Long bone fractures are commonly encountered in the emergency room setting and are most frequently associated with vehicular trauma. Other causes of long bone fractures include gunshots and falls. Regardless of the cause, fracture management principles are identical:

- Patient stabilization.
- Local wound management if a wound exists.
- Fracture stabilization by external coaptation (if fracture configuration permits).
- Provision of adequate analgesia to the patient.

Definitive treatment of the fracture can then be postponed until any concurrent injuries have been addressed and the patient is considered stable. Immediate immobilization of long bone fractures prevents further soft tissue and neurovascular damage and decreases the risk of fracture ends penetrating the skin to create an open fracture.

**DIAGNOSTIC CRITERIA**

**Historical Information**

**Age and Gender Predisposition:** None. Immature animals are susceptible to physeal injuries. Unsupervised outdoor dogs and cats (particularly intact males because of their increased roaming behavior) are more likely to become involved in vehicular trauma. Older dogs may develop pathologic fractures from neoplasia.

**Breed Predisposition:** None.

**Owner Observations:**

- Witnessing the traumatic event.
- Lameness of affected limb(s).

**Physiological Examination Findings**

Signs following trauma include:

- Lameness of affected limb(s), usually non-weightbearing.
- Pain (+ crepitus) on localized palpation.
- Soft tissue swelling/bruising.
- ± Injury to overlying skin (e.g., road rash, gunshot wound, penetration from underlying fracture fragment).
- ± Limb deformity.
- ± Bone fragments (if open fracture).

Animals with traumatic fractures (especially from vehicular trauma) often have concurrent external and internal injuries. Cardiovascular, pulmonary, urinary, and neurologic systems are most frequently injured. A complete physical examination is essential. If abnormalities are found, a differential diagnosis and diagnostic plan for each problem should be developed and additional diagnostic tests completed. Neurologic examination of the affected limb is difficult. At a minimum, deep pain sensation and voluntary movement should be evaluated.

**Inside this issue:**

**Peer-Reviewed Articles on**

1 Emergency Stabilization of Long Bone Fractures

6 Wound Management Using Sugar
Laboratory Findings
Laboratory abnormalities are not typical unless hemorrhage, internal organ system injury, or secondary bacterial infection has occurred. **Animals with high-energy trauma** should have full blood work (complete blood count, serum biochemistry profile) and urinalysis performed.

- Extensive soft tissue injury or secondary bacterial infection may produce an elevated WBC count with neutrophilia ± a left shift on a complete blood count. A concurrent stress leukogram may also exist. $\$_$
- Evidence of hemorrhage would be supported by a decrease in PCV/TP. $\$_$
- Serum biochemistry profile is often within normal limits unless there is concurrent internal organ system injury.
  - **Increased ALT/AST** indicates acute hepatocellular damage and is common in animals with vehicular trauma.
  - **Elevations in BUN/creatinine** usually arise from prerenal (dehydration/shock) or postrenal (urinary tract leakage) causes. $\$_$
- **Blood in the urine** on urinalysis suggests urinary tract trauma. These animals should be evaluated for urinary tract disruption. $\$_$
- Arterial blood gas analysis or pulse oximetry should be performed in animals with pulmonary lesions or respiratory signs. Animals with a $\text{PaO}_2 < 70 \text{ mmHg}$ or $\text{SaO}_2 < 94\%$ should receive oxygen supplementation. $\$_$

**Other Diagnostic Tests**
Definitive diagnosis of a fracture is made by radiography. A minimum of two orthogonal views of the affected region should be obtained. The contralateral (normal) limb may need to be radiographed to differentiate between radiolucent physes and fracture lines in immature animals. Stress radiographs may be necessary to diagnose intraarticular fractures (especially of the carpus and tarsus) because these types of injuries can present similarly to long bone fractures. Thoracic and abdominal radiographs should be performed in all animals with vehicular trauma. $\$_$$

- **Radiographs**—Show obvious bone malalignment, soft tissue swelling, ± gas pockets in the soft tissues surrounding the fracture site (open fractures). $\$_$$
- **Repeat electrocardiograms**—Performed for 48 hours after vehicular trauma to identify ventricular arrhythmias secondary to myocardial irritation or hypovolemia secondary to shock. $\$_$$

**Summary of Diagnostic Criteria**
- History of trauma or an event that led to the presenting complaint of acute lameness.
- Non-weightbearing lameness, soft tissue swelling, pain on palpation, ± skin wound on physical examination.
- Radiographic evidence of fracture.

