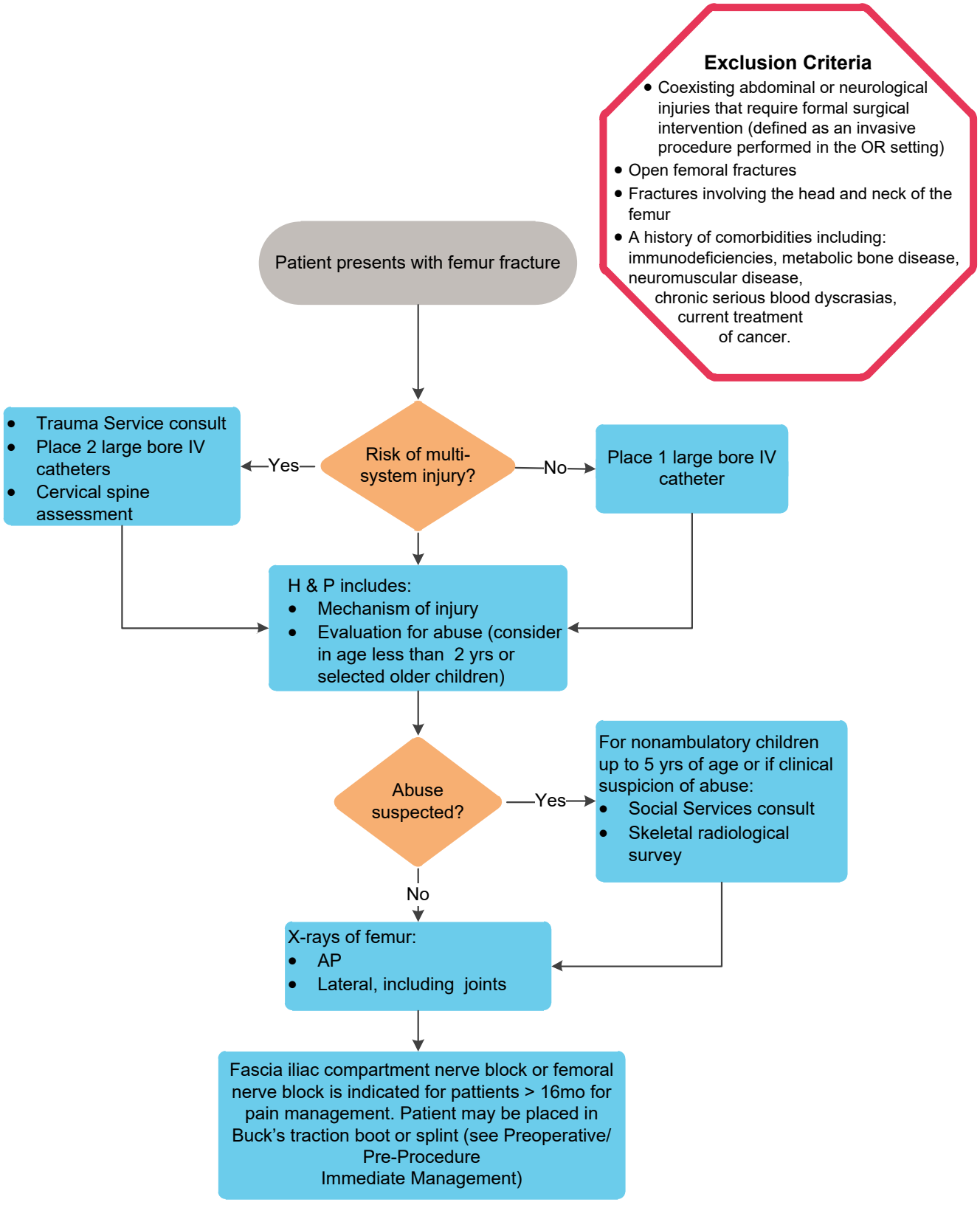
FEMORAL SHAFT FRACTURE

ALGORITHM- Initial Management of Femoral Shaft Fractures



SUMMARY

EVALUATION

- History and Physical Exam
  - History should include the mechanism of injury. Fractures may be caused by direct or indirect force, stress or fatigue of the bone, or they may be pathologic in origin
  - It is recommended, when abuse is suspected, that a consult with the Child Protection Team or medical social work be conducted to facilitate mandated reporting if necessary
  - Assess the cervical spine and the possibility of multi-system injury and document findings prior to fracture
  - Assess affected extremity with a complete neurovascular exam, including findings suggestive of compartment syndrome

