Guideline

1.0 SCOPE

1.1. Care of the Trauma Services Patient at CCHMC.

1.2. This guideline provides the minimum standard of care for the pediatric orthopaedic surgeons' expected response times and treatment recommendations that best meet the patient's needs and promotes best outcomes.

1.3. Orthopaedic injuries are rarely life threatening; however, they are commonly encountered in children with multiple injuries and can be a cause for long-term morbidity. The treatment of children with multiple injuries should follow the principles of Advanced Trauma Life Support (ATLS), and orthopaedic care must never precede the treatment of more serious life-threatening injuries.

2.0 DEFINITIONS

2.1. **Wash out of open fracture**- surgical management and cleaning within the operating room.

3.0 GUIDELINE

3.1. **Open Fractures-** Open fractures comprise about 2% of all fractures and 10% of fractures in children with multiple injuries.[1-9] Timely antibiotics, irrigation, debridement, and appropriate timing of wound closures are well-established methods of decreasing infection.

3.1.1. **ED Management**: Sterile dressing should be applied to cover the wound. Gross contamination (i.e. grass, dirt) should be removed before reducing the bone ends through the skin wound to avoid introducing contamination in the deep tissues. If the wound is declared a small Grade I open fracture, management in the ED may be an option once discussed with the Orthopaedic Attending.

3.1.2. **Surgical Timing**: Open fractures are usually classified according to degree of associated soft tissue injury using the modified Gustilo classification. Recent level II research does not support the widely accepted standard of operating within six hours from injury. At CCHMC, timing of treatment is based on grade of injury. Emergent surgery is not necessary for grade I and II open fractures if the patients have received early antibiotics.[11] For this population, operative management should be within 24 hours. [12] Grade III open fractures should be operatively treated within 6 hours due to high level of probable contamination [5].

3.1.3. **Antibiotics:** The first dose of antibiotics (see Table 1) should be given within one hour of presentation to the ED

3.1.3.1. Check with referring hospital for any antibiotics administered.

3.1.3.2. Check with transport/ambulance if antibiotics were administered.

3.1.3.3. Verify what type of surface the incident occurred on. It is suggested that ANY farm, grass, or synthetic surface, be managed as a Type III. *(Recommendation Strength: Weak)*

3.1.3.4. Use Table 1 for antibiotic selection and duration and Table 2 for dosing (see bullets for evidence grades)

3.1.3.4.1. Gram positive coverage with cefazolin is strongly recommended for grades I and II *(Recommendation Strength: Strong)*

3.1.3.4.2. Extended gram-negative coverage is strongly recommended for Gustillo grade III fractures *(Recommendation Strength: Strong)*

3.1.3.4.3. Clindamycin is recommended as an alternative to Cefazolin for patients with allergy or another contraindication *(Recommendation Strength: Moderate)*

3.1.3.5. **Duration**

3.1.3.5.1. 24 hours of therapy from wound closure is suggested for Gustillo grade I and II *(Recommendation Strength: Weak)*

3.1.3.5.2. 48-72 hours of therapy from wound closure is recommended for Gustillo grade III fractures *(Recommendation Strength: Moderate)*

3.1.4. **Tetanus prophylaxis** (Tdap) is recommended as needed based on immunization status (within 5 years) upon arrival as soon as possible *(Recommendation Strength: Weak)*

3.1.5. Cultures of tissue for aerobic, anaerobic, fungal and AFB are suggested if repeat washout is performed greater than 5 days after the initial injury. *(Recommendation Strength: Weak)*

3.1.6. Tissue or purulent material (from the anatomic site where infection is clinically suspected) submitted in a sterile specimen container has the highest microbiological yield.
3.1.7. Swabs are acceptable as additional specimens from sites which cannot be reasonably or safely accessed for tissue culture as part of the planned procedure. At least one tissue specimen is suggested.
3.1.8. Cultures at the time of injury are not recommended.
3.1.9. **Open finger and toe fractures** (Tuft, Seymour, Pinkney), which require a wash-out and repair in the Emergency Department, will receive 5 to 7 days of out-patient oral antibiotics and close follow up.
3.1.9.1. Gram positive coverage with Keflex is recommended.
3.1.9.2. Clindamycin is recommended as an alternative to Cefazolin for patients with allergies, another contraindication, or those that occurred in ANY farm, grass, or synthetic surface.
3.1.10. Those requiring OR fixation/repair will follow the intravenous in Table 1.

