Probing to Bone in Infected Pedal Ulcers

A Clinical Sign of Underlying Osteomyelitis in Diabetic Patients

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Objective.—To assess a bedside technique for diagnosing osteomyelitis.

Design.—We prospectively assessed infected pedal ulcers for detectable bone by probing with a sterile, blunt, stainless steel probe. We then examined the relationship between detection of bone and the presence or absence of osteomyelitis that was defined histopathologically and/or clinically.

Setting.—A tertiary care center.

Patients.—Seventy-five hospitalized diabetic patients with a total of 76 infected foot ulcers were studied.

Results.—Osteomyelitis was diagnosed in 50 instances (66%) and was excluded in 26 instances. Bone was detected by probing in 33 of 50 ulcers with contiguous osteomyelitis; in contrast, bone was probed in only four of 26 ulcers without contiguous osteomyelitis ($P<.001$). Bone detected on probing was visible in only three instances. Palpating bone on probing the pedal ulcer had a sensitivity of 66% for osteomyelitis, a specificity of 85%, a positive predictive value of 89%, and a negative predictive value of 56%.

Conclusions.—Palpation of bone in the depths of infected pedal ulcers in patients with diabetes is strongly correlated with the presence of underlying osteomyelitis. If bone is palpated on probing, specialized roentgenographic and radionuclide tests to diagnose osteomyelitis are unnecessary. Probing for bone should be included in the initial assessment of all diabetic patients with infected pedal ulcers.

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PEDAL infections occur in up to 25% of diabetic patients.[1-3] In this setting the differentiation between soft-tissue infection alone or infection that is complicated by contiguous osteomyelitis is often difficult. Roentgenographic and radionuclide tests have been used to diagnose pedal osteomyelitis in diabetics; however, their interpretation is confounded by arterial insufficiency and neuro-osteoarthropathy (Charcot's disease). We have considered the presence of bone in the depths of infected pedal ulcers in patients with diabetes to be indicative of osteomyelitis. Exposed, but not visible, bone in the depths of pedal ulcers in diabetic patients can be accurately identified by gently probing the ulcer base with a sterile, blunt probe during the initial wound evaluation. In search of an inexpensive, safe method to diagnose osteomyelitis adjacent to infected pedal ulcers, we prospectively examined the relationship between the detection of bone by probing and the presence of osteomyelitis.

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Patients and Methods

During a 2-year period beginning in December 1988 we conducted a prospective trial of antibiotic treatment for severe limb-threatening foot infection in hospitalized diabetic patients.[4] Contiguous osteomyelitis complicated 59 (61%) of the 96 infections treated in this study. All participants in this trial who had infected pedal ulcers were studied to assess the correlation between the detection of bone by probing the ulcer base and the presence of underlying osteomyelitis. Patients without pedal ulceration, with nonhealed recent surgical wounds, or with pedal infection that had been débrided in a manner likely to expose the adjacent bone were excluded. In patients with open ulcers, probing to detect bone was performed prior to débridement. When ulcers were covered by an eschar, probing was undertaken after débridement that was limited to removal of overlying eschar. Using a sterile, blunt, 14.0-cm, 5F, stainless steel eye probe held as one would hold a pencil, one of us (M.L.G. or A.W.K.) assessed the ulcers at the bedside for the presence or absence of palpable bone. This probe is a standard component of our routine surgical wound débridement kits (MedCare Custom Packaging, West Swanzey, NH). Bone was considered palpable (termed a positive probe test) when, on gentle probing, the evaluator detected a rock-hard, often gritty structure at the ulcer base without the apparent presence of any intervening soft tissue. The inability to detect bone (a negative probe test) was defined by the absence of such a finding.

See also p 712.

At the time of enrollment, wound cultures, blood cultures, and plain roentgenograms of the involved area were obtained. Special diagnostic studies, such as computed tomography, technetium Tc 99m bone scan, and other radionuclide tests, were ordered occasionally by attending physicians. In the following circumstances, biopsy specimens were obtained from bone contiguous with an infected ulcer or débridement was performed and the bone tissue was submitted for histological examination: (1) bone that was palpable on initial probing of the ulcer, (2) bone that was initially probe negative but became exposed subsequently during débridement of infected tissue, or (3) bone that was resected because of severe uncorrectable ischemia. Histological examination of bone was performed by one pathologist (K.B.) who was not aware of whether the bone had been detected by probing or exposed after extensive débridement. Bone specimens were fixed in 10% for-

malin, sampled, decalcified, embedded in paraffin, cut, and stained with hematoxylin-eosin. At least three tissue blocks were obtained from each specimen. The following criteria were required to establish a microscopic diagnosis of osteomyelitis: the presence of inflammatory cells within the bone, fibrosis of intertrabecular soft tissue, and destruction or necrosis of bone and reactive new bone formation.[5]

