PUNCTURE WOUNDS OF THE FOOT

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Puncture wounds of the foot are a relatively common problem confronting the physician. Patients sustaining this seemingly innocuous injury frequently receive inadequate therapy. Often an incomplete clinical history is recorded in the emergency room followed by superficial cleansing of the involved foot, inappropriate antibiotic coverage, and tetanus prophylaxis[1]. Many patients do not even seek medical attention for the injury. Although most patients do well with such treatment, serious complications can develop such as cellulitis, retained foreign bodies, and osteomyelitis. Many injuries are caused by nail punctures which constituted 98% of the injuries in one large study[2]. Other objects identified as causing such injuries are glass, tree branches, and wire.

HISTORY

The goal of taking a history is to determine the potential for contamination and depth of the wound. The information should include the type of penetrating object, the condition of the material, location in which the injury occurred, depth of penetration, and type of foot covering worn during the injury. An accurate history of tetanus prophylaxis must be obtained since such injuries carry an increased risk for development of tetanus. Upon completing an accurate history a proper treatment plan can be developed and carried out.

TREATMENT

Treatment should include adequate tetanus immunity, cleansing of the wound, removal of any foreign bodies, provision of a path for drainage, and appropriate antibiotic coverage.

Patients who have no or an incomplete history of tetanus immunization require a full series of immunization. This consists of three doses of 0.5 ml of tetanus toxoid given intramuscularly. The second dose of this toxoid should be administered four to six weeks after the initial dose, and a third dose should be given six to 12 months after the second. The patient should also be given 250-500 units of tetanus immune globin, depending upon the condition of the wound. The dose should be given intramuscularly at a different site from the toxoid.

Patients who provide a history of adequate immunization but have not had a booster in the last five years require administration of 0.5 ml of the tetanus toxoid intramuscularly [if the wound is older than 24 hours or considered tetanus prone.] Clean wounds only require a booster if tetanus immunization has been administered within the last ten years[3].

The history should serve as a guide to how aggressively the wound should be treated. Mechanical cleansing with a scrub brush and dilute povidone iodine or chlorhexidine solution should be the initial step. Sterile saline or sterile water should be used as the diluent instead of tap water due to possible contamination with *pseudomonas aeruginosa*[4]. Most patients will not tolerate this cleansing well and will require a local anesthetic. Anesthesia can be accomplished by a posterior tibial nerve block or through infiltration of anesthesia in the area of the puncture wound (Fig. 1). After cleansing, the wound should be probed to determine the depth and path of the puncture (Fig. 2). Adequate probing may require enlargement of the wound or debridement of the wound edges. Wounds which penetrate the deep fascia or a joint space tend to have a greater risk for infection[5].

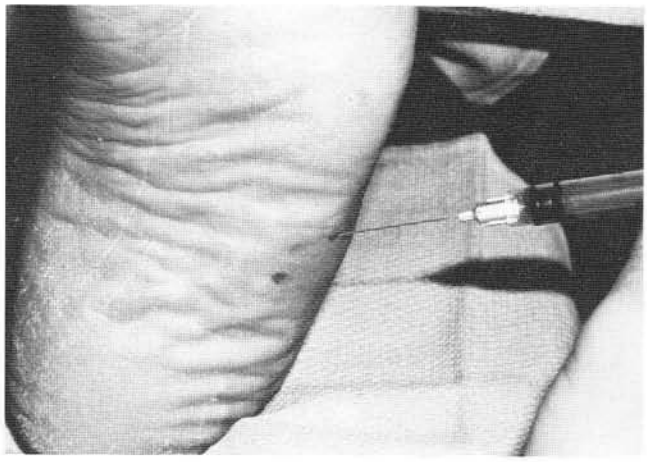

Fig. 1. Anesthesia may be obtained through local infiltration around the puncture site (as shown) or by a tibial nerve block.

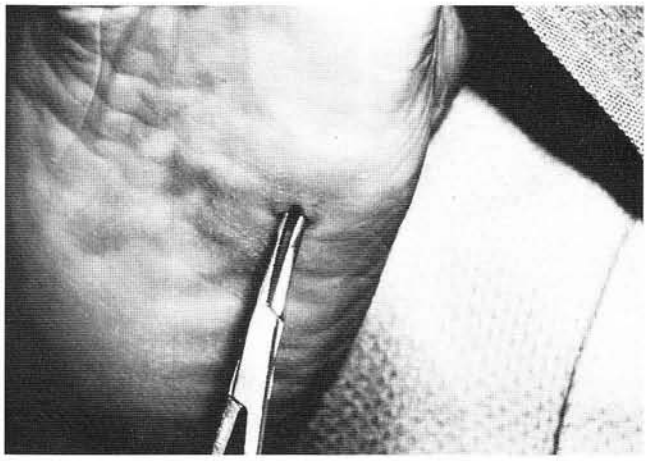

Fig. 2. Probing of the wound is necessary to determine the depth and path of the injury, and to identify any foreign bodies.

