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Outcomes of Foot Infections Secondary to Puncture Injuries in Patients With and Without Diabetes

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ABSTRACT

It is difficult to compare foot infections in patients with diabetes to those without diabetes because foot infections are uncommon in people without diabetes. The aim of this study is to compare clinical outcomes in people with and without diabetes admitted to the hospital for an infected puncture wound. We evaluated 114 consecutive patients from June 2011 to March 2019 with foot infection resulting from a puncture injury; 83 had diabetes and 31 did not have diabetes. We evaluated peripheral arterial disease (PAD), sensory neuropathy, the need for surgery and amputation, length of hospitalization, and presence of osteomyelitis. Patients with diabetes were 31 times more likely to have neuropathy (91.6% versus 25.8%, $p < .001$, confidence interval [CI] 10.2 to 95.3), 8 times more likely to have PAD (34.9% versus 6.5%, $p = .002$, CI 1.7 to 35), and 7 times more likely to have kidney disease (19.3% versus 3.2%, $p < .05$, CI 0.9 to 56.5). They also took longer before presenting to the hospital (mean 20.1 ± 36.3 versus 18.8 ± 34.8 days, $p = .09$, CI 13 to 26.5); however, this result was not statistically significant. Patients with diabetes were 9 times more likely to have osteomyelitis (37.3% versus 6.5%, $p = .001$, CI 1.9 to 38.8). In addition, they were more likely to require surgery (95% versus 77%, $p < .001$, CI 1.6 to 21.4), required more surgeries (2.7 ± 1.3 versus 1.3 ± 0.8, $p < .00001$, CI 2.1 to 2.5), were 14 times more likely to have amputations (48.2% versus 6.5%, $p < .0001$, CI 3.0 to 60.2), and had 2 times longer hospital stays (16.2 ± 10.6 versus 7.5 ± 9 days, $p = .0001$, CI 11.9 to 15.9. Infected puncture wounds in patients with diabetes often fair much worse with more detrimental outcomes than those in patients without diabetes.

Diabetes is a pandemic disease that is on the rise annually. According to the Centers for Disease Control National Diabetes Statistics Report in 2017, it is estimated that in the United States alone, 1.5 million Americans are newly diagnosed with diabetes every year. In 2017, 24.7 million Americans (~7.6% of total population) were diagnosed with diabetes. The estimated health care burden was $327 billion (1). Fifty to 80% of the 125,000 lower-extremity amputations each year are due to diabetes (2). Diabetic foot complications account for >40% of all diabetes-related hospital admissions (3,4). Infection is the main underlying cause of hospital admission, surgery, amputation, and readmission to hospital for reinfection.

It is difficult to compare foot infections in patients with diabetes to those without diabetes because foot infections are uncommon in people without diabetes. Puncture wounds are a good method of comparing the 2 patient populations because they have the same mechanism of injury. Seven percent of foot trauma cases presented to the emergency department are attributed to puncture injuries (5). There are few publications that compare clinical outcomes (2,6–9). By comparing the outcome of puncture wounds in people with and without diabetes, we can evaluate clinical characteristics, comorbidities, and clinical outcomes. The objective of this study was to compare the clinical presentation, risk factors, treatments, and clinical outcomes in patients with and without diabetes.

Patients and Methods

This study was approved by the Institutional Review Board at the University of Texas Southwestern Medical Center and Parkland Memorial Hospital. From June 2011 to March 2019, we retrospectively evaluated 114 patients who were admitted to hospital with an

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infected puncture wound in the foot. There were 31 patients (27.2%) without diabetes and 83 patients (72.8%) with diabetes.

We excluded patients aged <18 or >90 years old and those who did not have a pedal puncture wound. The diagnosis of diabetes mellitus was based on American Diabetes Association criteria (10). Demographic data was collected along with a medical history, wound characteristics, laboratory tests, and clinical and surgical outcomes. We documented medical history for peripheral neuropathy, foot ulceration, peripheral vascular disease, and amputation (11,12). We defined sensory neuropathy as abnormal vibration sensation or abnormal sensation with 10-g Semmes-Weinstein monofilament. We defined peripheral vascular disease as an ankle-to-arm systolic blood pressure ratio of <0.90. We defined foot wounds as full-thickness lesions involving any portion of the foot or ankle (11,13,14). Leukocytosis was defined as white blood count (WBC) $>11.0 \times 10^9$/L. The diagnosis of osteomyelitis (OM) was made based on histopathologic or microbiologic analysis of bone. Prior treatment was defined as any medical treatment, antibiotic, or drainage of wound before presenting to our institution for management.

