of function and progression to post-traumatic arthritis are common after tibial plafond fractures”.
  - Harris AM, Patterson BM, Sontich JK, Vallier HA. Results and outcomes after operative treatment of high-energy tibial plafond fractures. Foot Ankle Int. 2006 Apr;27(4): 256-265.
Talar neck fractures

- Difficult surgery.
- Prolonged healing.
- Nonunion and avascular necrosis is a huge problem.
- May need pantalar fusion in the future.

Talar fracture outcome

- Osteonecrosis 49%:
  - Collapse of the dome in 31%.
  - 54% had posttraumatic arthritis
    - comminuted fractures ($p < 0.07$)
    - open fractures ($p = 0.09$).
- Fractures of the talar neck are associated with high rates of morbidity and complications.
Calcaneal fractures

• People who fall:
  – Roofers
  – Dry wallers
  – Framers
  – Painters

Calcaneal fractures

• Most painful fracture that there is!
• Pain and difficulty walking on uneven ground.
• Wound issues after surgery.
• May need a subtalar fusion.
Cost of injury

• “Calcaneal fractures have been recognized as having relatively poor clinical outcomes and a major socioeconomic impact with regard to time lost from work and recreation”.
  

Wound Complications

• Smoking, diabetes, and open fractures all increase the risk of wound complication after surgical stabilization of calcaneus fractures.
  
Fracture Blisters

- "All blisters were unroofed, and antibiotic cream (Silvadene) was applied twice daily until the blister bed had re-epithelialized.
- "We urge caution when planning to make a surgical incision around … fracture blisters in diabetic patients because the zone of injury might extend beyond the borders of the fracture blister."


Open Tibial Fractures
Definitions

- **Fracture**: a *soft tissue* injury overlying a broken bone.
- “Soft tissue trauma is the more important injury”.
- **Open fracture**: any fracture associated with a laceration or puncture wound on the same limb segment.

Gustilo and Anderson Classification

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Infection</th>
<th>Antibiotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Clean, &lt;1 cm</td>
<td>0% to 2%</td>
<td>Ancef</td>
</tr>
<tr>
<td>II</td>
<td>&gt;1 cm, minimal soft tissue injury</td>
<td>2% to 7%</td>
<td>Ancef and Gentamycin</td>
</tr>
<tr>
<td>III</td>
<td>Extensive injury, segmental fx, GSW, farm injury, etc.</td>
<td>10% to 25%</td>
<td>Above + PCN</td>
</tr>
</tbody>
</table>

### Gustilo Classification

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIIA</td>
<td>Adequate soft tissue coverage</td>
<td>4% - 7%</td>
</tr>
<tr>
<td>IIIB</td>
<td>Inadequate soft tissue coverage, periosteal stripping</td>
<td>10% - 50%</td>
</tr>
<tr>
<td>IIIC</td>
<td>Arterial injury requiring repair</td>
<td>25% - 50%</td>
</tr>
</tbody>
</table>


### Type I
Definitely IIIC

Type II or IIIA?
Type II or IIIA?

Antibiotics

- A prospective double-blind randomized clinical trial comparing ciprofloxacin and cefamandole/gentamicin.
  - No difference in Type I or II open fracture wounds.
  - High failure rate for the ciprofloxacin Type III open fracture group, with patients being 5.33 times more likely to become infected than those in the combination therapy group.
- Single-agent antibiotic therapy with ciprofloxacin is effective in treatment of Type I and Type II open fracture wounds.
  
LEAP Study

- 527 patients in this multi-centered study.
- Bone loss was least significant variable determining limb salvage.
- Soft tissue injury severity has the greatest impact on decision making regarding limb salvage versus amputation.

LEAP at seven years

• 397 - amputation or reconstruction.
• “Physical and psychosocial functioning deteriorated between 24 to 84 months after the injury”.

• Poor outcome:
  – older age
  – female gender
  – lower education level
  – living in a poor household
  – current or previous smoking
  – low self-efficacy
  – poor self-reported health status before the injury
  – involvement with the legal system in an effort to obtain disability payments.

LEAP at seven years

• “… reconstruction for the treatment of injuries below the distal part of the femur typically results in functional outcomes equivalent to those of amputation.”
• Regardless of the treatment option, however, long-term functional outcomes are poor.
Poor outcomes in severe trauma

- “LEAP showed that at two years, most patients had poor outcomes, with only half of the patients returning to work.”
- “By seven years, half of the patients continued to report appreciable disability.”
- “…more than half of the patients who were managed with the current standard of care had treatment failure.”


The joys of call

- “Hey doc, sorry to call you at 2:30 AM. I have a really bad open xxx fracture here in the ER”
- xxx =
  - Tibial
  - Femoral
  - Pelvic
So what is acceptable?

- Is it standard of care to operate this fracture at 2:30 AM or should (can) I wait until morning?

Timing of debridement

- LEAP found that time from injury to surgical debridement was not contributory factor of infection.
- Timing from injury to the definitive treatment center was indicative of infection.
Timing of debridement

• Findings “should not be interpreted as an argument that operative debridement of open fractures should not be accomplished urgently”.