The presence of osteomyelitis was determined histologically. Because specimens of bone that were cultured were often obtained through the ulcer and thus likely contaminated, microbiological data were not considered in diagnosing osteomyelitis. If bone was not available for microscopic examination, radiological evidence of bone destruction in association with an infected ulcer and/or identification of purulent friable nonviable bone by the surgeon performing débridement was accepted as diagnostic of osteomyelitis. Osteomyelitis was considered absent if none of these conditions were met and if, after abbreviated antibiotic therapy, the infected ulcer healed and did not recur during a prolonged follow-up period. The initial 2 to 3 months of follow-up was performed by the patients' physicians and included examination of the feet. Subsequent follow-up was conducted by telephone with the patient. Antibiotic therapy was considered abbreviated if it was notably less than that commonly recommended for the treatment of this form of osteomyelitis: high-dose intravenous therapy for at least 28 days plus an oral regimen of 10 weeks' duration or total intravenous and oral treatment for 10 weeks[6]; 3 months of high-dose oral antibiotic therapy[7]; or 6 to 12 weeks of antimicrobial therapy.[3] Statistical analysis was by χ^2 or two-tailed Student's t test.

Results

We considered 76 patients with 77 infected pedal ulcers for inclusion in this study. One patient was studied twice because a second infected ulcer occurred at a different site. One patient was not studied because the pedal ulcer was too painful to be probed. The remaining 76 infected ulcers in 75 patients were evaluated. The average age of patients was 60±12 years (mean±SD) and 52 were men. Diabetes had been present for 19±10 years, and 59 patients required insulin. Sequelae of diabetes were common: 69 patients had peripheral sensory neuropathy, 61 had diminished or absent pedal pulses, and 25 had renal impairment (serum creatinine >110 μmol/L [1.2 mg/dL]). Among the 76 infected ulcers, 34 involved the toe, 28 were located beneath a metatarsal head, six involved a toe and metatarsal head area, and one was located at a previously healed amputation site. Four ulcers were present beneath the midfoot (tarsals) and three were located in the heel. Cellulitis was present in all episodes, purulent drainage in 56, soft-tissue necrosis in 32, lymphangitis in 27, elevated temperature (>37.8°C [>100°F]) in 27, and bacteremia in three episodes. The pathogens recovered from these infections were reported previously.[4]

Comparison of Diagnostic Techniques in the Identification of Pedal Osteomyelitis in Patients With Diabetes

Investigation	Source	Sensitivity, %	Specificity, %	Positive Predictive Value, %
Probe to bone	Current study	66	85	89
Plain radiograph	References 10-13, 17	28-93	50-92	74-87
Technetium Tc 99m bone scan	References 10-14, 17-19	68-100	18-79	43-87
Indium 111 leukocyte scan	References 10, 12, 14, 15, 18, 19	45-100	67-89	75-85
Magnetic resonance imaging	References 13-15, 20	29-100	78-89	50-93

Osteomyelitis was diagnosed in 50 (66%) of the 76 episodes. In 46 episodes the diagnosis was established histologically; additionally, osteomyelitis was evident by roentgenogram and by the surgeon's direct clinical evaluation in 16 and 21 episodes, respectively. In the four instances where bone was not examined microscopically, osteomyelitis was diagnosed on the basis of roentgenographic changes alone once, clinical criteria alone twice, and clinical and roentgenographic criteria once.

Contiguous osteomyelitis was absent in 26 instances (34%). In seven of these 26 instances, bone contiguous with the ulcer was examined histologically and failed to demonstrate osteomyelitis. The interval between the evaluation of the ulcer and obtaining bone for microscopic examination averaged 13.9 days (median, 9 days; range, 5 to 42 days). In the remaining 19 episodes, bone was not examined microscopically during initial treatment of the ulcer but osteomyelitis was absent based on clinical criteria. Additionally, osteomyelitis was not detected in 15 of these 19 episodes by roentgenogram and in one episode by roentgenogram and technetium bone scan. Also, in four of these episodes bone contiguous with the ulcer was resected during follow-up. In none of these bone specimens was histological evidence of osteomyelitis noted. None of these 19 patients developed evidence of osteomyelitis during follow-up despite receiving antibiotic therapy that would be considered inadequate treatment for osteomyelitis. The mean duration of parenteral antibiotic therapy was 12.5 days (median, 11 days; range, 4 to 30 days). Although one patient received 30 days of antibiotic therapy and another 25 days because of slowly healing ischemic ulcers, all of the other patients received less than 3 weeks of parenteral therapy. Additional oral antibiotics were given to nine of these patients for an average of 14.4 days (cephalexin to four patients, cefadroxil to three, dicloxacillin sodium to one, and a combination product of sulfamethoxazole and trimethoprim to one). Eighteen of these 19 patients were followed up for at least 26 weeks (mean±SD, 69.5±27.9 weeks; median, 83.5 weeks; range, 26 to 106 weeks). One patient without evidence of osteomyelitis was lost to follow-up after 21 weeks. In three of the 19 patients roentgenograms obtained 1 to 11 months after treatment did not reveal osteomyelitis.

