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Best Practice Guidelines for Open Fracture Management in Children and Adolescents

Disclosures

I have nothing to disclose

Part I:
DAMAGE ASSESSMENT

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Initial Assessment

- Provisional stabilization with clean dressing and a splint
- Assessment
  - Classify as best as possible
  - How much contamination, Vascular injury, Compartment Syndrome?
  - Verify tetanus status

	Clean Wound		Contaminated Wound	
Vaccination History	**Give Vaccine?**	**Give TIG?**	**Give Vaccine?**	**Give TIG?**
Unknown, or < 3 doses	Yes	No	Yes	Yes
≥3 doses	If > 10 years ago	No	If > 5 years ago	No

Classification

- Think about:
  - Skin
  - Muscle
  - Nerve/Perfusion
  - Contamination
  - Bone Loss

Gustilo-Anderson classification of open fractures

Subtype	Description
I	Wound <1 cm; clean; simple fracture pattern; minimal comminution; minimal soft tissue damage
II	Wound 1–10 cm; simple fracture pattern; moderate soft tissue injury
IIIA	Wound >10 cm; extensive soft tissue injury with maintained soft tissue coverage over bone; high energy, comminuted, or segmental injuries
IIIB	Extensive soft tissue damage with periosteal stripping; inadequate soft tissue coverage of the area of injury
IIIC	Vascular injury requiring repair

Gustillo-Anderson Type IIIA

- Skin – Large wound, though opposable
- Muscle – Viable
- Perfusion – No Injury
- Contamination - Moderate
- Bone Loss – comminution, but no loss

Open Fractures in Children

- Why classify?
  - Open tibia fractures in children
    - Infection risk:
      - Type II vs Type I **O.R. 1.9** (p=0.15)
      - Type III vs Type I **O.R. 3.5** (p=0.0008)
      - Type III vs Type II **O.R. 2.3** (p=0.009)
    - Mean union time
      - Type I: 11.6 weeks
      - Type II: 13.5 weeks
      - Type III: 16.1 week

Baldwin KD et al; Open fractures of the tibia in the pediatric population: a systematic review; J Child Orthop (2009) 3:199-208

Part II: ANTIBIOTICS

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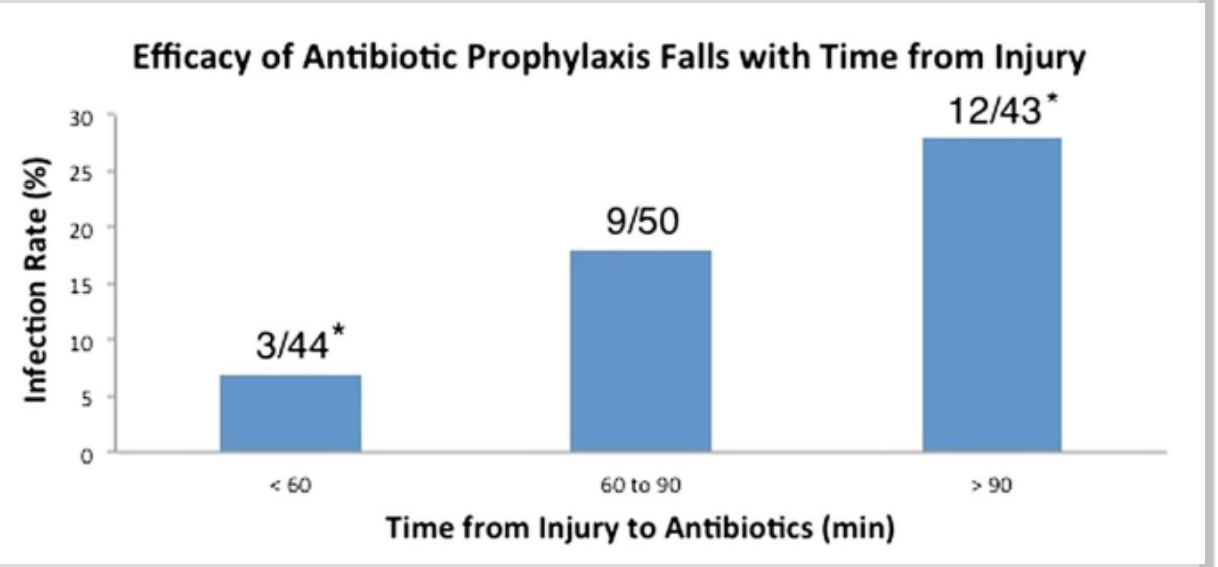
Antibiotic Timing

