CHAPTER 15

Emergency Management of Open Fractures

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Open fractures, defined as those in which fractured bone has been exposed to the external environment, represent between 5% and 10% of all fracture cases seen in small animal practice. Any open fracture must be considered contaminated and a source of potential infection. These fractures require immediate intervention and should be treated as surgical emergencies.

Open fractures have been classified into three types, based on the wounding mechanism and the degree of hard- and soft-tissue damage (Table 15-1). Type I open fractures are the result of the lowest energy trauma and are frequently associated with the sharp point of a fractured bone penetrating the skin from the inside. Wound size is generally less than 1 cm in length. There is little soft-tissue injury, wounds are often relatively clean, and there is no crushing component. The bone end may remain exposed but more commonly returns to lie beneath the skin. Fractures are usually transverse or oblique, with minimal if any comminution. The tibia and radius are common sites of type I open fractures in small animals because of the close proximity of bone to the skin in the antebrachium and crus.

In a type II open fracture an external force produces a penetrating wound that communicates with the fracture from the outside. Wounds are usually greater than 1 cm in length. These fractures have more severe soft-tissue injury and contamination. There is a minimal-to-moderate crushing component to skin and musculature, and fractures may be comminuted. These fractures are about twice as likely to become infected as type I open fractures. Common examples include bite wounds and certain low-velocity gunshot fractures.

Type III open fractures are caused by high-energy trauma from an external source and are characterized by severe soft-tissue damage and contamination. There is often soft tissue or bone loss, and bone may be stripped of soft-tissue attachments. There is generally a severe crushing component. Fractures are usually highly comminuted, and repair may result in cortical defects. Risk of infection is considered about four times that in a type I open fracture. Examples are degloving injuries with underlying fracture and high-velocity gunshot injuries.

INITIAL ASSESSMENT AND EMERGENCY MANAGEMENT

Treatment of an open fracture should be started at home. Owners are instructed to minimize all limb manipulation and to cover the wound and exposed bone with a sterile dressing if possible. A clean cloth or diaper is an appropriate alternative if bandage materials are not available. Owners should be warned that injured animals may bite, and they should consider placing a muzzle if necessary. Compression is usually sufficient to control hemorrhage during transport to the hospital. Initial veterinary management is directed toward evaluation and treatment of other potentially life-threatening injuries unless the wound is inadequately covered or is hemorrhaging profusely (Box 15-1). In this situation a sterile dressing and pressure wrap should be applied. Ligation of actively bleeding vessels is occasionally required. Bone protruding from the wound should not be reduced into the wound at this time since this allows additional contamination of the fracture site.

Evaluation of the stabilized patient is begun with a thorough case history. Owners are questioned regarding the cause of the injury and the environment in which the injury occurred. It is significant whether the animal was "run into" or "run over" because in the latter situation a significant crushing component is more likely. The environment where the injury occurred may help determine potential wound contaminants and dictate the choice of future antibiotic therapy.

Initial wound evaluation should be directed toward a careful assessment of the neurologic and vascular status of the limb since they may alter treatment options. Simple diagnostic tests include clipping a toenail short to check for active bleeding, evaluation of extremity pulses distal to the wound, limb temperature assessment, and patient recognition of extremity sensation. Although the degree of wound contamination and apparent soft- and bony-tissue trauma should be determined, limb manipulation must be minimized, and wound probing avoided because they increase contamination, cause vascular damage, and result in pain. Potential problems associated with small puncture wounds should not be underestimated because debris may be under the skin, deep in the wound and medullary cavity. Preliminary deep wound cultures should be obtained at the time of initial wound evaluation. In humans 50% to 70% of open fractures produce positive results when cultured at presentation, and in 66% of cases the bacteria cultured at presentation are the same as those isolated later in infected wounds.

After the wound is assessed and cultured, radiographs are obtained, and a more functional immobilization dressing is applied. The purpose of this bandage is to prevent additional contamination, preserve vasculature, and decrease pain. Most organisms that are recovered from the

Table 15-1

Classification of Open Fractures

Classification	Wounding Mechanism	Soft Tissue and Bony Damage	Common Fracture Configuration	Relative Risk of Infection
Type I	Bone fragment protrudes outward from within	Minimal	Transverse, oblique	1
Type II	Penetrating external wound contacts bone	Moderate	Some comminution	2
Type III	Severe external force causes wound	Severe	Severe comminution	4

wound after the development of an orthopedic infection can be traced to the hospital; thus early protection of the wound is critical. Sterile dressings should be used in all cases, and strict asepsis maintained. A splint is generally applied to support open fractures below the elbow or stifle, whereas a spica-type bandage is required to immobilize fractures more proximal on the limb. Fractures proximal to the elbow or stifle are frequently difficult to immobilize properly, and in many cases it may be preferable simply to cover the wound and confine the animal to a small cage.

