Management of Open Fractures

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Classification & Principle of Emergency Management

High Energy Trauma
High Risk of Complications
High Social Economic Cost
Open Fractures

- High energy trauma; injury to soft tissue and bone → impair local tissue vascularity
- Communicate with the exterior, resulting contamination of the wound with micro-organisms
- Increased risk of infection and complications of fracture healing; Incidence of wound infection ↔ extent of soft tissue damage, <2% type I to >10% type III
- Tendon, nerve and articular cartilage subjected to damage
Assessment of the patient

- Advanced Trauma Life Support
  - Airway
  - Breathing
  - Circulation
  - Disability
  - Exposure

- MESS (Mangled Extremity Severity Score)

Save the patient, then the limb!
Table 50-3  Mangled Extremity Severity Score

<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
<th>Injuries</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>SKELETAL/SOFT TISSUE GROUP</td>
<td>Low energy</td>
<td>Stab wounds, simple closed fractures, small-caliber gunshot wounds</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Medium energy</td>
<td>Open or multiple-level fractures, dislocations, moderate crush injuries</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>High energy</td>
<td>Shotgun blast (close range), high-velocity gunshot wounds</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Massive crush</td>
<td>Logging, railroad, oil rig accidents</td>
<td>4</td>
</tr>
<tr>
<td>SHOCK GROUP</td>
<td>Normotensive</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Transiently</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Prolonged</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>ISCHEMIA GROUP</td>
<td>None</td>
<td></td>
<td>0*</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td></td>
<td>1*</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td></td>
<td>2*</td>
</tr>
<tr>
<td></td>
<td>Advanced</td>
<td>Pulseless, cool, paralyzed and numb without capillary refill</td>
<td>3*</td>
</tr>
<tr>
<td>AGE GROUP</td>
<td>&lt;30 years</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>30 to 50 years</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>&gt;50 years</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>


*If ischemia time exceeds 6 hours, add 2 points.

MESS > 7 accurately predicted amputation in 100% of limbs in both retrospective and prospective studies.
Assessment of the patient

- Look for:
  - Life / limb threatening injuries
  - Other associated injuries
  - Check distal circulation, neurology
  - Check compartment pressure (if needed)
Assessment of the wound

From AED to OT theatre

- What is the nature of the wound?
- What is the state of the skin around the wound?
- Is the circulation satisfactory?
- Are the nerves intact?
Gustilo & Anderson Classification

- **Type I**: clean wound < 1 cm long
- **Type II**: wound > 1 cm, without extensive soft tissue damage
- **Type IIIA**: extensive soft tissue lacerations (> 10 cm) but maintain adequate soft tissue coverage of bone, or they result from high-energy trauma regardless of the size of the wound, includes segmental or severely comminuted fractures
- **Type IIIB**: extensive soft tissue loss with periosteal stripping and bony exposure, usually massively contaminated
- **Type IIIC**: with arterial injury that requires repair regardless of the size of wound.

Type I

**Wound size:**
small <1cm, clean puncture, a bone spike has protruded

**Soft tissue damage:**
little, no crushing

**Fracture:**
not comminuted

**Energy of trauma:**
low-energy
Type II

**Wound size:**
more than 1 cm, no skin flap

**Soft tissue damage:**
Moderate crushing

**Fracture:**
moderate comminution

**Energy of trauma:**
low-energy
Type IIIA

**Wound size:**
Large wound usu> 10cm

**Soft tissue damage:**
Extensive, contaminated
Fractured bone can be adequately covered by soft tissue

**Fracture:**
Comminuted

**Energy of trauma:**
High-energy
Type IIIB

**Wound size:**
Large wound, fractured bone can’t be covered by soft tissue (vs Type IIIA)

**Soft tissue damage:**
periosteal stripping (intra-op)

**Fracture:**
Severely comminuted

**Energy of trauma:**
high-energy
Type IIIC

**Wound size:**
Large, not adequate coverage of the bone

**Soft tissue damage:**
Vascular injury, needs to be repaired

**Fracture:**
Severely comminuted

**Energy of trauma:**
High-energy
Question 1. How to classify patient with gun shot wound?

- By definition, it is already Gustilo III injury
Question II. When to make the definitive classification?