CLINICAL MANAGEMENT

- Pre-operative/Pre-procedure Immediate Management
  - It is recommended that the emergency medicine physician, in coordination with Trauma Services, coordinate the care of the femur fracture patient who is in the emergency department (ED)
- Operative/Procedural Selection
  - Selection of treatment option should be guided by the patient's age, weight, and degree of skeletal maturity
- Timing of Surgical Repair (not applicable for spica casting)
  - Surgical intervention should be completed following appropriate clearance for surgery based on:
    - Trauma status, anesthesia risk, and assembly of appropriate members of the surgical team (within 18 hours of the injury)
- Post-operative Activity (not applicable for spica casting)
  - Physical therapy session(s) should begin once the patient has returned to the hospital room and has fully recovered from anesthesia

LABORATORY STUDIES | IMAGING

- Laboratory studies
  - Routine lab testing and crossmatch are not recommended for otherwise healthy patients with isolated femoral shaft fractures
- Imaging
  - Obtain an anterior-posterior (AP) view x-ray of the femur, including the joints above and below the suspected fracture
  - Obtain an AP pelvis x-ray in children 6-18 years of age weighing greater than 18kg if surgery is being considered
  - When abuse is suspected, obtain a skeletal survey in children less than 2 years of age or for selected children 2 to 5 years of age

THERAPEUTICS

- Pain Management
  - Fascia iliac compartment nerve block or femoral nerve block is recommended for patients ≥16 months with the exception of multiply injured patients or fractures involving the head or neck of the femur
  - See Table 1 for summary of recommended pain medications and doses

TABLE OF CONTENTS

TARGET POPULATION

Inclusion Criteria

- Patients who present with a closed femoral shaft fracture as their primary injury

Exclusion Criteria

Patients with:

- Coexisting abdominal or neurological injuries that require formal surgical intervention (defined as an invasive procedure performed in the OR setting)
- Unstable multitrauma
- Open femoral fractures
- Fractures involving the head and neck of the femur
- A history of comorbidities including: immunodeficiencies, metabolic bone disease, neuromuscular disease, chronic serious blood dyscrasias, current treatment of cancer

INITIAL EVALUATION

History and Physical Exam

- It is recommended that Trauma Services be consulted when the nature of the injury includes[1-3]:
  - motor vehicle collision (greater than 40 mph), unrestrained passenger
  - motor vehicle vs. pedestrian or bike
  - fall greater than 2 meters
  - possible child abuse including elevated LFT's, hematuria or abdominal bruising
  - any other mechanism that may place the patient at risk for multi-system injury[4]
- History should include the mechanism of injury. Fractures may be caused by direct or indirect force, stress or fatigue of the bone, or they may be pathologic in origin[5,6].
- It is recommended, when abuse is suspected, that a consult with the Child Protection Team or medical social work be conducted to facilitate mandated reporting if necessary [5-8].
  - The following circumstances are cause for suspicion of abuse:

        - discrepancy between the history and the degree of injury
        - inconsistencies in the history
        - delay seeking medical advice
        - repeated trauma, especially when treatment is sought in different locations
        - inappropriate parental response or noncompliance[6,8]
    - No significant difference in femur fracture patterns has been found when proven cases of child abuse are compared to a control group[6,9-11]
    - Among young children who sustain femoral shaft fractures, the likelihood of child abuse is much higher in non-walking children (42%), than in walking toddlers up to four years of age (2.6%)[12]
- Assess the cervical spine and the possibility of multi-system injury and document findings prior to fracture reduction[13]
    - Spinal injury must be assumed to be present in the child with multiple injuries until proven otherwise via clinical criteria in all cases and radiographic examination in selected cases[13]

