Conferences and Reviews

Soft Tissue and Bone Infections From Puncture Wounds in Children

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We report on the prevalence of osteomyelitis, the prevalence of soft tissue infections, and the type and number of pathogens encountered in bone and soft tissue infections caused by puncture wounds in children. In addition, we seek to establish whether shoe gear plays a role in the flora in infected puncture wounds and if laboratory indices are indicative of the presence of infection. The group consisted of 44 nondiabetic children admitted to hospital for puncture wounds of the foot. Cultures were positive for osteomyelitis in 7 patients (16%), all involving the forefoot ($P < .04$). The most common pathogen in soft tissue infections was *Staphylococcus aureus.* The most common pathogen in osteomyelitis was *Pseudomonas aeruginosa.* There was no significant difference in the prevalence of osteomyelitis and soft tissue infection based on footwear. There were no cases of osteomyelitis encountered among barefoot children ($P < .04$). In 10 cases (83%), *P aeruginosa* infection (both soft tissue and bone) occurred while the patients were wearing tennis shoes ($P < .04$). In this study, the leukocyte count (normal in 29 patients [66%]), erythrocyte sedimentation rate (normal in 28 patients [64%]), and temperature (normal in 44 patients [95%]) did not have any predictive value in differentiating soft tissue infection from osteomyelitis in children.

(Laughlin TJ, Armstrong DG, Caporusso J, Lavery LA. Soft tissue and bone infections from puncture wounds in children. West J Med 1997 Feb; 166:126–128)

Complications from puncture wounds of the foot are relatively common. About 1% of all emergency department visits by children are for the treatment of puncture wounds, 15% of whom present initially with signs of infection.[1] The medical literature primarily involves isolated case reports or small case series of children with *Pseudomonas aeruginosa* osteomyelitis.[2] Most reports have focused primarily on osteomyelitis. Several studies have suggested that shoe gear may play a role in the type of flora encountered in infected puncture wounds.[3] Other reports have suggested that laboratory indices such as the erythrocyte sedimentation rate may be helpful in guiding therapy.[4,5] We report on the characteristics of osteomyelitis and soft tissue infections due to puncture wounds in children, detailing the type and number of pathogens encountered. We seek further to establish whether shoe gear plays a role in the flora detected in infected puncture wounds and if laboratory indices are indicative of the presence of infection.

Patients and Methods

Participants in this study were children admitted to the emergency department of the University of Texas Health Science Center at San Antonio's University Hospital for the treatment of clinically apparent foot infections precipitated by a puncture wound. Admissions from January 1, 1985, to January 1, 1992, were reviewed. Patients were identified using the *International Classification of Diseases, 9th Revision, Clinical Modifications* (ICD-9-CM) code E920.8.[6] The group consisted of 44 nondiabetic children, 37 boys and 7 girls, with an average age of 9.0 ± 3.7 years (± standard error of the mean) and a range of 3 to 17 years. The vast majority of patients were Hispanic (36 [82%]), and 8 (18%) were white.

All patients had plain foot radiographs taken on admission. All were treated with incision, drainage, and exploration of the puncture site, followed by the collection of soft tissue specimens for gross and microscopic analysis and cultures. Each patient received parenteral antibiotics during the hospital stay. The diagnosis of osteomyelitis was based on microbiologic and pathologic analyses. The diagnosis of soft tissue infection was based on positive soft tissue cultures and clinical evidence of infection—some or all of pain, loss of function, warmth, redness, and purulent drainage.

A normal leukocyte count was defined as 4.0 to 11.0 $\times 10^9$ cells per liter (4,000 to 11,000 cells per mm^3).[7] The erythrocyte sedimentation rate (ESR) was measured

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ABBREVIATIONS USED IN TEXT

CI = confidence interval
ESR = erythrocyte sedimentation rate
OR = odds ratio

using the Westergren method.[8] A normal ESR was defined as 0 to 20 mm per hour. A normal temperature was defined as less than 38.3°C (<101.0°F).

