

## THE PSEUDOMONAS HOT-FOOT SYNDROME

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**ABSTRACT**

**Background** Between March and May 1998, there was an outbreak of a clinically distinct skin eruption on the soles of the feet of children who used a community wading pool.

**Methods** We reviewed the medical records of 40 children in whom this syndrome developed during this time. We treated 17 children and advised the attending physicians on the care of the other 23. Follow-up data were obtained for up to one year.

**Results** Exquisitely painful erythematous plantar nodules developed in 40 children (age, 2 to 15 years) within 40 hours after they had used a wading pool whose floor was coated with abrasive grit. Culture of the plantar pustules from one child yielded *Pseudomonas aeruginosa* with a pattern on pulsed-field gel electrophoresis that was identical to that of a strain of *P. aeruginosa* cultured from the pool water. A skin-biopsy specimen from this patient showed a perivascular and perieccrine neutrophilic infiltrate, and a specimen from another patient showed a dermal microabscess. Thirty-seven patients were treated symptomatically; three others were treated with cephalexin. All patients recovered within 14 days, but three children had recurrences of the painful plantar nodules within 24 hours after using the pool again. Folliculitis developed in one patient.

**Conclusions** The "pseudomonas hot-foot syndrome" is characterized by the acute onset in children of exquisitely tender plantar nodules and a benign, self-limited course. This community outbreak developed after exposure to pool water containing high concentrations of *P. aeruginosa*. (N Engl J Med 2001; 345:335-8.)

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**P**SEUDOMONAS *aeruginosa* is a well-recognized cause of outbreaks of folliculitis associated with the use of whirlpools, hot tubs, swimming pools, saunas, and hydrotherapy pools. Patients can present with pruritic follicular, maculopapular, vesicular, or pustular lesions on any part of the body that has been immersed in the water.<sup>1</sup> However, nodular lesions are distinctly uncommon. We describe an outbreak of a clinically distinct cutaneous disorder, characterized by painful nodules on the soles, among children who had used a community wading pool. This benign, self-limited disorder, which was apparently caused by *P. aeruginosa* infection, does not require antibiotic therapy, but it is a potentially important public health hazard.

**METHODS**

We reviewed the medical records of 40 children (16 boys and 24 girls; median age, 6 years; range, 2 to 15 years) in whom painful

plantar nodules developed after they had used a wading pool that was 2 ft (about 60 cm) deep in a public aquatic center that was opened in 1996 in Alberta, Canada. The pool was used mainly by young children, and its floor was coated with an abrasive grit to prevent slipping. The water temperature was maintained at 33°C. We did not observe any defective surfaces in need of repair, nor was there obvious contamination of the water with slime. All cases occurred between March and May 1998. We treated 17 patients and advised the attending physicians on the care of the 23 others. One five-year-old girl had autoimmune hemolytic anemia, and one eight-year-old girl had insulin-dependent diabetes mellitus; all other patients were otherwise healthy. None had a history of painful plantar nodules. We obtained follow-up data for up to one year on all 40 children through a telephone interview with the patients, their parents, or both. The DNA profile of *P. aeruginosa* was assessed by pulsed-field gel electrophoresis.

**RESULTS****Clinical Features**

All cases occurred 10 to 40 hours after the child had used the wading pool and followed a remarkably similar course. In all patients, the first symptom was intense pain in the soles, followed within hours by marked swelling, redness, a sensation of heat, and exquisite pain that made it impossible to bear weight on the affected areas. For some patients, wearing socks or shoes or even touching bedsheets caused severe pain. Physical examination of all patients showed strikingly similar findings. These consisted of diffuse, dusky erythema of the soles, with deep, exquisitely tender, red-to-purple, 1-to-2-cm nodules on the weight-bearing surfaces. The most commonly involved sites were the plantar surfaces of the toes, metatarsal heads, lateral surfaces of the foot, and heels (Fig. 1). Tenderness was mainly confined to the parts of the feet with erythema and nodules. Scratches on the soles were observed in only one patient, who had climbed a tree just before entering the pool, and none had callosities of the soles.

The most severely affected patients had a fever (temperature, 37.7 to 38.8°C), malaise, and nausea. One patient had a tender nodule on the palmar aspect of the right middle finger, and another had diffuse palmar erythema. Three patients had lymphangitic lines on the instep, without palpable lymph nodes in the inguinal region or popliteal fossa. No regional lymphadenopathy was identified. Bruised appearance and desquamation occurred in the affected areas after several days. One patient had folliculitis of the buttocks in addition to painful plantar nodules.

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**Figure 1.** Painful Erythematous Nodules on the Soles. Tenderness was confined mainly to the erythematous areas, and this patient was able to bear some weight on the noninflamed portions of the feet.

Three patients received oral cephalexin. The others were treated only symptomatically with cold compresses, analgesic agents, and elevation of the feet. In all cases, the signs and symptoms completely resolved in 1 to 14 days (within 7 days in 88 percent of the patients). Three patients had a recurrence of the plantar nodules, all within 24 hours after using the same pool at a later date.

