Management of Open Fractures

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Goals

- Review Historical Basis for Management of Open Fractures
- Review Accepted Practices of Open Fracture Treatment
- Examine Current Controversies and Methodology of Treatment of Open Fractures

Historical Perspective

- Pierre Desault (1731–1795)
- Promoted deepening of incisions to explore wounds, remove nonviable tissue, allow a path for drainage
- Coined the term “debridement”
- Stated the sooner debridement performed, the less likely an infection would develop
**Historical Perspective**

- Joseph Trueta (1897–1977)
- *The Principles and Practice of War Surgery*
  1. Enlargement of the wound to permit adequate visualization
  2. Assessment of injured tissue for viability
  3. Excision of all contaminants and all non-viable tissue
  4. Stabilization of fracture
  5. Establishment of appropriate Drainage

**Historical Perspective**

- World War II
- Penicillin becomes readily available by the end of the war
- Widespread use in the treatment of wounds from open fractures with good results

**The Basics**

- ATLS Guidelines / ABC’s
- Immobilize and apply sterile dressing to injured extremity
- Early IV Antibiotics
- Early operative irrigation and debridement with skeletal stabilization
- Repeated irrigation and debridement as necessary
- Thorough rehabilitation
**Initial Evaluation**

- **History**
  - Mechanism
  - Time of Injury
  - Type of Injury
    - Direct blow
    - Crush
  - Degree of contamination
  - Amount of soft tissue damage

**Physical Exam**

- Neurologic and vascular exam of extremity including ABI’s if indicated
- Wounds should be assessed once in ER, then covered with sterile gauze dressing until treated in OR - digital camera / cell phone
- True classification of wound best done after surgical debridement completed

**Classification**

- **Gustilo-Anderson Classification, JBJS 1976**

- Retrospective and Prospective review of 1,025 open fractures
  - 673 Retrospective
  - 352 Prospective
Classification

Gustilo Type I
- Low Energy
- Minimal soft tissue damage
- Minimal contamination
- Usually inside-out injuries

Gustilo Type II
- Low-Moderate energy
- Moderate soft tissue injury
- Moderate contamination
- Moderate comminution
- "Tricked out" skateboarder!!

Gustilo Type III
- Originally defined as:
  - Either an open segmental fracture, an open fracture with extensive soft-tissue damage, or a traumatic amputation
  - Special categories: GSW, farm injury, open fracture requiring vascular repair
Gustilo found Type III to be increasing in incidence and the category to be too inclusive. Significantly higher infection rates noted in Gustilo Type III fractures. Gustilo et al JOT 1984, subdivision of Type III fractures into three subtypes in order of worsening prognosis:

- **Gustilo Type IIIA**
  - High Energy
  - Severe, crushing soft tissue injury
  - High degree of contamination
  - Moderate–severe comminution

- **Gustilo Type IIIB**
  - High Energy
  - Severe loss of soft tissue coverage
  - Typically requiring a soft-tissue flap for coverage of the wound
  - High degree of contamination
  - Moderate–severe comminution
Classification

- Gustilo Type IIIC
  - High Energy
  - Arterial Injury requiring repair
  - Requires Skeletal Fixation to protect the repair
  - High Degree of contamination
  - Mod–severe Comminution

Classification

- Size of the wound, soft tissue damage can be difficult to judge on initial assessment
- Many factors affect the final classification
- Classify in operating room

Classification

- Brumback et al
  - JBJS 1994
  - 245 Orthopaedic surgeons showed 12 videotapes of open fractures, including intraop footage
  - Asked to assign Gustilo–Anderson classification
  - Overall agreement ~60%
Classification

- Important in directing treating surgeon to presence and extent of injury variables
- Only classify during surgery, during wound exploration and debridement

O.T.A. Fracture Classification

<table>
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<tr>
<th>Skin injury</th>
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<tr>
<td>Crevice</td>
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<tr>
<td>Overall</td>
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<tr>
<td>Muscle injury</td>
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<tr>
<td>No muscle in use</td>
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<tr>
<td>Contact muscle injury (fractured)</td>
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<tr>
<td>Devitalized</td>
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<tr>
<td>Overall</td>
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<tr>
<td>Nerve injury</td>
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<tr>
<td>None</td>
<td>0.93</td>
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<tr>
<td>Overall</td>
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<tr>
<td>Joint</td>
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<tr>
<td>None</td>
<td>0.93</td>
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<tr>
<td>Overall</td>
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Prevention of Infection

- All open fracture wounds are contaminated due to exposure to outside environment
- Bacterial colonization
- Presence of dead space and devitalized tissues
- Soft tissue damage
Objectives of Surgical Treatment