CLINICAL MANAGEMENT

Preoperative/Pre-Procedure Immediate Management

- It is recommended that the emergency medicine physician, in coordination with Trauma Services, coordinate the care of the femur fracture patient who is in the emergency department (ED). This includes:
    - Establishing and monitoring effective pain management [21]
        - at all handoff of care, communicate and continue use of the same age-appropriate pain score
        - Fascia iliaca compartment nerve block 23 or femoral nerve block is recommended for patients ≥16 months of age
    - Establishing intravenous (IV) access and fluid management,
    - Obtaining appropriate consultation based upon clinical presentation, and
    - Collaborating with and supporting the attending surgeons/physicians who provide definitive care
    - Early evaluation of splinting applied in the pre-hospital setting, and an orthopedic consult for:
        - any fracture requiring splinting, or
        - any improperly applied splint [21]
            - Traction splints applied in the field should be removed as soon as possible to reduce the risk of nerve palsy and skin breakdown (*E*)
    - Patients should not be in Hare traction for >6 hours. Depending on the age of the child, location of fracture, and attending provider preference, patient may be placed in Buck's traction boot or splint
        - If patient is placed in Buck's traction, please consult the policy and procedure document for Skin Traction for Femur Fractures
        - Recommended traction weight by age (*E*):
            - 0 to 3 years: 1 to 2 pounds
            - 3 to 10 years: 2 to 5 pounds
            - 10 years and older: 5 to 10 pounds
    - Depending on the age of child, gender (consider for all females), and anticipated time until surgical correction of fracture, consider placing indwelling urinary catheter
- Place 2 large-bore peripheral intravenous catheters (PIV)
    - 2 PIV for children who have risk of multiple trauma or hypovolemia, in order to minimize risk and to facilitate a well-hydrated status, and
    - 1 PIV for children whose femur fracture is caused by a low energy trauma, such as a fall at play[24]

Operative/Procedural Selection

- Selection of treatment option should be guided by the patient's age, weight, and degree of skeletal maturity:
  - Patients less than 3 years of age and body weight usually less than 18 kg (40 lbs):
    - Immobilization via spica casting or other similar type of immobilization[25-33].
  - Patients 4-5 years of age, effective results of spica cast vs fixation (*J Bone Joint Surg Am*, 2016 Feb 17; 98 (4): 267 -275)

Note 1: Among 117 patients less than 6 years of age and treated with immediate immobilization via spica casting, 90.6% met defined parameters for successful reduction based on final x-rays[30].

Note 2: Waterproof cast liners may be used under spica casts. These liners have been shown to improve skin condition by decreasing maceration as well as improve hygiene by enhancing the ability to clean the cast effectively. Disadvantages include increased cost and the care that must be taken to prevent cutting the waterproof liner with the cast saw because it melts at high temperatures[34,35].

Note 3: Acceptable outcomes have been observed in selected patients discharged immediately to home from the Emergency Department. In a review of 145 femoral shaft fracture patients treated with spica cast placement, 33% met discharge criteria which required that the patient:

- be awake
- be alert
- tolerate oral intake
- have no concurrent social issues
- have no other injuries requiring admission or observation, and
- sustained a low energy mechanism of injury, not requiring extended observation[30].

Note 4: In infants, a Pavlik harness is an option for immediate mobilization. Advantages of its use may include:

- decreased risk of skin complications,
- ease of application without general anesthesia,
- minimal hospitalization,
- ease of reduction,
- ability to adjust the harness (and therefore the fracture alignment) if the reduction is lost,
- minimal cost, and
- ease of feeding, bonding with, and changing diapers on the infant[31,32].

- Patients 3 to 6 years of age
  - Various options can be considered including spica casting as described, or flexible nailing vs submuscular plating based on fracture type and family preference.
- Patients 6 to 12 years of age and body weight usually 18 to 45.5 kg (40 to 100 lbs):
  - Flexible intramedullary nailing results in equivalent or superior clinical and functional outcomes while minimizing hospital stay and the need for cast immobilization[36-39].