Ex-fix vs. nail?

• External fixator had more surgical procedures, took longer to achieve full weight-bearing status, and had more readmissions than did those treated with an intramedullary nail.
Smoking

• Patients with unilateral open tibia fractures were divided into 3 baseline smoking categories: never smoked, previous smoker and current smoker.
• Smokers 37% less likely to heal.
• Previous smokers were 32% less likely to heal.


Smoking

• Current smokers twice as likely to develop an infection (P = 0.05) and 3.7 times as likely to develop osteomyelitis (P = 0.01).
• Smoking places the patient at risk for increased time to union and complications. Previous smoking history also appears to increase the risk of osteomyelitis and increased time to union.

Return to work

• 37 type III high-energy open tibial shaft fractures.
• (76%) returned to work.
  – 64% returned to work at a similar level of manual labor.
  – Average delay between injury and return to work was 11 months (range, 3-18 months).
  – 89% reported one or more subjective complaints.


There are no emergencies in orthopaedic trauma

• Femoral neck fractures
• Talar neck fractures
• Open fractures
• Open book pelvic fractures
• Unreduced dislocations
• Compartment syndrome
Rule #1 - Timing is everything

- Compartment syndrome (CS) is an emergency/urgency to save limb and possibly life.

#2 - Compartment syndrome is rare

- Incidence is 3.1/100,000 persons
  - Incidence for men: 7.3 per 100,000.
  - Incidence for women: 0.7 per 100,000.
Incidence

• 1.5%

• 7%

• 14.5%

• 29%

Causes

• Increase the contents of the compartment.
• Decrease the fascial volume of the compartment.
• Metabolic insults that disrupt the microvasculature.
#3 - Young people get CS more often

- Is a patient younger than 35 with a tibial fracture more likely to have a CS than a patient over 35 years of age?
- 3 times!

#4 - He can’t have a CS – he can still move his toes!

- The six dreaded “P’s”:
  - Paralysis
  - Pallor
  - Pulselessness
  - Pressure
  - Paresthesia
  - Pain out of proportion

- What exactly is pain out of proportion?
Pain out of proportion

- Pain is highly subjective.
- To know what pain is proportional, one would have to know how much pain a certain injury produces.
- As a CS progresses, pain may actually decrease masking the CS.

#5 – Pressure measurements are the best way to diagnose CS

- Whitesides’ method.
- STIC monitors.
- Arterial pressure monitor.

- Accurately measures pressure in the compartment.
Continuous monitoring

- One group with continuous monitoring compared with control clinical group.
- In monitored group, 18% had $\Delta p < 30$ mm Hg, but none developed compartment syndrome.
- Overall compartment syndrome incidence was 2.5%.
- Continuous monitoring is not indicated in alert patients.

Traumatic measurements

- 84% had at least one measurement within 30 mm $\Delta p$, and 58% had at least one measurement within 20 mm $\Delta p$.
- None of the patients ever manifested a compartment syndrome.
- Quantitative measurements may not accurately diagnose compartment syndrome.
Pressure measurements are the best way to diagnose CS

Clinical exam is key!

• “Clinical assessment is still the diagnostic cornerstone of ACS (acute compartment syndrome).”

Meta-analysis

• “The positive predictive value of the clinical findings was 11% to 15%, and the specificity and negative predictive value were each 97% to 98%.”
• “The clinical features of compartment syndrome are more useful by their absence in excluding the diagnosis than they are when present in confirming the diagnosis.”
What about the asensate or head injured patients?

• Close monitoring of clinical exam:
  – Firmness
  – High clinical suspicion
  – Pulses

• Release the compartments if in doubt.

#6 - To calculate Δp, use the intra-operative DBP

• Mean DBP in surgery was 18mm Hg less than pre-operative DBP.

• Intra-operative DBP may be spuriously low when for deciding to do a fasciotomy.
#7 - Open fractures can’t have compartment syndrome

- The tears in the fascia release the compartment pressure…

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CS in open fractures

- The incidence of compartment syndrome was found to be directly proportional to the degree of injury to soft tissue and bone; this complication occurred most often in association with a comminuted, type-III open injury to a pedestrian.

#8 - I can tell by the firmness…

- Well… orthopaedic residents can’t!
- Positive predictive value was 70%
- Negative predictive value was 63%.


One incision or two?
Single incision fasciotomy

• Centered over fibula.
• Superficial dissection can access anterior, lateral and superficial posterior compartments.
• Dissect posterior to fibula and release deep

Post-fasciotomy care

• NPWT for several days to a week.
• Often dictated by fracture care.
• Often require STSG.
#9 - I missed it – I’m in trouble!

**Liability**

- Increasing time from the onset of symptoms to the fasciotomy was associated with an increased indemnity payment ($p < 0.05$).
- A fasciotomy performed within eight hours after the first presentation of symptoms was uniformly associated with a successful defense.

Timing of Surgery…

- Study comparing the time of day or night when nailing femoral or tibial fractures.
- Need for revision surgery:
  - 27% from nighttime surgery.
  - 3% from daytime surgery.