Analysis was done using χ^2 and Fisher's exact tests with the odds ratio (OR) and associated 95% confidence interval (CI) to compare independent ordinal variables. A Mann-Whitney U test was used to compare differences in age, length of stay, laboratory values, and intervals of treatment of osteomyelitis and soft tissue infections. A χ^2 test for trend (χ^2_{trend}) was used to compare the proportion of puncture wounds in the forefoot, midfoot, and rear foot in both groups. Forefoot injuries were defined as punctures that involved the metatarsals and toes, the midfoot included the tarsals, and rear-foot injuries involved the heel and talus (Figure 1). For all tests, we used an alpha of .05.[9,10]

Results

A total of 44 patients with a mean age of 9.0 ± 3.4 years were admitted to the hospital for the treatment of infected puncture wounds of the foot. The vast majority of puncture wounds (n = 37) occurred in boys (84%). The average length of hospital stay was 8.2 ± 9.4 days. Children with osteomyelitis were significantly older (11.7 ± 3.5 versus 8.4 ± 3.6 years, $P < .05$) and had a longer hospital stay (23.0 ± 16.4 versus 5.8 ± 4.5 days, $P < .0001$) than children with soft tissue infections. The most common location on the foot to receive a puncture wound was the forefoot. There was a trend toward fewer puncture wounds as one moved proximally in the foot ($\chi^2_{trend} = 27.1$, $P < .0001$). The location of puncture wounds is shown in Figure 1. All cases of osteomyelitis occurred in the forefoot ($P < .04$, OR and CI = infinity), with the most common location being the first metatarsal head (71%, n = 5).

The mean interval from puncture wound to admission was 4.3 ± 10.8 days. The mean interval from puncture to surgical treatment was 6.8 ± 11.6 days. There was no significant difference between admission or surgical intervals based on sex or the presence of osteomyelitis.

The most commonly encountered bacterium on soft tissue culture was *Staphylococcus aureus*, which was present in 20 (54%) cultures. This was followed by *Staphylococcus epidermidis* (19%, n = 7) and *Pseudomonas aeruginosa* (16%, n = 6). The most common pathogen in bone infections was *P aeruginosa*, which grew out of 6 (86%) bone cultures. These data are summarized in Table 1.

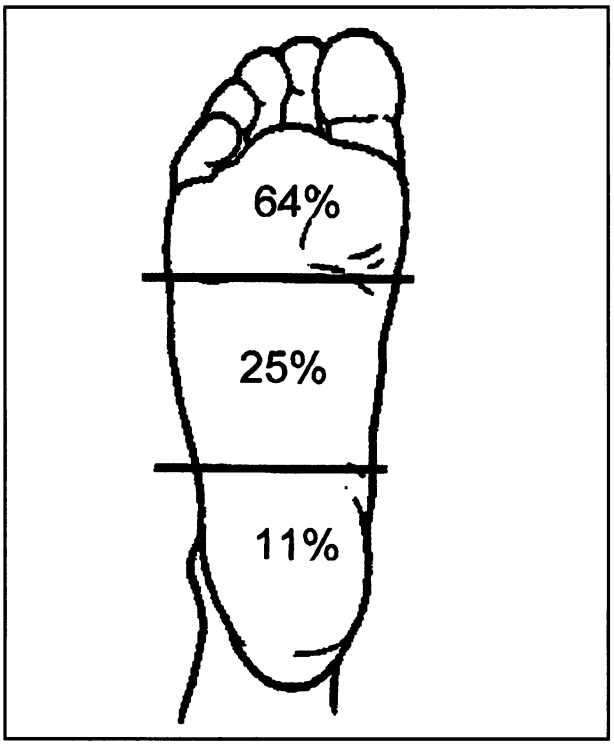

Figure 1.—The location of puncture wounds in children (n = 44) is shown.

The most common type of footwear reported at the time of puncture wound was the tennis shoe. There was no significant difference in the prevalence of osteomyelitis and soft tissue infection based on footwear (tennis versus other shoes). There were no cases of osteomyelitis among barefoot children (0 cases of barefoot osteomyelitis versus 17 cases [39%] of barefoot soft tissue infection, $P < .04$, OR and CI = infinity). There was no significant difference in the number of barefoot- or tennis shoe-related puncture wounds by calendar month. Of 12 cases (83%) of *P aeruginosa* infection (both soft tissue and bone), 10 occurred

TABLE 1.—*Bacterial Pathogens in Bone and Soft Tissue Infections Due to Puncture Wounds in Children**

	Total Population (n = 44)		Tennis Shoes (n = 22)		Barefoot (n = 17)		Other Shoes (n = 5)	
Organism	Soft Tissue, No. (%)	Bone, No. (%)	Soft Tissue, No. (%)	Bone, No. (%)	Soft Tissue, No. (%)	Bone No. (%)	Soft Tissue, No. (%)	Bone No. (%)
Staphylococcus aureus	20 (54)	1 (14)	8 (47)	1 (20)	9 (53)	--	3 (100)	0 (0)
Staphylococcus epidermidis	7 (19)	0 (0)	3 (18)	1 (20)	4 (23)	--	0 (0)	0 (0)
Streptococcus sp.	3 (8)	1 (14)	2 (12)	1 (20)	1 (6)	--	0 (0)	0 (0)
Pseudomonas aeruginosa	6 (16)	6 (86)	6 (35)	4 (80)	0 (0)	--	0 (0)	2 (100)
Enterococcus sp.	2 (5)	0 (0)	0 (0)	0 (0)	2 (12)	--	0 (0)	0 (0)
Klebsiella sp.	1 (3)	0 (0)	0 (0)	0 (0)	1 (6)	--	0 (0)	0 (0)

