CRUSH INJURIES OF THE FOOT

Stephen V. Corey, DPM

T.E. Pitts, DPM

The treatment of severe crush injuries involving the foot can be extremely complex. Many physicians find it difficult to treat crush injuries of the foot since the degree of damage to the surrounding bone and soft tissue is often deceptive. These compression type injuries may involve skin lacerations, soft tissue loss, fractures, tendon lacerations, and neurovascular compromise. The authors will present several important concepts in the evaluation and treatment of these injuries. These concepts will be useful in the management of crush injuries whether the extent of the trauma ranges from digital injuries to those involving the forefoot and/or rearfoot.

INITIAL EXAM

A detailed history of the injury should be obtained from the patient and/or witnesses. The mechanism of the injury will help the physician in determining the extent of tissue trauma as well as the chance for coexisting body injuries. Coexisting body injuries should always be suspected in the patient who presents with major foot trauma.

The vascular status of the foot is of primary importance in the initial examination of the acutely injured extremity. The classic signs of arterial insufficiency include decreased skin temperature, pallor, pulselessness, pain, paralysis, and paresthesia. The most remarkable signs of vascular insufficiency in the foot will be the color and temperature changes of the injured area. Palpation of pedal pulses is not a reliable test for arterial insufficiency in the traumatic foot due to the amount of edema associated with these injuries. If a pedal pulse is non-palpable, then a doppler ultrasound examination, including digital waveforms may provide additional information if time permits. A consultation with a vascular surgeon may also be beneficial in the perioperative treatment of severe crush injuries. The vascular exam should frequently be repeated in the presence of vascular compromise.

The neurologic status of the foot is sometimes difficult to assess due to the highly emotional state of the patient. Each dermatome of the foot should be evaluated for sensation. Lack of sensation distal to the injury may result from laceration of a sensory nerve supplying the affected dermatome, or from compression secondary to edema.

Evaluation of the musculoskeletal system is also difficult due to the amount of pain associated with a crush injury. All of the muscles of the foot and leg should be tested when possible. A tendon rupture or dislocation of a joint should be suspected when the digit and/or foot is abnormally positioned, or when a functional deficit is present. Radiographs consisting of at least three x-rays should be performed to rule out fractures and dislocations commonly associated with crush injuries.

INITIAL MANAGEMENT

After the initial clinical exam has been performed and the x-rays have been reviewed, the physician will determine if the patient's foot requires surgical treatment. Minor open crush injuries involving well-aligned fractures may be treated in the emergency room or private office. Injuries involving

major soft tissue loss, lacerated tendons, open fractures, or lacerated vital neurovascular structures will require surgical treatment.

Minor Crush Injuries

Treatment of minor crush injuries in the E.R. or private office includes:

1. Cultures
2. X-rays
3. Irrigation
4. Debridement of necrotic tissue
5. Closure (if relatively clean, <12 hours)
6. Dressing/Immobilization
7. Antibiotic/Tetanus prophylaxis

The protocol for tetanus prophylaxis should be followed as recommended by the Committee on Trauma of the American College of Surgeons. The committee's guidelines are listed in Table 1.

Irrigation of the wound should be performed using a high pressure system. A 10 cc syringe with an 18 gauge blunt tip needle can be used to create enough pressure. Irrigation in this manner will serve to mechanically debride the wound. Irrigation may be performed with sterile saline or a dilute anti-bacterial solution, such as betadine or chlorahexadine. Skin lacerations should be loosely approximated to allow for drainage, and prevent necrosis of skin edges. Antibiotic selection should be based on the potential infecting organisms and results of a Gram's stain. Remember that when treating this type of injury, antibiotic prophylaxis is no substitute for thorough local wound care. A follow-up examination in 48-72 hours to evaluate the status of the wound concerning viability and infection is extremely important.

TABLE 1

PROTOCOL FOR TETANUS PROPHYLAXIS

Tetanus History

A) Immunization & booster < 5 yrs ago.
B) Immunization, but no booster in last 5-10 yrs.
C) Old, dirty wound/ incomplete immunization/no booster 10yrs.

Tetanus Prophylaxis

Not necessary
0.5 m/s of tetanus toxoid booster.
0.5 m/s of tetanus toxoid plus 250 units of tetanus immune globulin (TIG).