Complications
So what is acceptable?

- Is it standard of care to operate this fracture at 2:30 AM or should (can) I wait until morning?
- All depends…

But sometimes you HAVE to operate…
23 yo ♂ in MVC

CHI, liver/splenic lacs, PTX, bilateral femur fx, open book pelvic fx
Damage Control Orthopaedics

![Image of a surgical procedure]

Damage Control Orthopaedics

![Image of X-rays showing bone fragments and implants]

Damage Control Orthopaedics
Ten days later…

**Damage Control Surgery**

- Initially developed as a strategy for exsanguinating patients with severe visceral injuries.
- First stage: rapid surgery to control hemorrhage and contamination.
**Damage Control Surgery**

- Second stage: further resuscitation, rewarming and correction of coagulopathy.
- Final stage: surgical re-exploration and definitive repair.

**History**

- Era of secondary fracture stabilization
- Era of early definitive fracture treatment
- Borderline era
- Era of damage-control orthopaedics
History

• Era of secondary fracture stabilization
  – Multiply-injured patients are too unstable to undergo surgical stabilization of their injuries.
  – Complex lab tests are unavailable and patient status is determined by clinical assessment.
  – The big problem is “fat emboli syndrome”.
  – Patients are treated in traction until they are stable enough (if ever) for definitive fixation.

History

• Changing thought:
  – Surgeons started stabilizing orthopaedic injuries in multiply injured patients.
  – “Early mobilization is essential for patients with multiple long bone fractures associated with other injuries in order to avoid complications.”
History

• Era of early definitive fracture treatment
  – Implication was to stabilize long bone injuries within 24 hours – especially in patients with increased severity of their injuries.
  – 178 femoral fractures – those fixed within 24 hours (rather than greater than 48 hours) had less ventilator time and decreased ICU management.

• Borderline era
  – Questioned the dogma of early fracture care.
  – The “borderline patient” was identified – that is – the patient would may not benefit from extensive early fracture care.
  – Identified with clinical and laboratory findings.
  – The big question remained “Who exactly are these patients that are too unstable for early fracture care?”.
History

• Era of damage control orthopaedics
  – Many patients are stable enough for early fracture care, but the unstable subgroup should undergo rapid and minimally traumatic stabilization of their injuries.
  – External fixation is the mainstay of this form of treatment.

External Fixation

• Increase in primary external fixation of femoral fractures in trauma patients:
Reamed IM nails

- Decrease in use of primary reamed intramedullary femoral nails:

DCO

- First stage: early, rapid, temporary fixation to minimize blood and heat loss.
- Second stage: physiologic stabilization.
- Third stage: planned definitive fixation.
Who are these patients?

- Polytrauma and additional thoracic trauma (AIS>2).
- Polytrauma + abdominal/pelvic trauma and hemorrhagic shock (initial BP<90 mmHg).
- Bilateral lung contusions on CXR.
- Initial mean pulmonary artery pressure (PAP)>24 mmHg.
- Increase in PAP during IM nailing of > 6 mmHg.


Second hit

- Patient outcome depends upon:
  - The “first hit” is the initial trauma.
  - The “second hit”:
    - Patient’s biological condition.
    - The timing and quality of subsequent medical intervention.
Second hit

• Factors contributing to the “second hit”:
  – Blood loss
  – Sepsis
  – Ischemia
• Lesser second hits:
  – Blood transfusions
  – Volume depletion

Timing of surgery

• Early total care (ETC).
• Stepwise approach:
  – Acute (1-2 hrs) – life saving.
  – Primary (1st day) – open fx, compartment syndrome.
  – Secondary (48-72 hrs) – generally avoid surgery.
  – Tertiary (>72 hrs) – open reduction and internal fixation of intraarticular injuries.
DCO in pelvic fractures

- Major concern is hemorrhage.
- 2-20% of pelvic fractures are hemodynamically unstable.
- Treatment:
  - Volume resuscitation.
  - Close volume.
  - Arterial embolization.
  - Pelvic packing.
So what procedures are DCO?

- Femoral fractures:
  - External fixation to establish length and alignment if possible.
  - Traction if external fixation is not possible.

So what procedures are DCO?

- Severe tibial fractures may be splinted and soft tissue injuries treated at the bedside.
- Spanning fixation of severe periarticular injuries should be done as soon as practical.
So what procedures are DCO?

• Open fractures – irrigate and debride if at all possible.
• May be done in ICU if necessary.
• At least cover wound(s) and administer IV antibiotics.

So what procedures are DCO?

• Intraarticular fractures – span with external fixation and perform definitive fixation on a delayed basis.
Trauma

Mountains Don’t Care

Notice how this trail divides on Flattop and wanders across broad expanses of rolling tundra, each route exposed above treeline for several miles. Beyond are precipitous cliffs and steep snow chutes. Weather conditions can rapidly become severe. In snow or fog, hikers can easily lose the trail, even though marked with rock cairns. Do not attempt this route in bad weather as “white-outs” are not unusual even in summer. Don't be afraid to turn back when in doubt.

Thank you