- Make in the **operating room** during first debridement, full exploration of the extent of wound and soft tissue injury
  - Extend of soft tissue injury and viability
  - Size of skin defect
  - Periosteal stripping
Principles of treatment

1. Resuscitation
2. Wound management
3. Anti-tetanus
4. Antiobiotics
5. Stabilization of fracture
6. Early wound coverage
7. Early return of function
I. Wound debridement
Debridement & Irrigation

- Adequate debridement is the single most important factor in the attainment of a good result in the treatment of an open fracture
- Systemic debridement
  - Removal of gross contamination and debris
  - From superficial to deep structures
  - All necrotic tissue should be excised
- Use of tourniquet should be minimized
- Wound extension for full evaluation of soft tissue injury
Systemic debridement

- Muscle viability is determined by the four C's:
  - contractility
  - color
  - Consistency
  - capacity to bleed.

- Evaluation of the bone: Periosteum & any completely free cortical fragments

- When it is difficult to fully determine the viability of all tissues at the time of initial debridement, repeated debridements at 24-48 hour intervals can be employed to eliminate devitalized tissue
Debridement of the wound
**Irrigation**

- Supplement a systematic debridement in removing foreign material and decreasing bacterial load
  - Anglen et al. 3L of irrigation for Type 1 fractures, 6L for Type 2 fractures and 9L for Type 3 fractures
  - Antiseptic solutions (e.g. povidone-iodine, Dakin’s solution and chlorhexidine) have not been shown to decrease infection rates. They have been linked to tissue damage and thus should be avoided
  - Surfactant (non-sterile soap) same effectiveness, less tissue damage and more economical
Antibiotic solution no better than soap for open fracture irrigation

- 400 patients, 458 open fractures of lower extremity
- Gp A: 166 patients with 194 Fxt
  - Bacitracin solution
- Gp B: 177 patients with 105 fxt
  - Castile soap solution
- No significant difference btw 2 groups

Jeffrey Anglen and colleagues found that the soap group had a 13% infection rate vs. 18% for the antibiotic group.
Irrigation

- Simpulse irrigation (HPPL: High pressure pulsatile lavage) system
- Pressures greater than 50psi have been shown to be detrimental to bone and soft tissue, slow bone healing and potentially drive bacteria further into the wound
- Brush-suction irrigation & bulb syringe removal inorganic contamination not less than HPPL

Debridement of cancellous bone: A comparison of irrigation methods.
Reid W Draeger et al. J Orthop Trauma Volume 20, Number 10, Nov 2006
Timing of Debridement & Irrigation

- Freidrich's 1898 study of guinea pigs. Debridement within 6 hours

- Most guideline recommended within 6 hours. The timing of effective initial surgical debridement of open tibia fractures remains controversial.

- The majority of current literature is unable to demonstrate an improved infection rate for open fractures initially debrided within 6 hours of injury
Definite timing for surgery

- Association btw time to definitive surgical management and the rates of nonunion and infection in open fractures resulting from blunt trauma.

- Time was not a significant factor in predicting either nonunion or infection ($p>0.05$)
  - Grade of injury
  - Presence of infection
  - Lower limb open fracture

The Effect of Time to Definitive Treatment on the Rate of Nonunion and Infection in Open Fractures

Brian J. Harley, Lauren A. Beaupre, C. Allyson Jones, Sukhdeep K. Dulai, and Donald W. Weber

*Division of Orthopaedic Surgery, Department of Surgery, University of Alberta Hospital, Edmonton, Alberta, Canada*
II. Antiobiotic
Antiobiotics & Infection

- 24-70% of open fractures are contaminated with bacteria
- 14-15% of open fracture complicated with infections in the absence of antibiotic prophylaxis
- Is Wound culture pre-debridement and post-debridement useful?
- Answer is **NO!**

Strong evidence for the efficacy of first generation cephalosporins in the management of open fractures in a prospective, randomised placebo-controlled study.

