The DEPA Scoring System and Its Correlation With the Healing Rate of Diabetic Foot Ulcers

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The purpose of this study was to examine the validity of a new scoring system in predicting the outcome of diabetic foot ulcers. The scoring system (DEPA score) includes the depth of the ulcer (D), the extent of bacterial colonization (E), the phase of ulcer healing (P) and the associated underlying etiology (A). The scoring system was validated against the clinical outcome in terms of healing and lower-limb amputations. Eighty-four patients were included in the study: 32 patients had a DEPA score of ≤6, 34 patients had a DEPA score of 7 to 9, and 18 patients had a DEPA score of ≥10. Using the Spearman nonparametric correlation test, DEPA scoring system was accurate in predicting the outcome of management (correlation coefficient, 0.78; 95% confidence interval, 0.68 to 0.86; P < .0001) at a mean follow-up of 20 weeks. The correlation was further validated by using a linear regression model (r = 0.85; slope best-fit value, 0.51; 95% confidence interval, 0.41 to 0.59; P < .0001). All patients with DEPA scores ≤6 had excellent healing, whereas only 15% of those with a score of ≥10 had complete healing in <20 weeks. In conclusion, an increasing DEPA score is associated with increased risk of amputation and poor healing. Furthermore, inclusion of the phase of ulcer healing into the DEPA system increases the accuracy of predicting the outcome of diabetic foot ulcers. (The Journal of Foot & Ankle Surgery 43(4):209-213, 2004)

Key words: DEPA score, foot ulcers, phase of ulcer, validity testing, amputation
of the ulcer, the extent of bacterial colonization, the phase of healing, and the associated underlying etiology (DEPA) (18). The aim of this study was to evaluate the accuracy of the DEPA system with respect to the success of healing and risk of amputation and to propose standardized guidelines of management based on this system.

Materials and Methods

Scoring System

The DEPA scoring system was used to evaluate 3 important parameters of diabetic foot ulcers in addition to the associated underlying cause. Each parameter was rated on a point scale according to severity and complexity (Table 1). The depth of the ulcer was given a score of 1 for superficial ulcers, 2 for ulcers extending down to the subcutaneous tissues and tendons, and 3 for ulcers reaching the bone. The extent of bacterial colonization was given 1 point for contamination, 2 points for active infection, and 3 points for sepsis or necrotizing infection. The phase of healing was graded as 1 for granulating phase, 2 for inflammatory phase, and 3 for the nonhealing phase. Finally, the associated underlying cause was given 1 point for neuropathic ulcers, 2 points for ulcers in association to structural deformity, and 3 points for ulcers in association with chronic lower-limb ischemia. Overall, a patient with grade of 6 or less was deemed to have a low-grade ulcer, a patient with grade of 7 to 9 would have a moderate-grade ulcer, and a patient with 10 or more points would have a high-grade ulcer (Table 2).

Study Population

This study was conducted at Jordan University Hospital and involved a total of 84 consecutive patients with type 1 or 2 diabetes and foot ulcers. Patients had at least 1 foot ulcer; if more than 1 foot ulcer was present, the ulcer deemed by the investigator to take the longest time to heal was designated as the target ulcer. The duration of the ulcers ranged from a few days to several months. All defects associated with wet gangrene were considered to be high-grade ulcers. Patients were excluded if: 1) osteomyelitis affecting the heel bone was present, 2) they showed large ulcers (greater than 40 cm²) in association with sepsis, 3) heel ulcers associated with necrotizing fasciitis extending proximal to the ankle joint, and 4) foot ulcers in association with acute foot ischemia were present. These patients were offered below-knee amputation at the time of presentation.

Management Guidelines

Specific management guidelines were based on the grade of the ulcer. Antibiotics were administered only for patients with clinical signs of infection, regardless of the grade of the ulcer. Oral antibiotics were selected for minor ulcers with infection, and parenteral antibiotics were used for all moderate- and high-grade ulcers. Low-grade ulcers were managed on an outpatient basis with oral broad-spectrum antibiotics in the presence of infection, blood-sugar control, and sharp debridement of the ulcer. Moderate-grade ulcers required intravenous broad-spectrum antibiotics in the presence of infection, insulin for blood-sugar control, sharp debridement, healing promoting agents, and pressure-relieving methods. High-grade ulcers were offered a trial of conservative treatment with antibiotics, insulin therapy, debridement, healing-promoting agents, and vascular reconstruction whenever indicated.
Definition of Successful Healing

Evaluation of healing was based on the intent-to-treat population, which included all patients with foot ulcers with minor-, moderate-, and high-grade ulcers who were treated according to the management protocol established in our diabetic foot clinic. Complete healing was defined as complete closure of the ulcer without the need of dressing. To facilitate validity testing of the DEPA grading system, the final outcome was ranked as excellent (complete healing in <10 weeks), good (complete healing by 20 weeks), poor (no healing at 20 weeks), or amputation (proximal amputation whenever it was indicated).