Note 1: Certain patients in this treatment category may have complex and/or comminuted femoral shaft fractures. In these situations, bridge plating of the femoral shaft fracture may be considered[40,41](*E*).

Note 2: In the setting of distal third pediatric femoral shaft fractures, *in vitro* biomechanical data suggest that retrograde flexible nail insertions could be beneficial.

Note 3: Comparisons between external fixation and flexible intramedullary nailing related to malunion and other parameters have not been studied[25,42].

- Patients 13 to 18 years old and body weight greater than 45.5 kg (100 lbs): antegrade locked intramedullary nailing [43].

Note 1: The decision to use antegrade locked intramedullary nails (versus flexible intramedullary nailing) is made based upon the patient's weight and adequate bone maturity, as assessed by radiographic exam[8,44,45].

Note 2: In those patients with an open growth plate adjacent to the capital femoral epiphysis (generally this includes girls under the age of 13 years and boys under the age of 15 years) the possibility of avascular necrosis

of the femoral head may be minimized if the greater trochanter is used as a starting point instead of the piriformis fossa[43,44,46-52](*E*).

  - flexible intramedullary nailing may be selectively used in this group with good clinical results[39].

Timing of Surgical Repair

(Not applicable for spica casting)

- Surgical intervention should be completed following appropriate clearance for surgery based on:
  - trauma status,
  - anesthesia risk, and
  - assembly of appropriate members of the surgical team (usually within 24 hours of the injury)[13,53,54](*E*).

Note 1: A delay of surgical repair beyond 24 hours of the injury may be associated with pulmonary complications, especially for patients with multiple injuries[54].

Note 2: Prompt stabilization and reduction of a femoral fracture can decrease pain, decrease length of stay (LOS) and avoid complications[55].

Postoperative Activity

(Not applicable for spica casting)

- Physical therapy session(s) should begin once the patient has returned to a hospital room and has fully recovered from anesthesia[36,90-94].

Note: Converting PIVs to saline locks as soon as possible in the postoperative period will increase mobility and ease instruction.

- Physical therapy sessions for surgical patients should include instruction on:
  - transfer training;
  - bed mobility;
  - exercise (ankle pumps, quadriceps sets, gluteal sets, internal and external hip rotation, hip abduction/adduction in supine, and straight leg raises); and
  - wheelchair management and/or mobility training[90,92,93].
- Mobilization with physical therapy is recommended on post-operative day 1 with toe touch weight bearing as tolerated based on the surgeon's assessment of post-operative stability.
- It is recommended that patients be discharged to home with a wheelchair postoperatively for long distances if appropriate.

Nursing Care – procedure specific

- In order to prevent skin breakdown, promote comfort and prevent cast soiling in children with a spica cast:
  - Elevate the head and upper body to allow gravity to pull urine and stool away from the cast,
  - Reposition patient periodically, and
  - "Petal" the edges of the cast[95]
- Elevate the fractured extremity to decrease pain and swelling [96-98].

Treatment of Elevated Temperature

- It is recommended that a septic workup ***not*** be completed for patients with temperature spikes to 38.5° C (101.3° F) or less.

Note: Hematomas associated with femoral shaft fracture has been shown to be a common cause of temperature elevation.

Compartment Syndrome

- If the diagnosis of compartment syndrome is suspected based on clinical examination, the orthopedic team should be notified to evaluate the patient promptly.

Note 1: Compartment syndrome occurs when local nerve and muscle becomes ischemic as a result of increased interstitial tissue pressure preventing capillary perfusion[100].

Note 2: Compartment syndrome is characterized by a tense swollen thigh, increasing pain (out of proportion to the injury), paresthesia, paresis, and increased compartment pressure[99,101,102].

Note 3: It has been shown that compartment syndrome may occur in conjunction with femoral shaft fractures in children[102,103].

LABORATORY STUDIES | IMAGING

Laboratory Assessment

- Routine laboratory testing and crossmatch are not recommended for otherwise healthy patients with isolated femoral shaft fractures[18,19].

Note: Hypotension and significant decreases in hematocrit have not been shown to occur in this patient population[11,18-22].