*Some cases had >1 pathogen isolated.

during tennis shoe wear. Of 35 nonpseudomonal pathogens isolated, 16 (46%) were from patients wearing tennis shoes ($P < .04$, OR = 8.3, CI = 1.6 to 44.6). Infection with *P aeruginosa* did not develop in any barefoot patient ($P < .002$, OR and CI = infinity).

Nails were the most commonly encountered puncture object (35 cases [80%]). All cases of osteomyelitis were inoculated by a nail ($P > .05$). Other puncture objects included glass (2%), needles (7%), and wood (4%). In three cases (<7%), the puncture objects were unknown to the parent or child on presentation.

Laboratory indices and temperature were grossly unremarkable on admission. The mean leukocyte count was $10.1 \pm 2.3 \times 10^9$ cells per liter. In 29 cases (66%), the leukocyte counts were within normal limits. The average ESR for all children was 21.5 ± 21.8 mm per hour, and in 28 (64%), it was at or below normal limits. Temperature was a mean 99.4°F ± 1.0°F on admission (95% within normal limits). There was no significant difference for any of the foregoing values between cases of osteomyelitis and those of soft tissue infections when evaluated as continuous or ordinal variables.

Of all subjective complaints, pain and redness were by far the most common, with 38 patients (86%) relating discomfort and 26 (59%) having erythema. Other complaints were relatively infrequent. These included fever (7 [16%]), wound drainage (7 [16%]), chills (6 [14%]), and nausea and vomiting (2 [4%]). There was no significant difference in any of these symptoms based on sex, location of injury, or the presence of osteomyelitis.

Discussion

Although many reports in the medical literature have focused on puncture wounds in children, these studies have largely been small case series or case studies of osteomyelitis. To date, the largest study focusing on soft tissue infections was undertaken in 1975, in which 16 cases of pediatric osteomyelitis and 26 cases of soft tissue infections precipitated by puncture wounds were reported.[1] The microbiologic results for both soft tissue and bone infections were similar to our findings, with *Staphylococcus* species predominating in soft tissue infections and *P aeruginosa* predominating in bone. The authors of that report did not, however, focus on footwear at the time of injury or the location of puncture wounds.

Since then, several researchers have focused on the prevalence of *Pseudomonas* species in bone infections.[2,11–13] Fisher and co-workers were the first to relate tennis shoe gear as a probable medium for pseudomonas infections.[3] This was subsequently confirmed clinically by other investigators.[2] The source of *Pseudomonas* species is the inner foam lining of tennis shoes.

The results from our study strongly corroborate the above-mentioned findings. Of the 7 cases of osteomyelitis at our institution, 6 (86%) grew out *P aeruginosa*. In addition, this species was strongly associated with the wearing of tennis shoes, with 10 (83%) patients with *Pseudomonas* species-positive puncture wounds reportedly wearing this type of shoe gear at the time of injury. None of the barefoot patients in our study had osteomyelitis. Furthermore, a pseudomonas infection (soft tissue or bone) did not develop in any barefoot patient. These data seem to support the theory that *P aeruginosa* does not grow on puncture objects, but rather is intimately associated with shoe gear.

The location of puncture wound as a risk factor for osteomyelitis and puncture wound infection was probably first proposed by Patzakis and colleagues.[13] This was later corroborated, and the authors reported that puncture wounds in the forefoot were more likely to result in osteomyelitis than those in rear-foot injuries.[14] The data presented in this report further support this observation, in which all cases of osteomyelitis were due to puncture wounds in the forefoot. The higher prevalence of forefoot osteomyelitis is probably due to the relative paucity of soft tissue interface between skin and bone in the forefoot when compared with the midfoot and rear foot.

Laboratory indices were relatively unremarkable in this study. This is consistent with previous studies that we have conducted on both diabetic and nondiabetic adults with foot infection.[15–17] In this study, the leukocyte count, ESR, and temperature did not seem to have any predictive value in differentiating soft tissue infection from osteomyelitis in children.

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