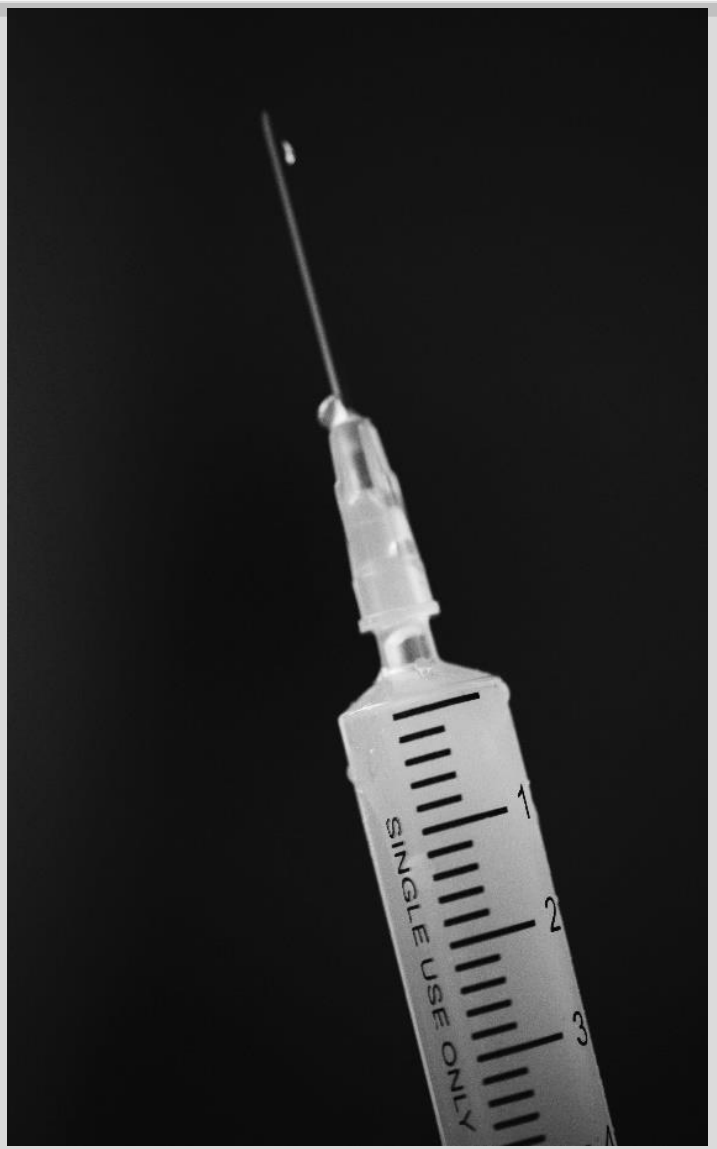
- Timing of antibiotics – **<u>as soon as possible</u>**
  - Lower rates of infection if IV antibiotics given < 3 hours from injury (4.7% vs 7.4%)[1]
  - Antibiotics > 66 minutes associated with infection in Type III tibia fractures (O.R. 3.78) [2]
    - Educate referring centers / first responders



1. Patzakis MJ, Wilkins J. Factors influencing infection rate in open fracture wounds. Clin Orthop Relat Res 1989;243:36–40.
2. 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.

Antibiotic Choice

- Antibiotic Recommendations[3-5]
  - Type I & II: 1st Generation Cephalosporin (ie: Cefazolin)
  - Type III: 1st Generation Cephalosporin + Aminoglycoside (ie: Gentamicin)
  - Type III with soil / farm: + Penicillin



3. Carver et al. Role of Systemic and Local Antibiotics in the Treatment of Open Fractures, Orthop. Clin N Am 2017 (48): 137-153
4. Chen AF, Schreiber VM, Washington W, et al. What is the rate of methicillin-resistant Staphylococcus aureus and gram-negative infections in open fractures. Clin Orthop Relat Res 2013;471:3135–40.
5. Torbert JT, Joshi M, Moraff A, et al. Current bacterial speciation and antibiotic resistance in deep infections after operative fixation of fractures. J Orthop Trauma 2015;29:7–17.

Antibiotic Duration

- IV antibiotics
  - 24 - 72 hours from injury
  - Prolonged antibiotics > 72 hours does not provide benefit[6]
- Discontinue by 24 hours after wound coverage, or 72 hours after injury (whichever is first)

6. Chang et al; Effects of Antibiotic Prophylaxis in Patients with Open Fracture of the Extremities: A Systematic Review of Randomized Controlled Trials. JBJS Rev, 2015;3(6):e2 1-12

Part III: SURGERY

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Timing of Debridement

- Adult systematic review: 3217 fractures, No difference in infection rate for early (<5-12 hrs) vs later debridement[7]
  - Heterogeneous sample
  - Factors not controlled for: abx, quality of debridement, infection definition, irrigation
- In Children: No difference in long bone open fracture infection rate < 6 hrs vs >7 hrs[8]
  - Even in Type III fractures