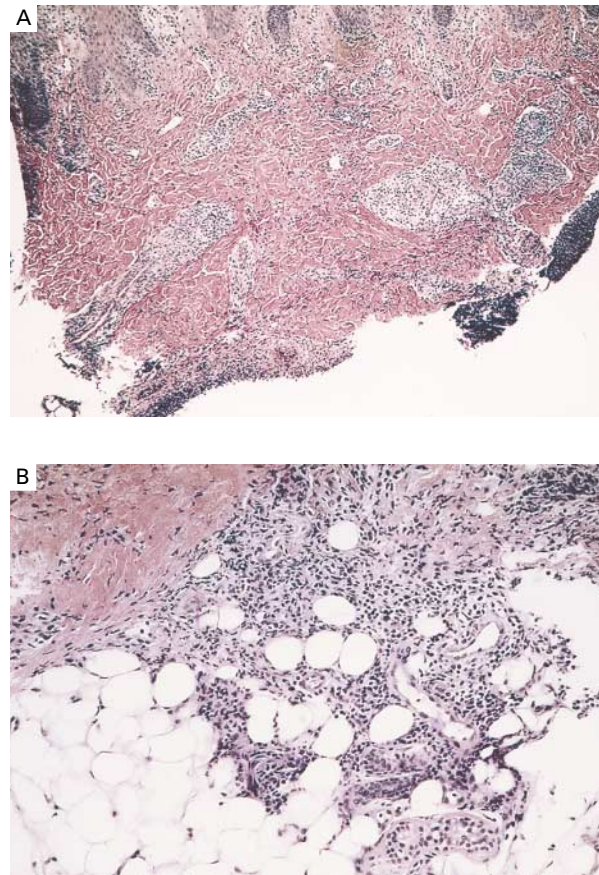
#### Histologic Findings

We performed punch biopsies of plantar nodules from two patients. In one patient, staining of the specimen with hematoxylin and eosin revealed intense perivascular, interstitial, and periadnexal infiltration of neutrophils that extended to the lobules of subcutaneous fat. Extravasated erythrocytes were present in the dermis in the absence of vasculitis. The punch-biopsy specimen of a painful nodule from the other patient showed a similar neutrophilic infiltrate surrounding the wall and lumen of eccrine sweat glands, a deep dermal abscess that extended to the adipose tissue, and a focal area of vasculitis with fresh thrombus in a blood vessel (Fig. 2).

Laboratory investigations were performed in seven patients; all had mild leukocytosis, neutrophilia, an elevated erythrocyte sedimentation rate, and an elevated level of C-reactive protein. The results of blood culture (performed in two patients), viral culture of specimens from the nasopharynx (three patients), chest radiography (one patient), and radiography of the feet (one patient) were all normal.

#### Microbiologic Findings

*P. aeruginosa* was isolated from a deep pustule of one patient. Eleven days after the first case was iden-



**Figure 2.** Biopsy Specimens of Plantar Nodules from Two Patients.

Panel A shows a superficial and deep mixed lymphocytic and neutrophilic inflammatory infiltrate with focal vasculitis (hematoxylin and eosin,  $\times 40$ ). Inflammatory exudate at the deep margin includes an underlying microabscess. Panel B shows the inflammatory infiltrate surrounding an eccrine sweat gland in the subcutaneous fat and extending into the wall and lumen of the gland (hematoxylin and eosin,  $\times 200$ ).

tified, culture of a water sample from the wading pool yielded 180,000 colony-forming units of *P. aeruginosa* per milliliter, with a pattern on pulsed-field gel electrophoresis that was identical to that of the strain isolated from the patient. Culture of water samples from a large swimming pool and a whirlpool housed in the same building did not yield *P. aeruginosa*.

#### Public Health Measures

Thirty-four of the cases were identified within the first nine days of the outbreak. On day 9, the pool was closed and the water was drained and superchlorinated (chlorine concentration, 10 parts per million). Over the next 14 days, seven consecutive samples of pool water yielded no growth on bacterial culture and the

pool was reopened. During the next two days, new cases were reported, even though the water chlorine concentration was further increased (to 200 parts per million), the sand filter was changed, and the floor of the pool was sanded to reduce its roughness. Culture of swabs from the inlets, the floor, and a drain yielded *P. aeruginosa*, but the water remained sterile. The pool was closed again, and the floor, water pipes, and inlets were scrubbed with a quaternium ammonium compound and then treated with ozone. The pool was reopened in March 1999, and no new cases have been reported to date.

### DISCUSSION

We describe an outbreak of a clinically distinct syndrome for which we propose the name "pseudomonas hot-foot syndrome." It is characterized by the acute onset of exquisitely painful plantar nodules in children and a benign, self-limited course. Forty cases occurred as a community outbreak after exposure of children to pool water containing high concentrations of *P. aeruginosa*, the suspected causative agent. This syndrome is a potentially important public health hazard that can be prevented by superchlorination of pool water; reduction of the abrasiveness of pool floors; and scrubbing of the floors, water pipes, and inlets of pools with quaternium ammonium compounds, followed by treatment with ozone to disrupt the contaminated biofilm.