Statistical Analysis

To determine whether the DEPA grading system was predictive of outcome, validity testing was performed. Validity was assessed by using the nonparametric (Spearman) correlation to assess the trend association between increasing DEPA score and the lack of ulcer healing or lower-extremity amputation. To further determine whether the scoring system was accurate in predicting healing within the study period, linear regression analysis was subsequently performed. Both tests were performed by using Instat 2 for Windows (Graph Pad, San Diego, CA). A value of \( P < 0.05 \) was considered to reject the null hypothesis. The correlation coefficient \( r \) ranges from -1.0 to 1.0. An \( r \) value of 0 indicates that the 2 variables do not correlate at all. A positive fraction indicates that the 2 variables increase or decrease together, with 1.0 representing a perfect correlation. A negative fraction indicates that the 2 variables change inversely.

Results

Eighty-four consecutive patients with diabetic foot ulcers were assessed between September 1997 and December 2002. There were 32 women and 52 men with a mean age of 62 years (range, 30 to 93 years). All patients had at least 1 ulcer: there were 41 toe ulcers, 24 plantar forefoot ulcers, 7 lateral foot ulcers, 3 dorsal ulcers, and 9 ankle and heel ulcers.

Thirty-two patients had low-grade ulcers (DEPA < 6), 35 patients had moderate-grade ulcers (DEPA 7 to 9), and 17 patients had high-grade ulcers (DEPA >10). The mean follow-up was 20 weeks (range, 4 to 24 weeks). The final outcome was considered excellent (complete closure of the ulcer in <10 weeks) in 49 patients, good (complete healing in 10 to 20 weeks) in 16 patients, poor (no healing at 20 weeks) in 6 patients, and amputation in 13 patients (Fig 1).

A DEPA grade of 6 or less correlated well with excellent healing, whereas a grade of 10 or more was predictive of poor healing. Patients with DEPA grades between 6 and 9 had good to excellent healing at the end of 20 weeks. Using the Spearman nonparametric correlation test, the scoring system was accurate in predicting the outcome of management (correlation coefficient, 0.78; 95% confidence interval, 0.68 to 0.86; \( P < 0.0001 \)) at a mean follow-up of 20 weeks (range, 4 to 24 weeks). This correlation was further validated by using a linear regression model (\( r = 0.85; \) slope best-fit value, 0.51; 95% confidence interval, 0.44 to 0.59; \( P < .0001 \)). All patients with DEPA of 6 or less had excellent healing, whereas 15% of those with a score of 10 or greater had nonhealing ulcers. The 13 patients who required amputation had a DEPA score of 11 to 12, and their ulcers were located on the heel in 6 patients, on the forefoot in 4 patients, and on the lateral side of the foot in 3 patients (Fig 2).

The number of these patients presenting with more than 1 ulcer or recurrent ulcer in the same location was too small to perform a statistical analysis on them. Only 2 patients in this series required arterial reconstruction (aortobifemoral bypass) because of symptomatic severe proximal aortoiliac disease. The rest of the patients with peripheral arterial disease had distal disease at the level of tibial vessels and...
were not offered bypass surgery. There were no other adjunctive procedures performed on any of the patients. Insulin was used to control hyperglycemia in all patients with moderate- or high-grade ulcers regardless of whether they were using insulin or oral hypoglycemic agents to control their diabetes.

Discussion

Diabetic foot ulcers are the most common reason for hospital admission in patients with diabetes, and the average length of stay is 59% longer than for patients with diabetes without ulceration (19, 20). Foot ulcerations in patients with diabetes are responsible for more than 50% of the patients who undergo lower-limb amputations. Prompt and aggressive management of diabetic foot ulcers can often prevent exacerbation of the problem and eliminate the threat of amputation. The aim of therapy should be early intervention to control infection, to promote healing of the ulcer, and to prevent recurrence once it is healed. Foot ulcers will develop in up to 15% of patients with diabetes during their lifetimes, and it is strongly associated with diabetic neuropathy, joint deformity, and peripheral arterial disease (1–4, 21, 22).