Antibiotics are always indicated for animals with open fractures because all wounds are contaminated and wounds that occurred longer than 6 to 8 hours before definitive surgical débridement and lavage are infected. In humans antibiotics administered within 3 hours of injury significantly decrease the rate of future wound infection. Risk of infection may be greater in animals with open fractures because of decreased host defense mechanisms caused by stress, or vascular compromise. Choice of antibiotic is based on the cause of injury, nature of the wound, likely bacterial contaminants, and knowledge of commonly isolated bacteria from patients with osteomyelitis. *Staphylococcus* spp. cause between 50% and 60% of bone infections in dogs, and many of these infections are monomicrobial. In general, concerns about penetration of antibiotics into bone interstitial fluid are unfounded.

First-generation cephalosporins such as cefazolin (Kefzol, Lilly, 20 mg/kg q8h) are often the initial drugs of choice because they are broad spectrum, can be given intravenously, are usually effective against β-lactamase–producing *Staphylococcus* spp., and are relatively inexpensive. If contamination with a gram-negative organism is expected, a fluoroquinolone antibiotic such as enrofloxacin (Baytril, Bayer, 5 mg/kg SQ q24h) or a penicillin-derivative such as imipenem (Primaxin, Merck, 5 to 10 mg/kg IV q6-8h) may be added. Anaerobic infections are more common than previously thought, and clindamycin (Antirobe, Upjohn, 5 to 10 mg/kg PO q12h) or metronidazole (Flagyl, Searle, 25 to 40 mg/kg PO q12h) should be considered in addition to first-generation cephalosporins in animals with severely necrotic, avascular wounds. The initial choice of antibiotic is altered when culture and sensitivity test results become available. In type I and II open fractures that are not infected, antibiotic use can be discontinued immediately after fracture repair. In any type III open fracture or in type I or II open fractures that are infected, more prolonged use is indicated. In general, antibiotic therapy is continued for about 1 month in these cases. Antibiotics can be discontinued at that time if there is no clinical or radiographic evidence of infection.

Recognition of pain is difficult in dogs and cats because even animals with severe pain may show no overt clinical signs. Open fractures are associated with extensive pain and anxiety in humans, and a similar situation is expected in animals. Pain should be treated with narcotic analgesics. In general, pure opioid agonists such as hydromorphone (Dilaudid, Abbott, 0.05 to 0.1 mg/kg IV q6h) or oxymorphone (Numorphan, Dupont, 0.05 to 0.1 mg/kg IV or IM q6h) should be used to treat the severe pain associated with an open fracture (see also Chapter 2). A dermal fentanyl patch may be an adjunct for providing longer-term analgesia.

Box 15-1

Treatment Protocol for Management of Patients With Open Fracture

1. Evaluate patient status and treat life-threatening injuries.
2. Control hemorrhage.
3. Place sterile dressing and bandage during patient stabilization.
4. Assess vascular and neurologic status of limb.
5. Obtain preliminary deep wound culture.
6. Start antibiotic therapy.
7. Manage pain.
8. Obtain radiographs.
9. Perform definitive surgical débridement and fracture fixation within 6-8 hours if possible.

SURGICAL DÉBRIDEMENT

Patients with open fractures frequently require long hospitalization, multiple surgical procedures, and expensive medications; thus, before initiating definitive wound management and fracture repair, owners should be apprised carefully of the potential prognosis and cost. It is essential that the veterinarian communicate treatment options and prognosis in a manner that allows clients to understand the situation and then make rational, realistic decisions for themselves and their pets. An estimate in writing of the anticipated expense and treatment should be provided. Limb amputation may be a necessary alternative in some cases. Definitive surgical débridement of the open fracture wound should be performed as soon as safely possible, preferably within 6 to 8 hours after injury. This period is considered the "golden period" in which the wound is contaminated but bacteria have not had the opportunity to multiply and spread through adjacent tissues. If the patient is not yet stable for anesthesia, initial débridement can be attempted with a local anesthetic or a regional anesthesia technique such as an epidural. Neuroleptanalgesia can also be considered.