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7. Schenker M et al. Does Timing to Operative Debridement Affect Infectious Complications in Open Long-Bone Fractures? A Systematic Review. JBJS 2012;94L1057-64
8. Skaggs DL et al. The Effect of Surgical Delay on Acute Infection Following 554 Open Fractures in Children. JBJS 2005; 87-A(1),8-12

TABLE IV Rate of Infection According to Time to Débridement and Type of Open Wound*

Delay	Rate of Infection†			
	Type I	Type II	Type III	Total
0 to 6 hours	2% (3 of 173)	3% (3 of 110)	10% (6 of 61)	3% (12 of 344)
7 to 24 hours	2% (2 of 126)	0% (0 of 40)	6% (2 of 36)	2% (4 of 202)
25 to 72 hours	0% (0 of 3)	0% (0 of 4)	0% (0 of 1)	0% (0 of 8)
Total	2% (5 of 302)	2% (3 of 154)	8% (8 of 98)	3% (16 of 554)

*According to the system of Gustilo and Anderson[1]. †The data are given as percentages, with the numbers of fractures in parentheses.

<u>Cautions with this study:</u>

Underpowered to detect true difference in infection rate

Bias – more subjectively contaminated type III / severe fractures treated earlier?

No control of other factors (antibiotics, extent of debridement, timing to fixation)

Best Practice Bottom Line for debridement Timing

- Literature suggests acceptable outcomes with non emergent debridement of open fractures
- Debride fractures as soon as reasonably possible < 24 hours from injury
- Use Judgement
  - Severely contaminated with farm/feces/mud
  - Compartment/Vascular

Type of Irrigation

- Irrigate using **low pressure saline irrigation**
  - No difference in reoperation compared to high pressure[9]

- Irrigate using normal SALINE

  - No difference in infection risk bacitracin (18%) vs castile soap irrigation (13%)[10]
    - More wound healing problems with bacitracin (9.5%) vs castile soap (4%) irrigation

  - Castile soap vs saline
    - Soap with significant higher reoperation rate within 12 months (H.R. 1.32)[9]

Image credit: AO Trauma

9. The FLOW Investigators; A Trial of Wound Irrigation in the Initial Management of Open Fracture Wounds. N Engl J Med 2015;373:2629-41
10. Anglen JO. Comparison of soap and antibiotic solutions for irrigation of lower-limb open fracture wounds. A prospective, randomized study. JBJS 2005;87:1415-22

Local Antibiotics

- Rationale: Creates high local, rather than systemic concentration of antibiotics

- Antibiotic delivery to traumatized / stripped tissues

    - Options:
        - Local injection
        - Antibiotic beads
            - Requires removal surgery
        - Local antibiotic powder

Local Antibiotics

- Favorable outcomes when combined with systemic antibiotics in adults
  - Bead Pouch w/ Aminoglycoside
    - For Type III fractures: Infection rate 20.6% with IV antibiotics vs 6.5% IV antibiotics + local gentamicin beads[11]
  - Local injection of Aminoglycoside (2 mg / mL) at wound closure
    - 14.2% deep infection with systemic abx only vs 6% systemic abx + local aminoglycoside (O.R. 3.0)[12]
  - Systematic Review
    - 11.9% risk reduction of infection in systematic review of 8 studies[13]

11. Ostermann PAW et al; Local Antibiotic Therapy for Severe Open Fractures. A review of 1085 consecutive cases. JBJS Br 1995:77-B:93-7
12. Lawing CR et al; Local Injection of Aminoglycosides for Prophylaxis Against Infection in Open Fractures, JBJS 2015; 97: 1844-51
13. Morgenstern et al; The effect of local antibiotic prophylaxis when treating open limb fractures. Bone Joint Research 2018; 7:447-456

Local Antibiotics

- Potential development of antibiotic resistance
- Is it necessary in children?

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Local Antibiotic Therapy to Reduce Infection After Operative Treatment of Fractures at High Risk of Infection: A Multicenter, Randomized, Controlled Trial (VANCO Study)