3.2. **Long Bone Fractures**- Long bone fractures are very common in the pediatric population. Treatment options include both operative and non-operative approaches and are primarily dependent on the child's age and weight.
3.2.1. **Surgical Timing:** Optimal timing and sequence for the treatment of long bone fractures in children is associated with lessened incidence of complications and improved outcomes. Priority block time for operative management is scheduled early on week-days. There is strong evidence in the adult literature that long bone fractures should be stabilized within 24 hours to prevent pulmonary complications, particularly in the multiply injured patient. Based on the severity of the patient's condition, in collaboration with the attending trauma surgeon, the goal of the pediatric orthopaedic team is to provide treatment of these fractures within 24 hours of injury. [13, 14]
3.2.2. **Antibiotics:** To ensure adequate blood level at the time of surgical incision, it is recommended that a prophylactic antibiotic be given within one hour before incision.

3.3. **Pelvic Fractures** [15-17]- Pediatric pelvic fractures are more uncommon than in the adult population. [18] The evaluation and treatment are significantly different from the adult population, because of important anatomical differences between the two populations. Pediatric pelvic fractures are most frequently caused by high-energy mechanisms such pedestrian collisions with moving vehicles and motor vehicle crashes. Therefore, when a pelvic fracture occurs in a child, there should be a high suspicion for multi-system trauma, including possible head, thoracic, urologic, and abdominal injuries.
3.3.1. **ED Treatment**: Blood loss after pelvic fracture has been found to occur less frequently in the pediatric population. [19, 20] When a displaced pelvic fracture is diagnosed in a hemodynamically unstable patient, a pelvic binder should be placed during the initial trauma evaluation for an unstable ring injury. This should decrease intra-pelvic volume and potentially tamponade any bleeding from vessels and bone.
3.3.2. **Management:** The Torode and Zieg (1985) classification is the most widely used system for classification of pelvic fractures in children. A modified Torode classification of pediatric pelvic fractures was developed in 2012 and subdivides Type III pelvic fractures into 2 groups depending on the location of the fracture.[21] Rationale for this modification was the likelihood of type III-B injuries showing similar characterizes (i.e. blood requirement, operative management) to those children with type IV injuries.
- Type I – avulsion fractures.
- Type II – iliac wing fractures.
- Type III-A – stable anterior pelvic ring fractures.
- Type III-B – stable anterior and posterior pelvic ring fractures.
- Type IV – unstable pelvic ring injuries.

3.3.3. The pediatric orthopaedic team, in association with the surgical team, will determine the severity of injury and the necessary treatment plan. Treatment is individualized based on patient age, fracture classification, stability of the pelvic ring, and extent of concomitant injuries. Treatment can differ significantly between skeletally immature and skeletally mature pelvic fractures. The most reliable method of deciding skeletal maturity is the status of the triradiate cartilage. After triradiate closure, injury patterns are close to that of an adult. On average, the triradiate cartilage closes at 14 years in boys and 12 years in girls.[15]
3.3.4. Most stable pelvic injuries in the pediatric population will be managed non-operatively with protected weight bearing and gradual return to activity. Patients that have an unstable ring fracture merits operative reduction and fixation, regardless of the patient's age or skeletal maturity.

3.4. **Acetabular Fractures** [15]- Overall, acetabular fractures are not common. Most pediatric acetabular fractures are in adolescents, with very few reported at less than 10 years of age. Fractures of the acetabulum may occur with less energy than adult acetabular fractures.
3.4.1. **ED Treatment:** After standard trauma evaluation, the most urgent situation to an acetabular fracture is a concomitant hip dislocation, which should be reduced urgently in attempt to preserve blood supply to the femoral head.
3.4.2. **Management:** Treatment of acetabular fractures will depend on the grade of injury. The nature of the developing hip joint necessitates an individualization of treatment for each pediatric acetabular fracture.

Those cases requiring operative intervention will be managed in a timely fashion with the available assistance of an orthopaedic traumatologist. The consultation of the adult traumatologist will be obtained when in the opinion of the team, the adult institution expertise exceeds the pediatric expertise.