Surgical preparation and removal of gross debris may be performed in the surgical preparation area, but definitive débridement is performed in the operating room. Most orthopedic infections originate from hospital organisms, thus strict aseptic technique is important. Sterile water-soluble gel can be placed in the wound to avoid contamination with hair while clipping. A water-impermeable barrier is placed between the limb and the rest of the body and surgery table during débridement to prevent wicking of contaminated fluids from the environment into the operative field.

The goal of surgical débridement is to convert a contaminated wound to a clean one. All foreign material and contaminated or dead tissue is removed, but undermining wound edges and extensive soft tissue dissection are avoided. Sharp dissection technique is preferred. Dependable features for predicting viability of muscle are ability to bleed, consistency, and contractility. Although commonly used, color is actually a relatively poor criterion because it depends greatly on the available light. If viability is questionable, it is better to leave tissue in place and remove it if necessary during a second procedure. As a guideline for débriding bone, if the bone has no soft-tissue attachment and is not critical for reconstruction of the fracture, it is excised. Bone that has no soft-tissue attachment but is critical for fracture reconstruction should be saved. Any bone that has good soft-tissue attachment is saved in the fracture site.

Wounds are irrigated with liters of isotonic saline or 0.05% chlorhexidine. Tap water has been used for wound irrigation but is not recommended because the hypotonicity of tap water may potentiate cellular damage. There is little evidence for incorporation of antibiotics into lavage fluids in dogs and cats. A pulsating irrigation delivery system is helpful, or lavage can be accomplished with a 35-ml syringe and an 18-gauge needle. Bullets retrieved from gunshot fracture wounds should be saved because of the potential for future litigation. A deep wound culture is obtained at the end rather than the beginning of surgery because this has been shown to correlate better with later infection.

FRACTURE REPAIR

Fracture fixation is performed as soon as safely possible, preferably during the initial wound débridement. If immediate fixation is planned, the operative field, the equipment, and the surgeon's gown and gloves should all be changed after the wound débridement. Rigid stabilization of the fracture increases patient comfort, improves blood supply to the tissues, facilitates wound healing, and promotes resistance to infection.

A number of techniques can be used for fracture repair. In general, after surgical débridement type I open fractures can be treated in the same manner as a closed fracture. Higher-grade open fractures require special consideration when planning repair. External coaptation with splints and casts is rarely appropriate since wound care is difficult and stabilization is generally inadequate. Use of intramedullary pins is avoided if possible, because they impede medullary circulation, may spread bacteria through the medullary cavity, and when used alone do not provide rigid stabilization. Bone screw and plate fixation can be used, but placement of a large metallic foreign body at the fracture site is a disadvantage. Implants potentiate bacterial proliferation because the surfaces become covered with glycolipid, which allows *Staphylococcus* spp. and other gram-positive organisms to adhere. The extensive open surgical approach required for bone plating also further compromises vascularity. Despite these limitations, rigid fixation with a bone plate and screws is generally acceptable and usually results in uncomplicated healing.

External skeletal fixation is generally the fixation technique of choice, since fixation pins can be placed away from damaged tissue and rigid stabilization is possible. External skeletal fixation is economical, readily available, and does not require specialized equipment. The wound can be visualized and treated as needed. The Ilizarov ring external skeletal fixator may be particularly useful in these patients because very small fixation pins under tension are used.

Autogenous cancellous bone grafts are indicated in many open fractures, since cortical defects are common and these fractures may heal slowly because of vascular and soft-tissue damage. Transplanted cancellous bone facilitates bone healing by means of osteoconductive, osteoinductive, and osteogenic properties. Cancellous bone grafts rarely become infected, and, when they do, they undergo harmless liquefactive necrosis. The graft should be collected with a separate set of equipment and gloves to avoid contamination of the graft site. Alternately a combination of cancellous allograft and demineralized bone matrix providing osteoconductive and osteoinductive properties can be obtained commercially (Osteo-Allograft Mix, Veterinary Transplant Services). In severely avascular wounds bone grafting should be delayed 1 to 2 weeks to allow sufficient proliferation of granulation tissue to provide vascular support for the graft. If delayed grafting is performed, the incision should be through previously undamaged tissue if possible. Although cortical allografts have been used successfully in open fractures, they are not recommended, because the risk of sequestration and resorption is high. Autogenous vascular bone grafts transplanted by microsurgery may prove beneficial in the future.

WOUND CLOSURE

Wound closure can be performed if débridement results in a surgically clean wound with adequate vascularity that can be closed without tension. Dead space drainage should be accomplished with aseptically placed closed suction drains. In general, more severe type II and all type III open fractures should be handled as open wounds with delayed primary or secondary closure. If there is any doubt, it is always better to leave the wound open.

References and Suggested Reading

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