**Differential Diagnosis**
There are many other causes of severe lameness ± soft tissue swelling, which are definitively ruled out radiographically by absence of a radiolucent fracture line. History (absence of trauma), signalment, physical examination, radiographs, and arthrocentesis are the main tools used to diagnose these conditions. Differential diagnoses include:

- **Cranial cruciate ligament rupture** (a very common injury)—Positive cranial drawer sign.
- **Joint luxation.**
- **Arthropathies**—Degenerative, immune mediated, or infectious; joint effusion on physical examination.
- **Developmental orthopedic diseases:**
  - Osteochondrosis dissecans
- **Root signature pain** (e.g., disk herniation)—Associated neck or lower back pain.
- **Soft tissue injury** (e.g., sprains, strains, tendon/ligament ruptures)—Physical examination findings (e.g., joint laxity); soft tissue swelling radiographically.

### TYPES OF OPEN FRACTURES

- **First-degree open fractures**—Created when skin is penetrated from the inside by bone fragment; wounds are usually <1 cm with minimal soft tissue contusion.
- **Second-degree open fractures**—Exist when wound is created from outside; wounds have a larger skin defect and more soft tissue contusion than seen with first-degree open fractures; increased wound contamination due to foreign material being dragged into wound at time of injury.
- **Third-degree open fractures**—Occur as a result of high-energy injuries from external sources (e.g., gunshot); extensive skin, soft tissue, and muscle injury and loss; neurovascular structures may be compromised.

### TREATMENT RECOMMENDATIONS

Treat for shock and other concurrent life-threatening conditions prior to addressing the fracture. Cover open wounds/fractures with a clean bandage with minimal pressure during emergency treatment. The principles of emergency fracture management are:

- Patient stabilization (first priority).
- Wound management.
- Fracture stabilization.
- Analgesia.
- Nursing care.

**Wound Management** (see box on page 4): Clean the wound and minimize contamination prior to surgical fixation.

- **Obtain cultures** from deep within the wound.
- **Cover the wound** with water soluble lubricant (sterile gel) so hair debris does not fall in during clipping.
- **Clip hair** around the wound.
- **Commence broad-spectrum systemic antimicrobial therapy** immediately. First-generation cephalosporins are a good choice while awaiting culture results (e.g., cefazolin: 20 mg/kg IV, SQ, or IM q8h).
- **Perform irrigation ± debridement.** First-degree open fractures usually require only wound cleaning (isotonic saline, lactated Ringer’s solution, or 0.05% chlorhexidine solution) and covering with a sterile dressing. More extensive second- and third-degree open fractures require copious wound irrigation and surgical debridement as soon as anesthesia can be safely administered.

- **Adhere to aseptic technique** for wound irrigation and debridement to minimize nosocomial contamination.

- **Use warm isotonic crystalloid fluids** (lactated Ringer’s solution or 0.9% saline) for wound irrigation. Chlorhexidine may be added (0.05% solution) for antiseptic properties and is safe to exposed tissue. Irrigate with a 60 ml syringe and 18 g hypodermic needle to generate necessary pressure.

- **Surgical debridement** requires removal of all devitalized tissue while preserving as much skin and soft tissue as possible and providing adequate drainage of dead space. Repeated surgical and mechanical debridement can be performed daily in place of anesthesia. Debridement needs to be conservative. Removing too much tissue may interfere with healing and subsequent limb function. When in
doubt, tissues should remain undisturbed.

- **Cover open wounds** with sterile wet-to-dry bandages (i.e., sterile gauze sponges soaked in isotonic saline/lactated Ringer’s solution, placed against the wound, and covered in sterile dry roll cotton).

- **Perform fracture fixation** as early as possible in patients with second- and third-degree open fractures.

### Fracture Stabilization

Temporary stabilization of long bone fractures should be performed when possible. Fracture stabilization requires immobilization of the joint above and below the fracture. Temporary fracture stabilization is easiest for fractures below the elbow and stifle.

- Fractures can be stabilized with a heavy cotton bandage alone (e.g., Robert Jones bandage) or (preferably) in conjunction with a splint.
  - Fractures below the mid-antebrachium and tarsus are best stabilized using a caudal splint (e.g., spoon splint).
  - Fractures of the mid-antebrachium, tibia, and tarsus are best stabilized using a lateral splint.
  - Temporary fracture stabilization is not usually performed for fractures of the shoulder, humerus, femur, elbow, and stifle.
  - A spica splint could be used for fractures of the proximal forelimb if necessary.
  - Femur fractures are best left immobilized.
  - Bandages placed proximal to the stifle and/or elbow joint (when possible) help decrease swelling, limit motion, and increase patient comfort.

### Analgesia

Early fracture stabilization is the most important factor in providing analgesia for patients with long bone fractures. Systemic opiates are the basis of analgesic drug therapy for fracture patients. They are usually administered intermittently and parenterally, although CRI dosages exist for some opiates. Pure opiates (e.g., morphine, oxymorphone, fentanyl) are preferred over partial opiates (e.g., butorphanol, buprenorphine) due to potency.