- Prevent Sepsis
- Achieve Union
- Restore Function

Antibiotics

- NOT PROPHYLACTIC...THERAPEUTIC

Timing of Antibiotics

- Patzakis and Wilkins study of 1104 open fractures
  - ABX given < 3 hrs from time of injury
    - 17/364 developed infection (4.7%)
  - ABX given > 3 hrs from time of injury
    - 49/661 developed infection (7.4%)
- Antibiotic therapy to be initiated as soon as possible following injury
- Seventy two hour duration

ABX given < 3 hrs from time of injury
17/364 developed infection (4.7%)
ABX given > 3 hrs from time of injury
49/661 developed infection (7.4%)
Antibiotics

- First Generation Cephalosporin
- +/- Aminoglycoside
- +/- Pen G or Clindamycin if Pen allergic
- No Cipro alone Patzakis MJ, J Orthop Trauma Nov 2000
- 24-72hr course

Local Antibiotics
- Antibiotic Beads
  - Ostermann et al J&J 1993
  - 1,085 open fractures
  - Group 1
    - 240 fractures treated with PO abx only
    - Resulted in 12% infection rate
  - Group 2
    - 845 fractures treated with PO abx + abx beads
    - Resulted in 3.7% infection rate
  - **Fractures treated with local abx more likely to undergo early wound closure

- Aminoglycoside-impregnated PMMA
  - Used in more severe fractures
  - Placed inside bony defects and covered with a liner
  - Much greater local concentrations of ABX without as many systemic side effects
  - Wound sealed from external environment
Bone Defects: Bead Pouch

PMMA – aminoglycoside +/- vancomycin
Bead pouch
Solid spacer

Bone Defects

Don’t Forget the Tetanus
Debridement of Wound

- Goals
  - Extension of the traumatized wound to allow identification of the zone of injury
  - Allow for superficial and deep exploration of the wound
  - Allows for best classification of the fracture

Debridement of Wound

- Goals
  - Removal of debris and non-viable tissue
  - Begin irrigation
  - Assess 3C's of muscle

Lessons from Mama!

“THE SOLUTION TO POLLUTION IS DILUTION”
Wound Irrigation

- Volume
  - Ideal volume not clearly defined
  - Gustilo-Anderson
    - Originally described use of 10–15 Liters for irrigation of all wounds
  - Commonly used guidelines
    - Type I: 3–6 Liters
    - Type II: 6–9 Liters
    - Type III: 9 Liters

Irrigation


Large Fragments: What to do?

- Infection Rates with retained – 21%
  Edwards CC, Severe open tibial fractures. Results treating 202 injuries with external fixation. CORR 1998
- Infection Rates with removed – 9%
- Use to assist in determining length, rotation and alignment
Soft Tissue Coverage

- Definitive coverage should be performed within 7-10 days if possible
- Most type 1 wounds will heal by secondary intent or can be closed primarily. Hohmann E. Comparison of delayed and primary wound closure in the treatment of open tibial fractures. Arch Orthop Trauma Surg 2007
- Delayed primary closure usually feasible for type 2 and type 3a fractures

Treatment of Soft Tissue Injury

- Careful planning of skin incisions
- Longitudinal incisions / “Z” plasty
- Essential to fully explore wound as even Type 1 fractures can pull dirt/debris back into wound and on fracture ends
- All foreign material, necrotic muscle, unattached bone fragments, exposed fat and fascia are debrided

Treatment of Soft Tissue Injury

- After initial evaluation wound covered with sterile dressing and leg splinted
- Appropriate tetanus prophylaxis and antibiotics begun
- Thorough debridement and irrigation undertaken in OR within 6 hours if possible
- Photo documentation
Wound Closure

- Wound extensions can be closed primarily
- When feasible, primary wounds should be closed under minimal tension
- Allgower–Donati Suture Technique

Relative Contraindications to wound closure
- Grossly contaminated wound
- Delay in Antibiotic initiation beyond 12 hours from injury
- Questionable tissue viability at the time of debridement

Complications
- Infection, sepsis, chronic osteomyelitis
- Nonunion, malunion
- Loss of function (muscle loss, nerve injury, unrecognized compartment syndrome)
- SIRS, ARDS, multi-system organ failure
Conclusions

- Open Fractures present a challenging situation to even the most experienced Orthopaedic surgeon.
- Treatment should be prompt and antibiotics given therapeutically and aimed at appropriate contaminants.
- Classification of open fractures is a consistently evolving process and is best done in the operating room after debridement and exploration.

Conclusions

- All open fractures should be thoroughly irrigated and debrided.
- Wound closure and coverage should be completed as soon as possible to prevent nosocomial infection.
- Some aspects of the ideal management of open fractures are yet to be elucidated.

Thankyou!