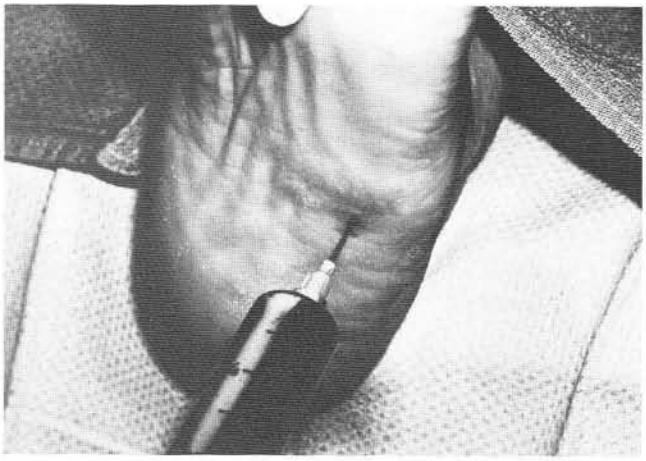

Fig. 3. Irrigation with a dilute disinfectant allows for proper cleansing and mechanical debridement of the wound.

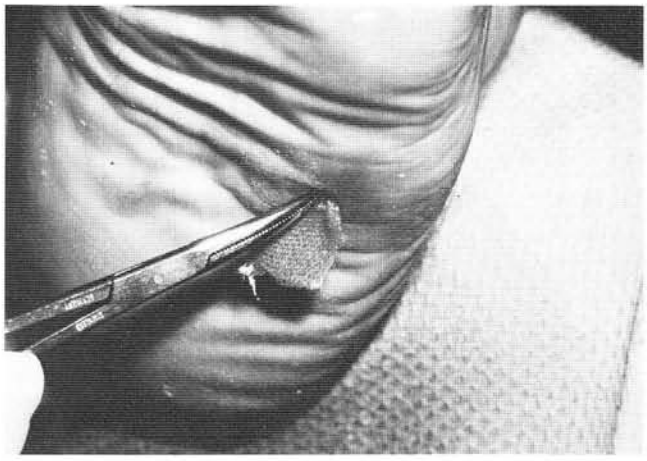

Fig. 4. A drain prevents premature closure of the wound.

Pedal x-rays should be taken to determine if any foreign bodies remain. Often the implanted material is of a non-metallic nature such as wood, plastic, rubber, or fabric and therefore, cannot be seen by routine radiographs. The use of xeroradiography may be helpful in these cases. If a foreign body cannot be removed with gentle probing a surgical excision may be necessary.

High pressure irrigation using a 20 cc syringe and an 18 gauge blunt-tipped needle should be performed after adequate probing of the puncture (Fig. 3). This allows for irrigation and mechanical debridement of the wound. A drain should be placed in the wound to allow for adequate drainage and prevent premature closure of the wound (Fig. 4). The wound should be dressed with a sterile compressive dressing. The patient should be instructed to be non-weight bearing and should have a follow-up appointment in three to four days.

The use of antibiotics is controversial. No antibiotic therapy can take the place of adequate debridement and irrigation of the wound. Antibiotic selection will be discussed in the section on complications.

COMPLICATIONS

The three most serious complications that result from a puncture wound of the foot are cellulitis, osteomyelitis, and retention of a foreign body[6]. Infections develop in about 8-15% of the patients following a puncture injury[7]. Cellulitis, secondary to gram positive organisms, accounted for the majority of these cases[8]. The most common organism isolated is *staphylococcus aureus*. The

second most common organism is beta hemolytic *streptococcus*[8]. Therefore empiric therapy should consist of a beta lactamase resistant penicillin (oxacillin, cloxacillin, dicloxacillin). Dicloxacillin at 12-25 mg. per kg. per day given every six hours is the drug of choice due to its high serum levels. In patients who exhibit a true penicillin allergy, erythromycin orally or vancomycin intravenously may be used as a substitute. Therapy should be continued for a minimum of seven days with a usual course of approximately 10 days. Oral cephalosporins should be considered second-line drugs due to their inferior coverage of the most commonly found organisms[9]. More serious infections may require incision and drainage and intravenous antibiotics.

Osteomyelitis can be a devastating complication of puncture injuries. *Pseudomonas aeruginosa* is, without question, the most common organism responsible. Johanson first reported this prevalence in 1969[10]. He termed this injury osteochondritis since the site of involvement usually involves cartilaginous tissue. Since that time many authors have reported this occurrence in both children and adults[11-16]. The reason for the prevalence of pseudomonas as a cause of osteomyelitis following puncture wounds is a matter of speculation. The early literature contended that the overuse of penicillin was the cause[17]. It was felt that the use of penicillin caused a decrease in the gram positive population in the wound and *pseudomonas aeruginosa* was then left uninhibited to flourish. The use of tap water, which may harbor pseudomonas, in the solution that was used for foot soaks was thought to be a source of contamination[4]. At this time it is still recommended that sterile solutions be used to prevent this possible source of contamination.