Diabetic foot ulcer classification systems (Meggitt, Wagner, Pecoraro, and University of Texas classification systems) currently used for grading of diabetic foot ulcers do not adequately assess all of the important parameters related to ulcer healing (23). Although the Wagner system is the most widely used to describe the natural history of the ulcer (grade 0 to 5), it does not consider the presence of infection, lower-extremity ischemia, or the healing phase of the ulcer as important parameters for the final outcome. On the other hand, the University of Texas system (4 grades and 4 stages) addresses both infection and ischemia but does not reflect the phase of the ulcer healing, which is important to predict healing.

Controlling infection in diabetic foot ulcers is the first step in management. However, many uninfected diabetic foot ulcers do not progress to healing because of inadequate blood supply or a lack of the growth factors necessary for healing. Three main healing phases exist: the acute inflammatory phase, the proliferative phase, and the maturation phase. The inflammatory phase is the first stage of ulcer healing, beginning at the time of injury and continuing for 5 to 7 days in most ulcers. The next phase is proliferation, characterized clinically by the development of granulation tissue, contraction, and epithelialization (24). The appearance of granulation tissue in the ulcers after the first week is the best clinical indicator of good healing. Faulty wound healing will result in a chronic ulcer that contributes to poor healing. Failure of granulation tissue development after 2 weeks of ulceration marks the progression toward nonhealing and the development of a chronic ulcer. Such ulcers are chronic because they do not heal within an expected timeframe.

In 2002, the authors developed a new scoring system to assess the most important parameters related to diabetic ulcers: the depth of the ulcer, the extent of bacterial colonization, and the phase of healing reflecting the body’s response to the ulceration process (18). We also added the associated underlying etiology as an important parameter in the development of foot ulcers.

This study has several limitations, mainly the small number of patients with moderate- and high-grade ulcers. Patients with diabetic heel ulcers pose a problem for this system; therefore, a different system should be used for their classification. Further testing of the validity of this system in a large group of patients is required. However, we believe that some conclusions can still be drawn regarding the proposed scoring system of diabetic foot ulcers.

Conclusion

DEPA, consisting of 4 items that are easily evaluated during physical examination of the ulcer, was able to predict the course of healing in diabetic patients. Diabetic foot ulcers with a DEPA score of 6 or lower have an excellent prognosis with almost complete closure in 4 to 6 weeks. In cases in which the DEPA score is 10 or greater, poor healing can be anticipated, and amputation may be preferable to

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<th>TABLE 3</th>
<th>Suggested guidelines for management of diabetic foot ulcers based on the DEPA score</th>
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<td>Low-grade ulcers (DEPA ≤ 6)</td>
<td>Outpatient care&lt;br&gt;Daily normal saline bath dressing&lt;br&gt;Superficial debridement if necessary&lt;br&gt;Oral antibiotics if necessary&lt;br&gt;Adequate control of hyperglycemia</td>
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<tr>
<td>Moderate-grade ulcers (DEPA 7–9)</td>
<td>In-hospital care for 1–2 weeks&lt;br&gt;Insulin to control hyperglycemia&lt;br&gt;Intravenous antibiotics&lt;br&gt;Scheduled debridement once daily to remove necrotic tissues&lt;br&gt;Healing-promoting agents (colloids, growth factors)&lt;br&gt;Offloading of pressure</td>
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<tr>
<td>High-grade ulcers (DEPA 10–12)</td>
<td>Hospital care until stabilization&lt;br&gt;Insulin to control hyperglycemia&lt;br&gt;Intravenous antibiotics&lt;br&gt;Scheduled debridement once daily to remove necrotic tissues&lt;br&gt;Healing-promoting agents (colloids, growth factors)&lt;br&gt;Vascular evaluation and reconstruction if indicated&lt;br&gt;Correction of deformity if present&lt;br&gt;Amputation for ischemic ulcers or ulcers associated with wet gangrene</td>
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prolonged conservative treatment with lengthy hospital stays, high costs, and potential life-threatening complications such as sepsis. The ability of the DEPA system to identify potential candidates for amputation at an early stage in treatment is enticing. Patients with scores between 7 and 10 had good to excellent outcomes and could be treated conservatively. Based on this scoring system, we have suggested standardized management guidelines of diabetic foot ulcers (Table 3). The DEPA scoring system seems to correlate well with the healing rate of the diabetic foot ulcer and we recommend its use.

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References