- Oxymorphone (Numorphan®): 0.05–0.1 mg/kg SQ, IM, or IV q4–8h. $\$
  - Morphine: 0.2–1.0 mg/kg SQ or IM q4–8h. $\$
  - Transdermal fentanyl (Duragesic®): Dosages are based on the relative size of the animal (Table 1). $\$
  - Butorphanol (Torbugesic®): 0.1–0.5 mg/kg SQ, IM, or IV q2–4h. Some references list higher SQ doses (up to 0.8 mg/kg in cats and 1.2 mg/kg in dogs). $\$
  - Buprenorphine (Buprenex®): 5–15 µg/kg IM or IV q6–12h. $\$
  - Consider epidural opiate administration ± local anesthetics for hindlimb injuries (e.g., preservative-free morphine [Duramorph®], 0.1 mg/kg). Epidural opiates can be used whenever the situation warrants (e.g., at time of presentation, cast application, or surgery). $\$
  - Consider concurrent use of NSAIDs (e.g., carprofen, ketoprofen, meloxicam, etodolac). $\$

#### TABLE 1 Dosages for Transdermal Fentanyl Patches

<table>
<thead>
<tr>
<th>Patient Weight</th>
<th>Dose</th>
<th>Fentanyl Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cats and dogs (&lt;10 kg) $^a$</td>
<td>25 µg/hr</td>
<td>2.5 mg</td>
</tr>
<tr>
<td>Dogs: 10–20 kg</td>
<td>50 µg/hr</td>
<td>5 mg</td>
</tr>
<tr>
<td>Dogs: 20–30 kg</td>
<td>75 µg/hr</td>
<td>7.5 mg</td>
</tr>
<tr>
<td>Dogs: &gt;30 kg</td>
<td>100 µg/hr</td>
<td>10 mg</td>
</tr>
</tbody>
</table>

$^a$ Cats and small dogs (<5 kg) may be dosed with half a patch, but do not cut the patch; instead, cover one half of the gel membrane with tape. Half patch dosing is suggested for pediatric, geriatric, and systemically ill cats and small dogs.
Nursing Care
- Strict cage rest with soft bedding.
- Provision of adequate nutrition and hydration.
- Bladder expression/placement of urinary catheter to prevent urine retention if patient is unable to walk.

Patient Monitoring
- Check bandages at least twice daily for wetness, odor, rub sores, and swelling of toes. Change bandages if any of these occurs.
- Second- and third-degree open fractures will need daily bandage changes until surgery is performed. Adhere to aseptic technique to minimize nosocomial contamination.
- Check body temperature at least daily (especially in dogs with open fractures) for an indication of infection.
- Evaluate patient frequently to ensure provision of adequate analgesia and to detect signs of opiate overdosing or adverse effects of other drugs (e.g., NSAIDs).
- If concurrent injury exists, monitor for deterioration of systemic signs.

Home Management
Owners may need to continue nursing care (strict cage rest, monitoring bandages, nutrition, antibiotic and analgesic therapy).

Treatment Contraindications
- Do not use pure opiate drugs and partial opiate drugs concurrently (especially avoid the use of butorphanol or buprenorphine in association with fentanyl patches).
- Transdermal fentanyl patches take 12–24 hours to reach therapeutic levels. Supplemental opiates (oxymorphone or morphine) are necessary in the first 12–24 hours to provide analgesia.
- Avoid overzealous movement of affected limb(s).

PROGNOSIS
Favorable Criteria
- Closed or first-degree open fractures have the same low infection rate.

UNFAVORABLE CRITERIA
- Second- and third-degree open fractures have higher bone infection rates.
- Loss of deep pain sensation in the affected limb.
- Extensive injury/ischemia to surrounding soft tissues.
- Concurrent systemic injury.
- Older, debilitated animals.
- Pathologic fractures secondary to neoplasia.
- Polytrauma.

ON THE NEWS FRONT
The authors have had success using granulated sugar as a source of debridement and decontamination for severe, degloving, and contaminated wounds. These wounds have been able to be closed sooner than expected based on the formulation of a healthy bed of granulation tissue. For more information, see the article that follows.

RESOURCE LIST
- Buprenorphine—Buprenex®, Reckitt Benckiser, Richmond, VA
- Butorphanol—Torbugesic®, Fort Dodge Animal Health, Fort Dodge, IA
- Oxymorphone—Numorphan®, Endo Pharmaceuticals, Chadds Ford, PA
- Preservative-free morphine—Duramorph®, Elkins-Sinn, Cherry Hill, NJ
- Transdermal fentanyl—Duragesic®, Janssen Pharmaceutical, Titusville, NJ

STANDARDS OF CARE: EMERGENCY AND CRITICAL CARE MEDICINE