- Type I & II: cefazolin 1g ivi
- Type III: + Aminoglycosides (Gentamicin ivi)
- Farm/ soil injury: + Metronidazole ivi
Timing & Duration of prophylaxis

- Antibiotic prophylaxis should be initiated as soon after the injury as possible as the timing of the antibiotic prophylaxis has been shown to be important for prevention of infection.

- Duration of prophylaxis should be limited to a 24 hour course with repeated 24 hour courses likely indicated for subsequent debridements, wound closures, bone grafting or other major surgical procedures.
Stabilization of fracture
Stabilization of the fracture

NON-OPERATIVE

- Splintage
- POP slab for temporarily fixation of fracture
  - Goal:
    - Pain relief
    - Facilitate nursing care
Skeletal stability achieved in OT

OPERATIVE FIXATION
Early stabilization of fractures

- Stabilizing the open fracture
- Protects the soft tissues from further injury by fracture fragments
- Facilitates the host response to microbe despite the presence of implants
- Improves wound care, and allows early motion of adjacent joints and early mobilization of the patient.
Open fractures & Compartment syndrome

Irrigation and debridement +/- fasciotomy +/- EF or IF
Compartment syndrome

- Rockwood et al 2006
- Compartment syndrome is a complication in open and closed tibia fracture

- Internal pressure or external confinement or restriction can proceed to the point that the cellular exchange is diminished. This sets up an ischaemic environment that when left untreated can lead to tissue damage
Post-op Monitoring

- Pain
- Neurovascular status
- Compartment syndrome
- Gas gangrene esp soil or form contamination (clostridium myonecrosis)
- Infection

- Keep dressing intact
- Elevation
- Report and marking of any oozing from the dressing
- Adequate analgesia
- Antiobiotic administration
Early wound cover surgery
Wound management

- Multiple wound debridement if in doubt, within 24-48 hours interval
- Early wound covering preferrably within one week
- Occlusive dressing, allow no pressure
- Circulation and neurological monitoring
Immediate primary skin closure

- S. Rajasekaran et al
- India study w/ Strict criteria:
  - Debridement within 12 hours of injury, no sewage or organic contamination, no skin loss either primary or secondarily during debridement
  - Polytrauma patients excluded
  - Physiological status stable, presence of bleeding skin margins, ability to approximate wound edges without tension and the absence of peripheral vascular disease

Immediate primary skin closure in type-III A and B open fractures

RESULTS AFTER A MINIMUM OF FIVE YEARS
Immediate primary skin closure

- 173 patients
- Mean FU 6.2 years; Outcome study
  - Excellent in 150 (86.7%)
  - Good in 11 (6.4%)
  - Poor in 12 (6.9%)
- 33 total complications in 23 patients
  - 11 superficial infection
  - 5 deep infection (3 require flap surgery)
  - 6 nonunion (require further surgery)
  - 1 established infected nonunion
Delayed wound closure +/- flap coverage

- Bone graft for definitive fracture management
- Definitive fracture fixation method
- Skin coverage reconstruction ladder
Summary: Open Fracture

- Resuscitation
- Watch out for life threatening complications
- Cleansing & Dressing
- Debridement & Irrigation
- Antiobiotic prophylaxis & anti-tentanustoxoid
- Stabilization of fractures
- Definite fracture and soft tissue management
- Nutritional support & Nursing care
- Rehabilitation
Reference:


- Brian J. et al. The Effect of Time to Definite Treatment on the Rate of Nonunion and infection in open fractures. JOT Vol 16. No 7 pp484-49