Radiologic Assessment

- Obtain an anterior-posterior (AP) view x-ray and a lateral view x-ray of the femur, including the joints above and below the suspected fracture.
- Also obtain an AP pelvis x-ray in children age 6 to 18 years with a weight greater than 18 kg (40 lbs) (for whom surgery is being considered, see recommendation #12), to evaluate the status of growth plates near the proximal femur as well as to aid in ruling out the presence of femoral neck fracture[14 15].
- When abuse is suspected, in children less than two years of age or for selected children two to five years of age[6,16,17]. Obtain a standard skeletal survey
- Obtain an anterior-posterior (AP) view x-ray and a lateral view x-ray of the uninjured femur at the discretion of the attending orthopedic surgeon.

THERAPEUTICS

Pain Management

See Table 1 for summary of recommended doses for pain medications.

- It is recommended that pain be routinely assessed using standard age appropriate scales[56,57].
  - Valuable information regarding pain management may also be obtained through the measurement of physiologic changes, behavioral observation, and caregiver/parental input[57].

Procedure specific recommendations for pain management

  - Spica cast:
  - Pharmacologic sedation should be used for children undergoing fracture reduction with a spica cast. In selected cases the treating surgeon may also opt for other methods including fascia iliaca compartment or femoral nerve block, hematoma block and/or general anesthesia[58-61].

- Surgical incision:
  - For patients whose treatment includes surgical incision, the incision should be infiltrated with a local anesthetic at the conclusion of the surgical procedure[58,59,62].

Note 1: Wound infiltration with local anesthetic has been shown to decrease postoperative analgesic requirements[62].

Note 2: In children undergoing elastic stable intramedullary nailing, a hematoma block (with ropivacaine) can effectively aid in early postoperative pain control[63].

- For the mid-shaft femur fracture, fascia iliaca compartment nerve blocks (FICNB) or femoral nerve blocks (FNB) using ropivacaine should be considered an appropriate adjunct for aiding in the control of postoperative pain for up to eight hours[64-66].

Note 1: FNB are more effective for mid-shaft than for proximal or distal femoral fractures because the ends of the femur receive additional innervation from the sciatic and obturator nerves[64-66].

Note 2: If several administrations of local anesthetic are considered (e.g. hematoma block and wound infiltration), total dose of all injections must be calculated to avoid toxicity.

- It is recommended that around-the-clock analgesia dosing be used rather than a pro re nata (PRN) schedule. Around-the-clock dosing has been associated with more effective analgesia and increased patient satisfaction[62,67].

Note: Infants less than three to six months of age have reduced clearance of morphine and may be at higher risk for adverse effects than older children[68].

- For patients who can take medications by mouth (PO), consider:
  - mild pain – administer acetaminophen
  - moderate-severe pain – administer acetaminophen with hydrocodone or oxycodone
  - mild to moderate pain, and as an adjunct for more severe pain – consider ibuprofen administration[57,69].

Note 1: Adequate pain management may necessitate the coordination of activities among healthcare professionals such as premedicating for pain before a physical therapy session *(E)*.

- For children who are unable to take medications by mouth (NPO) or require additional pain control, consider:
  - IV opioid medications[62,77];
  - IV ketorolac [69,78-80];
  - hematoma block (with bupivacaine)[63];

- indwelling femoral nerve catheter *(E);*
- multi-modal therapy *(E).*

Note: The co-administration of ketorolac with morphine may result in decreased use of opioids and in improved pain relief[78].

- It is recommended that diazepam be administered as needed to relieve muscle spasms.

Note: Use with caution in neonates and young infants as metabolism of diazepam is decreased. The active metabolite, desmethyldiazepam, can accumulate with repeated use causing increased toxicity[81,82].

Surgical Site Infection Prophylaxis

(Not applicable for spica casting)

- It is recommended that one dose of IV cefazolin, 40 mg/kg of body weight (maximum dose 2000 mg), be administered 0 to 60 minutes prior to incision to decrease the risk of surgical site infection [83-87].