Table 1: Treatment of Open Fractures in the Emergency Department

Open Fracture Type	First Line Antibiotic	Alternative Antibiotic[1]	Duration Following Wound Closure
Gustilo Type I and II Wound < 10 cm, minimal to moderate soft tissue damage	Cefazolin 40 mg/kg IV Max dose 2 grams (if > 100 kg, max 3 grams)	Clindamycin 10 mg/kg Max dose 900 mg	24 hours[2]
Gustilo Type III Wound > 10 cm, extensive soft-tissue damage, or farm injuries.	Ceftriaxone 50 mg/kg IV Max dose 2 grams **AND** Metronidazole 10 mg/kg IV Max dose 500 mg **IF water or fecal contamination then use:** Piperacillin/tazobactam 100 mg/kg IV Max dose 3,375 grams	Piperacillin/Tazobactam 100 mg/kg IV Max dose 3,375mg Meropenem 20 mg/kg IV Max dose 1 gram	Up to 48-72 hours

[1] Alternative agent recommended when a confirmed allergy to a first-line agent or another contraindication is present
[2] Up to 48 hours of therapy may be considered for patients with Gustillo Type II

Table 2: Treatment of Open Fractures intra-operatively and post-operatively

Antibiotic	Intra-op dose (mg/kg)	Intra-op max per dose (mg)	Intra-Op Re-Dosing Interval (Determined by GFR)				Post-Op Dose Timing (Assumes normal renal function)
			Normal GFR>60	GFR 30-60	GFR 10-29	GFR <10; Dialysis	
Cefazolin	**40**	**2000 (3000 if >100 kg)**	**Q3H**	Q6H	Q8H	N/A	8 hrs after last intra-op (Change to 25 mg/kg, 2000mg max)
Ceftriaxone	**50**	**2000**	**Q12H**	Q12H	Q12H	Q12H	24 hrs after last intra-op
Clindamycin	**10**	**900**	**Q6H**	Q6H	Q6H	Q6H	6 hrs after last intra-op (Change to 600mg max)
Metronidazole	**15**	**1000**	**Q12H**	Q12H	Q12H	Q12H	8 hrs after last intra-op (Change to 10mg/kg, 500mg max)
Piperacillin/Tazobactam (Dose in Pip+Tazo)	**100**	**3375**	**Q2H**	Q3H	Q6H	Q8H	6 hrs after last intra-op
Meropenem	**20**	**2000**	**Q4H**	Q6H	Q8H	N/A	8 hrs after last intra-op (Change to 1000mg max)

4.0 REFERENCES

4.1. Abdelgawad, A.A.M.D.D.S. and E.M.M.D. Kanlic, Orthopedic Management of Children With Multiple Injuries. Journal of Trauma-Injury Infection & Critical Care, 2011. 70(6): p. 1568-1574.

4.2. Hauser, C.J., C.A. Adams Jr, and S.R. Eachempati, Prophylactic antibiotic use in open fractures: An evidence-based guideline. Surgical Infections, 2006. 7(4): p. 379-405.

4.3. Pace, J.L., M.S. Kocher, and D.L. Skaggs, Evidence-based review: Management of open pediatric fractures. Journal of Pediatric Orthopaedics, 2012. 32(SUPPL. 2): p. S123-S127.

4.4. Walton, R., et al., Immediate care of open extremity fractures: Where can we improve? BioMed Research International, 2014. 2014.

4.5. Weber, D., et al., Time to initial operative treatment following open fracture does not impact development of deep infection: A prospective cohort study of 736 subjects. Journal of Orthopaedic Trauma, 2014. 28(11): p. 613-619.

4.6. Schenker, M.L., et al., Does timing to operative debridement affect infectious complications in open long-bone fractures? A systematic review. Journal of Bone and Joint Surgery - Series A, 2012. 94(12): p. 1057-1064.

4.7. Pollak, A.N., et al., The relationship between time to surgical débridement and incidence of infection after open high-energy lower extremity trauma. Journal of Bone and Joint Surgery - Series A, 2010. 92(1): p. 7-15.

4.8. Stewart Jr, D.G., R.M. Kay, and D.L. Skaggs, Open fractures in children: Principles of evaluation and management. Journal of Bone and Joint Surgery - Series A, 2005. 87(12 I): p. 2784-2798.

4.9. Weant, K.A., Antibiotic Prophylaxis for Open Fractures in the Emergency Department. Advanced emergency nursing journal, 2015. 37(1): p. 23-29.

