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 Johansen K, *J Trauma* April 1991
- 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 Retrospecitve – 352 Prospective

Classification

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

Classification

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

Classification

- 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

Classification

- 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

Classification

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

Classification

- 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

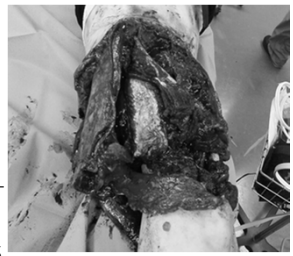
- Gustilo Type IIIC
  - High Energy
  - Arterial Injury requiring repair
  - Requires Skeletal Fixation to protect the repair
  - High Degree of contamination
  - Mod-severe Comminution

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

	Skin Injury	
1	Can be approximated	0.79
2	Cannot be approximated	0.01
3	Extensive degloving	0.79
Overall		0.69
	Muscle Injury	
1	No muscle in area, no appreciable muscle necrosis, some muscle injury with intact muscle function	0.51
2	Loss of muscle but the muscle remains functional, some localized necrosis in the zone of injury that requires excision, intact muscle–tendon unit	0.21
3	Dead muscle, loss of muscle function, partial or complete compartment excision, complete disruption of a muscle–tendon unit, muscle defect does not approximate	0.52
Overall		0.40
	Arterial Injury	
1	No injury	0.9
2	Artery injury without ischemia	0.9
3	Artery injury with distal ischemia	0.0
Overall		0.9
	Bone Loss	
1	None	0.70
2	Bone missing or devascularized but still some contact between proximal and distal fragments	0.65
3	Segmental bone loss	0.00
Overall		0.65
	Contamination	
1	None or minimal contamination	0.52
2	Surface contamination (easily removed not embedded in bone or deep soft tissues	0.16
3	Contaminant embedded in bone or deep soft tissues or high risk environmental conditions (barnyard,	0.69

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 CORR 1989
  - 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

Antibiotics

Surgical Infection Society guideline: prophylactic antibiotic use in open fractures: an evidence-based guideline. Hauser CJ, *Surg Infect*, Aug 2006

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

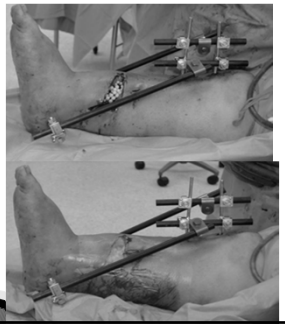
Local Antibiotics

- Antibiotic Beads
  - Ostermann et al JBJS Br 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

Local Antibiotics

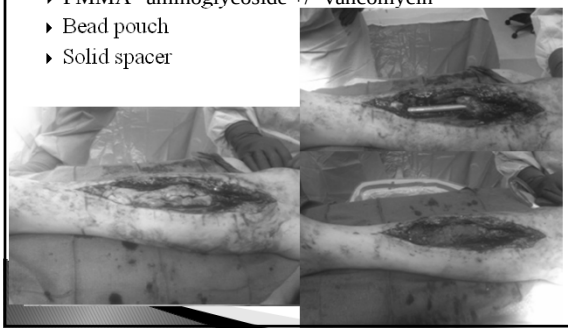
- Aminoglycoside-impregnated PMMA
  - Used in more severe fractures
  - Placed inside bony defects and covered with a liner
  - Much greater local concentrations of ABX without as many systemic side effects
  - Wound sealed from external environment

Bone Defects: Bead Pouch



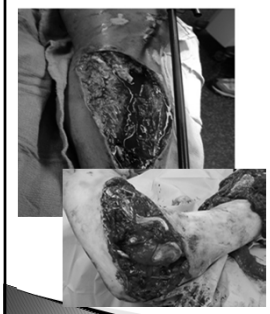
Bone Defects

- PMMA –aminoglycoside +/- vancomycin
- Bead pouch
- Solid spacer



Don't Forget the Tetanus

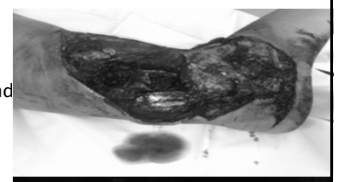
Debridement of Wound



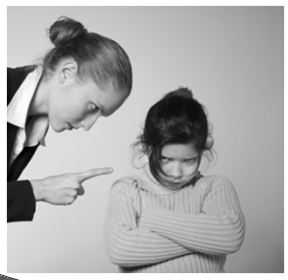
- Goals
  - Extension of the traumatized wound to allow identification of the zone of injury
    - Allow for superficial and deep exploration of the wound
    - Allows for best classification of the fracture

Debridement of Wound

- Goals
  - Removal of debris and non-viable tissue
  - Begin irrigation
  - Asess 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

- Saline +/- surfactants (soap) Anglen J, Removal of surface bacteria by irrigation. *J Orthop Res 1996*
- Pressure – avoid high pressure / pulse lavage Polzin B, Removal of surface bacteria by irrigation. *J Orthop Res 1996*
- Timing > 6 hrs Crowley DJ, Debridement and wound closure of **open fractures: The impact of the time factor on infection rates.** ***Injury 2007***

Large Fragments: What to do?

- Infection Rates with retained – 21%
- Infection Rates with removed– 9%

  Edwards CC, Severe open tibial fractures. Results treating 202 injuries with external fixation. *CORR*, 1998
- 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

Wound Closure

- 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!