This recommendation follows the principles of antibiotic prophylaxis:

- This procedure is classified as a Class I – clean wound as per CDC Guidelines;
- Cefazolin is long-acting, safe, and inexpensive[87].

Note 1: There is no evidence that additional reduction in risk of infection is realized with multiple, versus single, preoperative dosing of prophylactic antibiotics[83,84].

Note 2: For patients with penicillin allergy, it is recommended that IV clindamycin, 10 mg/kg of body weight (maximum dose 900 gm), be the alternative antibiotic of choice[87]. Vancomycin use is discouraged as it promotes emergence of vancomycin-resistant organisms[88].

Note 3: Reduced risk of wound infection has been demonstrated with prophylactic antibiotics administered up to two hours before surgery[85].

- It is recommended, to assure adequate blood levels, that a second dose of antibiotics be administered after three hours of operating time prior to wound closure[87,89].

DISCHARGE CRITERIA

- Discharge to home is appropriate when the following criteria have been met:
  - adequate pain management;
  - family/caregivers demonstrate ability and willingness to care for child at home including safe transfers;
  - necessary home equipment delivered;
  - absence/resolution of postoperative complications;
  - tolerating diet;
  - able to void;
  - Social Services notified for safe discharge for suspected child abuse cases and others as appropriate.
- It is recommended, when possible, that follow-up appointments with Orthopedic Surgery (and Physical Therapy for patients with flexible intramedullary nailing) be scheduled before discharge, and when not possible, that the family be counseled regarding the need to schedule these appointments as soon as possible.

FOLLOW-UP

First Outpatient Visit – procedure specific

- It is recommended that patients be seen for orthopaedic outpatient follow up (to include biplanar x-rays of the fractured femur) within 2 to 6 weeks of the day of their injury, depending on fracture pattern and stability. This visit is aimed at identifying the small but real percentage of patients whose fracture will "slip" thus losing adequate reduction.

PATIENT | FAMILY EDUCATION

- Education for the patient and family should:
  - begin upon admission and continue throughout the hospital course;
  - be geared to the developmental age of the patient and the learning abilities of the family/caregivers;
  - promote understanding of treatment options, care of the child after discharge and activity alterations[95,104];
  - include assessment of the accessibility of the bathroom and sleeping area in the home as well as access to school and requirements for individual school's home tutoring[105];
  - address relevant topics including treatment plan, cast care, diapering/toileting, pain management, skin care, nutrition, repositioning, recreational activities, use of automobile restraint, selection of durable medical equipment (DME), school coordination and follow up[95,104,105].
- It is recommended that all children, including those who must wear a body cast (spica cast) as part of their femur fracture care, utilize automotive restraint systems appropriate for age and weight[106-108].
- **Note**: If a disability parking placard is needed by the family, a prescription may be written certifying that the patient has an "orthopaedic condition" for a specific time duration.
- It is recommended that families of all children with fractured femurs be advised to provide 24-hour attendance through the recovery course, since limited mobility increases the risk of further accidental injury. The child may overestimate his/her own ability, be overzealous in interactions with siblings/peers and have limited ability to react to home disasters such as fires.
- It is recommended that children be re-entered into the school system as soon as possible in order to maintain school performance:
  - address explicit concerns regarding accessibility (stairs, toileting, etc), and
  - make arrangements for home tutoring if the school is unable to accommodate the child's medical needs[105].