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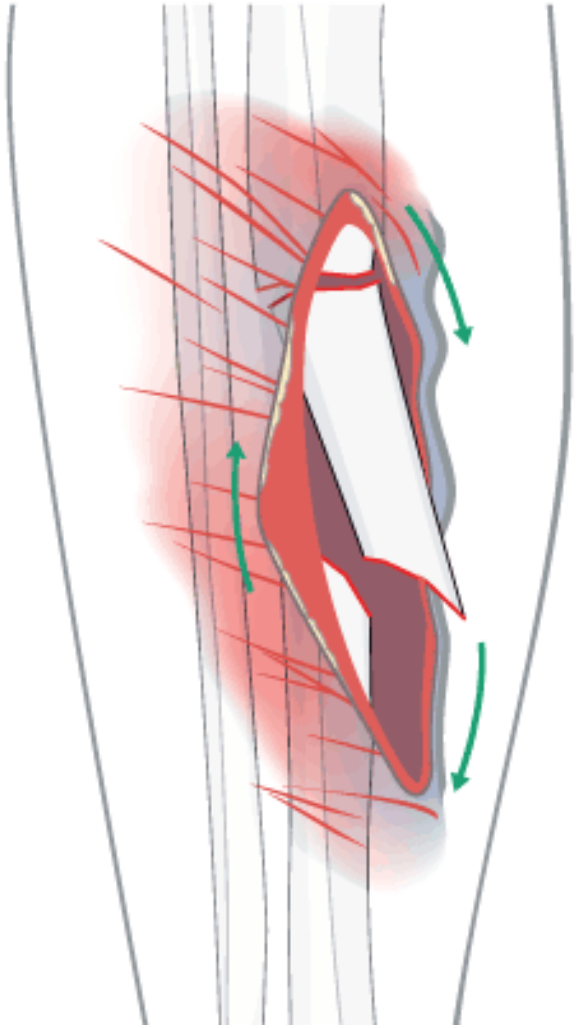
…Awaiting Results (In Adults)…

CAUTION

There is no substitute for the QUALITY of Surgical Debridement



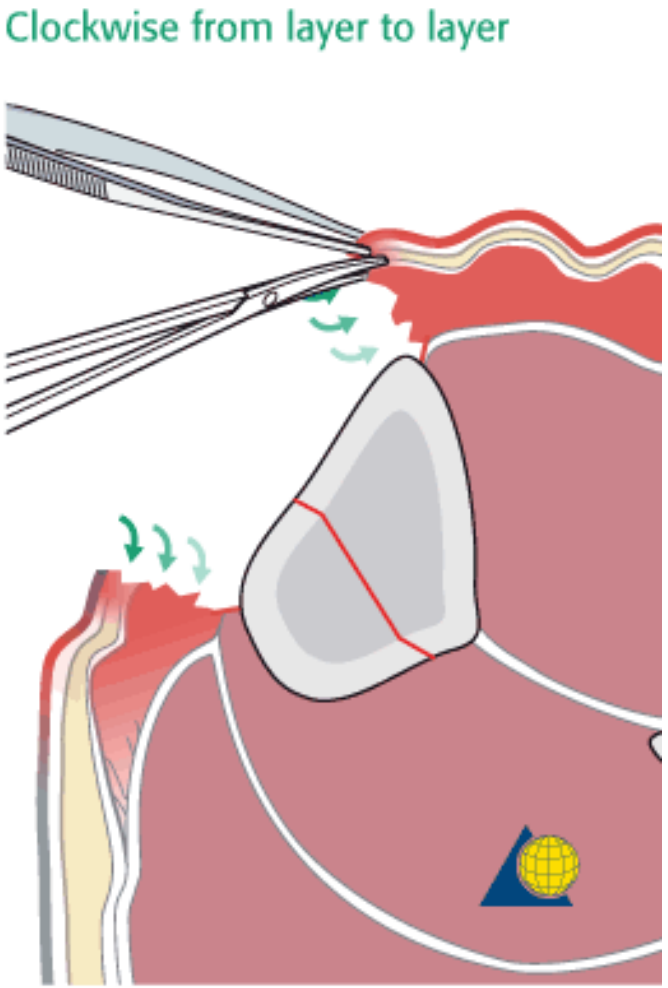


Image Credit: AO Trauma

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Tissue Management Principles

- Attempt definitive wound coverage at time of fixation (No later than 1 week)
  - Type III open tibia fractures: Fix + Cover Together vs Separate operations
    - Infection rate 4.2% (2/48) vs 34.6% (9/26)
  - Collaborate with plastic surgery early!

Part IV: CONTROVERSY – Type I Open Fractures

Surgical Debridement for Type I open fractures in children

- Case Series 0 – 4% infection rate[15-19]
  - Protocols varied
    - Discharge from ED < 24 hours
    - Admit for 24-72 hours IV ABX
  - Comparable infection rates of pediatric type I open fractures in surgical debridement vs no surgical debridement
  - Majority forearm fractures

15. Iobst CA et al; Nonoperative management of pediatric type I open fractures. JPO 2005;25(4):513-517
16. Doak J et al: Nonoperative management of pediatric grade I open fractures with less than a 24-hour admission. JPO 2009;20(1):49-51
17. Bazzi AA et al; Is nonoperative treatment of pediatric type I open fractures safe and effective? J Child Orthop 2014;8(6):467-471
18. Iobst CA et al: A protocol for the management of pediatric type I open fractures. J Child Orthop 2014;8(1):71-76
19. Godfrey J et al; Management of Pediatric Type I Open Fractures in the Emergency Department or Operating Room: A Multicenter Perspective

Bottom Line Type I Open Fractures

- Literature suggests acceptable low infection rates with non surgical management of type I open fractures
- Use best judgment

Questions