In the early 70s shoe gear was implicated as the possible source of contamination of the wound. Studies performed by Fritz[16] and Goldstein[18] did not recover pseudomonas from either the inside or the outside of children's footwear. However, in a study performed by Fisher, in 1984, he recovered *pseudomonas aeruginosa* from the inner layers of the soles of sneakers[19]. The organism was not present in new sneakers that were examined. However, when the soles became worn and the inner layers became damp, a suitable environment is created for the growth of pseudomonas. Using a special enzyme typing, he proved that the same organism present in the wound corresponded with that found in the inner layers of the sole. Similar results were reported by Jacobs and Rice in 1986.[20] Therefore, the inner layers of the sole are a probable source of these pseudomonas infections.

Pseudomonas aeruginosa has a high predilection for cartilaginous tissue (the physeal plate or the articular surface). Pseudomonas is frequently responsible for bacterial infections of the external ear (perichondritis) and for other cartilaginous structures including sternal chondral joints and intervertebral discs[10]. The relative avascularity of this tissue allows the organism to multiply and survive. It then penetrates the bone leading to osteomyelitis.

Fig. 5A. A 25 year old male who sustained a puncture wound plantar to the first metatarsophalangeal joint. A. No apparent radiographic changes on initial x-rays.

Fig. 5B. Severe erosion of the tibial sesamoid noted. 19 days after the injury the sesamoid was subsequently excised.

The clinical and laboratory presentations of this pathogen are well documented[10,17]. The course usually begins with a decrease in clinical signs and symptoms following the initial care of the injury. However, localized tenderness, erythema and edema return to the puncture site usually one to three weeks following the initial incident. Constitutional symptoms are usually negligible; absent or low grade fever, no elevation in the white count, and a moderate elevation in the erythrocyte sedimentation rate. Radiographic changes are not appreciated until 10 to 14 days following the clinical symptoms (Fig. 5A,B).

The treatment of pseudomonal osteomyelitis is a mixture of surgical and pharmacologic therapy. The literature reports that clinical improvement cannot be expected until after adequate debridement of all involved tissues.[21] Simple drainage or joint aspiration was not effective in eradicating infection when bone or cartilage was involved. This can be explained by the fact that cartilage being relatively avascular receives poor penetration of the antibiotic.

Presumptive antibiotic therapy should include a combination of an aminoglycocide and an anti-pseudomonal penicillin[22]. The patient's serum creatinine, serum drug levels, urine, auditory function and balance should all be evaluated and monitored while receiving aminoglycocides due to their potential nephro- and ototoxicity. These potential side effects cause many physicians to turn to mono drug therapy with a third generation cephalosporin. Single drug therapy has not been shown to be effective against pseudomonal osteomyelitis[9]. Ceftazidime has exhibited some success in clinical cases, however, a modest amount of resistance has been reported when the agent was used alone[9]. Imipenem, a new antibiotic, has also met a significant amount of organism resistance, thus limiting its utilization[9].

The quinilones, such as ciprofloxacin, show great promise in the treatment of pseudomonas osteomyelitis. Ciprofloxacin achieves excellent bactericidal levels in bone when given parenterally as well as orally[23]. However, greater time and experience is necessary to determine the possible development of resistance. Due to the devastating consequences of re-occurrence of osteomyelitis, this author recommends the use of combination therapy to insure proper eradication of the organism.

The duration of antibiotic coverage following debridement is a matter of controversy. The usual time recommended for the treatment of osteomyelitis is four to six weeks. However, Jacobs reported in his study that only 10-14 days is necessary following adequate surgical debridement of the involved tissue[21]. Most authors, however, agree that six weeks of intravenous antibiotics is indicated with an absolute minimum of four weeks[22].

Retained foreign bodies occurs in about 3% of the patients seeking medical attention for puncture wounds of the foot[8]. Objects commonly found are small pieces of footwear or socks. The foreign body may cause granuloma and/or abscess formation. Such circumstances require incision and drainage with retrieval of the object.

SUMMARY

Puncture wounds of the foot are relatively common injuries, especially in the summer months. Although these injuries are often regarded as innocuous, serious sequela can develop. Treatment of acute injury should consist of a thorough history, proper tetanus immunization, aggressive wound irrigation and debridement, removal of any foreign objects and antibiotic coverage if indicated. Cellulitis, osteomyelitis and retained foreign bodies are the most common complications which follow puncture injuries. These complications should be carefully evaluated and treated to prevent devastating disability.

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