TABLE 1. PAIN MEDICATIONS AND DOSING

Medication	Indication	Dose	Frequency	Route	Maximum Dose *(the lowest of either the mg/kg/dose or mg/dose)*	Comments
Morphine (less than 6 months of age)	• Perioperative, around-the-clock analgesia • Patients on NPO status	0.03 to 0.05 mg/kg	Observe closely, repeating doses based on observed effects	IV	0.1mg/kg/dose	Reduced clearance of morphine in this age group
Morphine (greater than 6 months of age)	• Perioperative, around-the-clock analgesia • Patients on NPO status	0.05 to 0.1 mg/kg starting dose 0.2 mg/kg max	Every 2 to 4 hours	IV	Infants: 2 mg Children: 1 to 6 years: 5 mg Children 7 to 12 years: 8 mg Adolescents: 15 mg	In opioid naïve patients, start with lower dose and repeat if needed
Ketorolac	• Perioperative, around-the-clock analgesia • Patients on NPO status	0.5 mg/kg	Every 6 hours	IV	30 mg *or* 0.5 mg/kg/dose	Maximum duration = 48 hours
Acetaminophen	Mild pain	Per standardized dosing		Oral	Oral : 500 mg Rectal: 650 mg	Use as adjuvant for moderate to severe pain.
Acetaminophen with Oxycodone	Moderate to severe pain	0.05 to 0.15 mg/kg (dosing based on oxycodone)	Every hours	Oral	10 mg of oxycodone/dose (2 tablets/dose) *or* 0.15 mg/kg/dose	Use caution when prescribing multiple products containing acetaminophen
Acetaminophen with Hydrocodone	Moderate to severe pain	0.2 mg/kg (dosing based on hydrocodone)	Every 4 hours	Oral	0.2 mg/kg/dose *or* Less than 2 years: 1.25 mg/dose 2 to12 years: 5 mg/dose Greater than12 years: 10 mg/dose	Use caution when prescribing multiple products containing acetaminophen
Oxycodone	Moderate to severe pain	0.05 to 0.15 mg/kg	Every 4 hours	Oral	10 mg/dose *or* 0.15 mg/kg/dose	
Ibuprofen	• Mild to moderate pain • Adjunct for more severe pain	5 to 10 mg/kg	Every 6 to 8 hours	Oral	800 mg/dose or 3200 mg/day *or* 10 mg/kg/dose	
Diazepam	Muscle spasms	0.1 mg/kg	Every 4 to 6 hours	Oral or IV	5 mg/dose *or* 0.2 mg/kg/dose	Use with caution in neonates and young infants
Ondansetron	Post-operative nausea/vomiting	Per standardized dosing	Every 6 hours	Oral or IV	4 mg *or* 0.15 mg/kg/dose	
Ropivacaine 0.2% *or* Bupivacaine 0.25% with epinephrine 1:200K	Local anesthetic for fascia iliac compartment nerve block	Children less than 20 kg: 0.75 mL/kg Children greater than 20 kg: 0.5mL/kg	Once		0.75 mL/kg or 30 mL for patients less than 20 kg 0.5mL/kg or 30 mL for patients greater than 20kg	In order to detect inadvertent intravascular injection, the therapeutic dose should be preceded by a test dose of 0.1ml/kg of 0.25% bupivacaine (or 1-1.5% lidocaine) with 1:200k epinephrine; ECG should be monitored for T wave changes for 30 seconds. The therapeutic dose should be injected with a 22g B-bevel (block or short bevel) needle incrementally with frequent pauses and aspirations, and ECG continually monitored.
Ropivacaine 0.2% *or* Bupivacaine 0.25% with epinephrine 1:200K	Local anesthetic at conclusion of surgical procedure	0.3-0.4 mL/kg	Once		0.5ml/kg or 30 mL for patients greater than 20kg	In order to detect inadvertent intravascular injection, the therapeutic dose should be preceded by a test dose of 0.1ml/kg of 0.25% bupivacaine (or 1-1.5% lidocaine) with 1:200k epinephrine; ECG should be monitored for T wave changes for 30 seconds. The therapeutic dose should be injected with a 22g B-bevel (block or short bevel) needle incrementally with frequent pauses and aspirations, and ECG continually monitored.

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Clinical Care Guideline and Measures Review Committee – approved prior to committee formation

MANUAL/DEPARTMENT	Clinical Pathways/Quality
ORIGINATION DATE	June 14, 2012
LAST DATE OF REVIEW OR REVISION	March 15, 2019 (Colorado Springs alignment)
COLORADO SPRINGS REVIEW BY	 Michael DiStefano, MD Chief Medical Officer, Colorado Springs
APPROVED BY	 Lalit Bajaj, MD, MPH Medical Director, Clinical Effectiveness

REVIEW | REVISION SCHEDULE

Scheduled for full review on April 14, 2020

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