4.10. Hoff, W.S., et al., East practice management guidelines work group: Update to practice management guidelines for prophylactic antibiotic use in open fractures. Journal of Trauma - Injury, Infection and Critical Care, 2011. 70(3): p. 751-754.

4.11. Skaggs, D., Effect of delay of surgical treatment on rate of infection in open fractures in children. Journal of pediatric orthopaedics, 2000. 20(1): p. 19-22.

4.12. Skaggs, D.L., et al., The effect of surgical delay on acute infection following 554 open fractures in children. The Journal of Bone & Joint Surgery, 2005. 87(1): p. 8-12.

4.13. Mendelson, S., Early versus late femoral fracture stabilization in multiply injured pediatric patients with closed head injury. Journal of pediatric orthopaedics, 2001. 21(5): p. 594-599.

4.14. Hedequist, D., Early Versus Delayed Stabilization of Pediatric Femur Fractures: Analysis of 387 Patients. Journal of orthopaedic trauma, 1999. 13(7): p. 490-493.

4.15. Amorosa, L.F., High-energy Pediatric Pelvic and Acetabular Fractures. The Orthopedic clinics of North America, 2014. 45(4): p. 483-500.

4.16. Shore, B.J., et al., Pediatric pelvic fracture: A modification of a preexisting classification. Journal of Pediatric Orthopaedics, 2012. 32(2): p. 162-168.

4.17. Banerjee, S., Paediatric pelvic fractures: 10 years experience in a trauma centre. Injury, 2009. 40(4): p. 410-413.

4.18. Marmor, M., Short-term pelvic fracture outcomes in adolescents differ from children and adults in the National Trauma Data Bank. Journal of children's orthopaedics, 2015. 9(1): p. 65-75.

4.19. Zhang, H., Fanelli, M., Adams, C., Graham, J., & Seeley, M. (2017). The emerging trend of non-operative treatment in paediatric type I open forearm fractures. *Journal of children's orthopaedics*, *11*(4), 306-309.

4.20. Elia, G., Blood, T., & Got, C. (2020). The Management of Pediatric Open Forearm Fractures. *The Journal of hand surgery*, *45*(6), 523-527.

4.21. Singh, A., Bierrum, W. R. N., Wormald, J. C. R., & Eastwood, D. M. (2020). Non-operative versus operative management of open fractures in the paediatric population: A systematic review and meta-analysis of the adverse outcomes. *Injury*, *51*(7), 1477-1488.

4.22. Bankhead-Kendall B, Gutierrez T, Murry J, Holland D, Agrawal V, Almahmoud K, Pearcy C, Truitt MS. Antibiotics and open fractures of the lower extremity: less is more. Eur J Trauma Emerg Surg. 2019 Feb;45(1):125-129. doi: 10.1007/s00068-017-0847-x. Epub 2017 Dec 16. PMID: 29248992.

4.23. Salomon B, Griffard J, Patel J, Wideman M, Mcgee T, Corbitt N, Rowe AS, Price C, Heidel R, McKnight CL. Efficacy of Cefazolin versus Ceftriaxone for Extremity Open Fracture Management at a Level 1 Trauma Center. Surg Infect (Larchmt). 2022 Sep;23(7):675-681. doi: 10.1089/sur.2022.049. Epub 2022 Aug 4. PMID: 35925762.

4.24. Rodriguez L, Jung HS, Goulet JA, Cicalo A, Machado-Aranda DA, Napolitano LM. Evidence-based protocol for prophylactic antibiotics in open fractures: improved antibiotic stewardship with no increase in infection rates. J Trauma Acute Care Surg. 2014 Sep;77(3):400-7; discussion 407-8; quiz 524. doi: 10.1097/TA.0000000000000398. PMID: 25159242.

4.25. Okike K, Bhattacharyya T. Trends in the management of open fractures. A critical analysis. J Bone Joint Surg Am. 2006 Dec;88(12):2739-48. doi: 10.2106/JBJS.F.00146. PMID: 17142427.

5.0 APPROVALS

All revisions of this guideline are approved by the Trauma Services Department. This guideline is reviewed every three years or sooner if deemed necessary. Authority for this document resides with the Trauma Services Department. This guideline is approved by the Trauma Services Manage and the Director of Trauma Services.

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