Detection of bone beneath an infected ulcer by probing was associated with contiguous osteomyelitis. Among the 50 ulcers with contiguous osteomyelitis, bone was palpable by probe in 33 (66%). In only three of these 33 instances was bone visible in the ulcer. In contrast, in the 26 ulcers without contiguous osteomyelitis, bone was detected by probing in only four ($P<.001$). Contiguous osteomyelitis was associated with 33 (89%) of the 37 ulcers wherein bone was palpable. In three instances, bone was palpable, but osteomyelitis was not identified on histological examination, although one specimen had changes consistent with periostitis and another had evidence of chronic bone ischemia. In the fourth probe-positive, osteomyelitis-negative episode, bone was not examined microscopically; however, there was no evidence of osteomyelitis on the initial roentgenogram or three-phase technetium bone scan and infection did not recur during 86 weeks of follow-up. As an indication of underlying osteomyelitis, the sensitivity of a positive probe test was 66% and specificity was 85%. Palpable bone on probing had a positive predictive value for underlying osteomyelitis of 89%, while the predictive value of a negative probe for the absence of underlying osteomyelitis was only 56%.

The interval between palpation of bone and the documentation of osteomyelitis did not suggest that bone infection developed after the ulcer evaluation. Among the 31 instances with palpable

bone and histologically confirmed osteomyelitis, the average interval between probing and obtaining bone for histological examination was 8.1±7.1 days (median, 6 days; range, 1 to 28 days), and in only three instances did the intervals exceed 16 days (24, 24, and 28 days). In the two instances with palpable bone where histological confirmation was lacking, the intervals between probing and the radiological or surgical diagnosis of osteomyelitis were 2 and 84 days, respectively. Among 15 episodes with osteomyelitis in the absence of palpable bone, an average of 31.4±57.4 days elapsed from probing to histological diagnosis (median, 9 days; range, 2 to 210 days); in two of these episodes 120 and 210 days elapsed before bone specimens were obtained. In the two additional episodes of clinically diagnosed osteomyelitis in the absence of palpable bone, the intervals between probing and diagnosis were 4 and 182 days.

Comment

The early recognition of underlying pedal osteomyelitis in diabetic patients with limb-threatening infection is important since recommended treatment frequently entails extremely long courses of antimicrobial therapy or extended courses of antibiotic therapy in combination with débridement of infected necrotic bone. In contrast, pedal infection restricted to soft tissue generally can be treated with limited débridement and abbreviated courses of antimicrobial therapy.[3,6-9]

In this prospective study of diabetic patients hospitalized with limb-threatening infection, the depth of the infected pedal ulcers was often masked by infected, necrotic tissue, and gentle probing was necessary to determine whether the ulcer extended to underlying bone. The identification of palpable bone in the ulcer base by probing with a blunt stainless steel instrument was significantly associated with underlying osteomyelitis in these patients with a high frequency of complicating osteomyelitis. Whether the association of palpable bone and osteomyelitis extends to nonhospitalized diabetic patients with less severe infection is not known. However, Newman et al,[10] studying a population composed predominantly of outpatients, confirmed pedal osteomyelitis by bone biopsy in all nine diabetic patients with detectable bone in an infected ulcer (six by visual inspection, three by probing). Probing should not be used to diagnose pedal osteomyelitis in diabetic patients with surgically exposed bone, eg, with unhealed surgical wounds or extensively débrided ulcers. If patients who had undergone recent surgical treatment were excluded, detection of bone by probing had a sensitivity of 66% and specificity of 85% for identifying contiguous osteomyelitis. Although, the predictive value of a positive probe test for underlying osteomyelitis (89%) is very high, a negative probe test does not exclude osteomyelitis (negative predictive value, 56%).

The relatively short interval between the evaluation of the ulcers and obtaining specimens for histological examination in patients with palpable bone and osteomyelitis strengthens the association between these findings. In four patients in this group the interval exceeded 20 days. Notably, throughout the interval each of these patients remained in a health care facility, was restricted from bearing weight on the ulcer, and received intensive antibiotic therapy. Thus, it is unlikely that infection extended from soft tissue to bone during the somewhat longer intervals in these four patients.

Roentgenographic and radionuclide procedures have been evaluated as diagnostic tests for pedal osteomyelitis in diabetic patients. The studies of these procedures are limited by retrospective design, small size, selected target population, unblinded protocol, or lack of definitive criteria for the diagnosis of osteomyelitis.[3,16] Nevertheless, the diagnostic accuracy of probing for bone compares favorably with the reported sensitivity, specificity, and positive predictive value of these diagnostic tests (Table).[10-20]

The evaluation and management of pedal osteomyelitis in some patients with diabetes can be simplified and made less costly by early detection of bone in infected ulcers. Osteomyelitis contiguous to infected ulcers could be diagnosed clinically by palpating bone in 66% of our patients and in 32% of the patients studied by Newman et al.[10] The high positive predictive value for osteomyelitis associated with a positive probe test obviates additional roentgenographic and radionuclide tests. Thus, upon palpation of bone in an ulcer, evaluation may proceed directly to microbiological and histological confirmation of osteomyelitis by either percutaneous needle biopsy or open débridement and thereafter to treatment. We suggest that probing for bone be incorporated into the routine initial assessment of diabetic patients with infected pedal ulcers.

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