MAJOR CRUSH INJURIES

Pre-Operative

Treatment of major crush injuries hinges on the amount of vascular compromise to the foot. If significant compromise is present, the patient needs to go to surgery immediately for decompression and re-vascularization. Local wound care is usually delayed until surgery, since a severe amount of pain is already present with this injury. A Gram's stain and culture of the wound may be obtained prior to surgery. A dry, sterile dressing should be applied. If bleeding persists, a compression dressing may be applied until hemostasis can be addressed in the operating room. Prophylactic antibiotics should be started while the patient is in the emergency room or at least prior to surgery. Most author's recommend an IV cephalosporin such as Ancef (Cefazolin) or Zinacef (Cefuroxime) for initial antibiosis. If the patient's injury occurred in an area where livestock dwell or where clostridia is likely to harbor, then penicillin should be administered as part of the antibiotic regimen. Tetanus prophylaxis should be employed according to the regimen previously mentioned.

The appropriate laboratory studies should be ordered based on the history and physical exam and age of the patient. While these patients often present with severe pain, it is important to remember that the informed consent should be signed prior to the administration of any narcotic analgesic in uncomplicated cases. Toradol, an IM non-steroidal anti-inflammatory agent, is an effective pain reliever and may be a useful adjunct in those cases where administration of a narcotic analgesic is delayed.

Intra-operative

Once in the operating room, a thorough decompression and debridement should be performed with removal of all foreign debris. Irrigation with 3 - 5 liters of saline or dilute antibacterial solution is recommended with this type of injury, since a

considerable amount of soft tissue damage is present. Intra-op cultures should be obtained prior to surgery if no cultures were taken preoperatively. Viability of the soft tissues should be grossly assessed and any non-viable soft tissue and muscle should be sharply excised. Debridement of bone remains controversial, however most authors recommend saving any bone fragments that will add to the stability of the involved bony structure when re-attached. The primary objective of this surgery is to assure vascular stability. Reduction of any fracture or dislocation should be delayed if it will jeopardize perfusion to the foot or digits.

If vascular stability is achieved, fractures and dislocations can be reduced and stabilized with K-wires. Plate and screw fixation may also be utilized in certain instances for additional stabilization. Lacerated tendons are then re-approximated under physiologic tension. Any exposed bone is covered by deep fascia when possible. Skin lacerations are loosely re-approximated to prevent necrosis of skin edges. If vascular compromise to a digit or portion of the foot is present, then aggressive debridement of the area in question should be avoided, and the dysvascular tissue should be allowed to demarcate over the next several days to weeks.

Postoperative

Following surgery, ice and elevation of the extremity should be avoided to facilitate arterial perfusion to the digits. Hanging the leg in a dependent position should also be avoided since this may cause excessive edema which could lead to constriction of blood vessels. The neurovascular status of the digits should be evaluated frequently. A significant change in the vascularity of a digit may require the removal of sutures or fixation devices. The first dressing change is usually performed within 48-72 hours in order to evaluate the wounds for viability and infection. Any open wounds may require daily dressing changes with irrigation and packing with gauze. Additional debridements at bedside or in the O.R. may also be necessary. Depending on the size and location of the open wound, a delayed primary closure of the defect may be performed once the wound is clean and without evidence of infection or the wound may be left to heal by secondary intention. Skin grafting and other reconstructive techniques may also be required. The foot should be immobilized and elevated upon discharge to decrease edema formation and prevent delayed healing as well as hypertrophic scar formation.

BIBLIOGRAPHY

Bolognini N, Goldman F: Management of Major Forefoot Trauma *J Foot Surg* 24:88-98, 1985.

Graziano TA, Snider DW, Steinberg RL: Crush and Avulsion Injuries of the Foot *J Foot Surg* 23: 445-450, 1984.

Heckman JD, Champine, MJ: New Techniques in the Management of Foot Trauma. *Clin Orthop* 240:105-114, 1989.

McAndrew JP, Lantz BA: Initial Care of Massively Traumatized Lower Extremities *Clin Orthop* 243:20-29, 1989.

Reis ND, Michaelson M: Crush Injury to the Lower Limbs *J Bone Joint Surg* 68(A)L 414-418, 1986.