*P. aeruginosa* has rarely been implicated as a cause of tender cutaneous nodules, and our search of the English-language literature found only two such reports. During one outbreak of pseudomonas hot-tub folliculitis, "larger, deep tender nodules and abscesses primarily on the extremities" developed in three teenage girls, including one who had "many deep tender nodules on the plantar surfaces."<sup>2</sup> Culture of one cutaneous nodule yielded a heavy, pure culture of *P. aeruginosa*, and all patients recovered in 7 to 10 days. In another outbreak among nine patients with pseudomonas hot-tub folliculitis, one 22-year-old patient had redness and swelling of the plantar surface of the right fourth and fifth toes and subcutaneous induration of the right heel, and the plantar surface of the left great toe became firm, hot, and red, as did the palmar surface of the tip of the right fourth finger.<sup>3</sup> *P. aeruginosa* was recovered from several of the papules, and she recovered in seven days without antibiotic therapy. Histologic findings were not described in either of these outbreaks.

Recovery of *P. aeruginosa* from a pustule of one of our patients provided evidence in support of *P. aeruginosa* as the cause of the outbreak, and recovery of a strain from a culture of the pool water with an identical DNA pattern on pulsed-field gel electrophoresis strongly implicated the pool as a source of the outbreak. Three patients had a recurrence of the lesions within 24 hours after again using the pool, further

implicating the pool water as a source. It is possible that *P. aeruginosa* was inoculated onto the skin of the soles by repeated trauma caused by rubbing against the abrasive surface of the pool. The pool was a shallow wading pool used mainly by children, which may explain why this outbreak involved only children. Furthermore, the stratum corneum of a child's skin is thinner than that of an adult, which may facilitate entry of microorganisms as a result of rubbing against a rough surface. During the period covered by this study (March to May 1998), one additional person who used the pool had classic pseudomonas folliculitis of the buttocks and trunk without plantar nodules; this person was not included in our study.

The principal condition in the differential diagnosis is recurrent idiopathic palmoplantar hidradenitis. This is an uncommonly reported condition, and our search of the English-language literature found 47 cases.<sup>4-12</sup> The pathogenesis is unknown, but trauma-induced rupture of the eccrine glands<sup>6,8</sup> and exposure to wet occlusive footwear<sup>9,10</sup> have been implicated. As was true of our patients' illness, idiopathic palmoplantar hidradenitis is characterized by self-limited, tender, erythematous plaques and nodules on the soles of young children.<sup>6,7</sup> Most reported cases resolved within a few weeks, and treatment included oral corticosteroids,<sup>4</sup> oral ibuprofen,<sup>5</sup> topical corticosteroids,<sup>5,12</sup> topical nonsteroidal antiinflammatory agents,<sup>6</sup> oral cephalixin,<sup>7</sup> and oral amoxicillin.<sup>8</sup>

In contrast to the outbreak that we describe, the palmar lesions occurred in half of the patients,<sup>6</sup> all cases were sporadic, and searches for infectious organisms, including Gram's staining of biopsy specimens, had negative results.<sup>4,8</sup> Up to half the patients had recurrences,<sup>6</sup> and some patients had as many as eight episodes within three years.<sup>9</sup> Histologic studies showed nodular infiltrates consisting predominantly of neutrophils that were confined to the eccrine apparatus, especially the coils.<sup>4-8,12</sup> In contrast, in both of our patients in whom biopsies were performed, periadnexal neutrophilic infiltrates extended to the lobules of subcutaneous fat. Some believe that idiopathic palmoplantar hidradenitis is a variant of neutrophilic eccrine hidradenitis,<sup>5</sup> but the latter is distinguished by syringosquamous metaplasia and by its frequent association with the use of chemotherapeutic agents.

Suppurative panniculitis caused by *P. aeruginosa* infection has been described in 17 cases.<sup>13</sup> However, those cases differ from ours in several important respects. First, all cases of suppurative panniculitis were sporadic, and none occurred as part of community outbreaks.<sup>13</sup> Second, sepsis occurred in 16 of the 17 cases, and blood cultures were positive in 13 of these cases.<sup>13</sup> Third, all patients required antibiotic therapy, and incision and drainage of deep fluctuant nodules were advocated.<sup>14</sup> Fourth, lesions were reported on the leg, with complete sparing of the soles.<sup>13</sup> In one sporadic case of a subcutaneous nodule caused by *P. aeru-*

*ginosa* infection, sepsis did not occur but oral levofloxacin was required for treatment.<sup>13</sup>

Other alternative diagnoses include erythema nodosum, a septal panniculitis that often involves the legs but rarely the soles.<sup>15</sup> Traumatic-pressure urticaria is characterized by tender plantar macules and papules resulting from mechanical stress such as running and dancing; its pathophysiology is thought to be similar to that of delayed-pressure urticaria.<sup>16</sup> "Pool palms" refers to linear plaques on the palms that are caused by contact with rough pool surfaces, but it has not been reported on the soles.<sup>17</sup>

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