The data were compiled using Microsoft Excel (Microsoft Corp.). We reported continuous data as median, mean ± standard deviation. A chi-squared test was used to compare dichotomous variables, ANOVA was used to evaluate continuous variables with an α of 0.05, and Mann-Whitney *U* test was used for nonparametric data with an α of 0.05.

Results

There was no difference in age or sex in people with and without diabetes (Table 1). The majority of the patients in both groups were male (80% with diabetes [DM group] versus 68% without diabetes [no DM group], $p = .29$). Although patients with diabetes tended to take longer to seek medical care than people without diabetes (median 7 versus 3 days; mean 20.1 ± 36.3 versus 18.8 ± 34.8 days, $p = .09$), this difference did not reach statistical significance with the numbers available. The most common foreign body causing the injury in both groups was a nail (DM 47% versus no DM 35%, $p = .27$). The majority of patients in both groups were wearing shoes at the time of injury (DM 59.0% versus no DM 61.3%, $p = .83$, odds ratio [OR] 0.91).

Patients with diabetes were more likely to present with leukocytosis (WBC >11,000) than patients without diabetes (54.2% DM versus 19.4% no DM, $p < .001$). In addition, patients with diabetes had significantly higher WBC at the time of admission (12.2 ± 4.8 versus 9.2 ± 2.8, $p < .001$), significantly lower albumin (3.4 ± 0.5 versus 3.9 ± 0.8 g/dL, $p < .005$), and a higher prevalence of kidney disease than in patients without diabetes (19% versus 3%, $p < .05$). Patients with diabetes were 31.2 times more likely to have sensory neuropathy (91.6% versus 25.8%, $p < .001$, confidence interval [CI] 10.2 to 95.3, OR 31.2), 7.8 times more likely to have peripheral arterial disease (35.3% versus 6.5%, $p = .002$, CI 1.7 to 35, OR 7.8), and 9.0 times more likely to have OM as a result of the injury (37.3% versus 6.5%, $p = .001$, CI 1.9 to 38.8, OR 8.6) than patients without diabetes.

Compared with patients without diabetes, patients with diabetes had worse clinical outcomes, manifested by increased need for surgery (95% versus 77%, $p < .001$, CI 1.6 to 21.4), more surgeries required (mean 2.7 ± 1.3 versus 1.3 ± 0.8, $p < .001$), and more amputations (48.2% versus 6.5%, $p < .001$). The length of hospitalization was twice as long in patients with diabetes (16.2 ± 10.6 versus 7.5 ± 9.0 days, $p < .001$).

Table 1
Demographic, clinical, and laboratory features (N = 114)

	Diabetes	No Diabetes	Odds Ratio	95% CI	*p* Value
n	83	31			
Age (yr)	52, 52 (10.2)	52, 47 (13.3)		48.7 to 52.8	<.05
Male	66 (79.5)	21 (67.7)	1.9	0.7 to 4.7	.29
Glycated hemoglobin (%)	10.5, 10.45 (2.4)	5.4, 5.5 (0.4)		9.2 to 10.3	<.001
Location of injury					
Forefoot	65 (78.3)	17 (54.8)	3.0	1.2 to 7.2	<.05
Midfoot	13 (15.7)	9 (29)	0.5	0.2 to 1.2	.18
Hindfoot	5 (6)	5 (16.1)	0.3	0.1 to 1.2	.18
Days to emergency room	7, 20.1 (36.3)	3, 18.8 (34.8)		13 to 26.5	.09
Shoe	49 (59)	19 (61.3)	0.9	0.4 to 2.1	.83
Neuropathy	76 (91.6)	8 (25.8)	31.2	10.2 to 95.3	<.001
Peripheral arterial disease	29 (34.9)	2 (6.5)	7.8	1.7 to 35	<.005
Laboratory values					
White blood count	11.3, 12.2 (4.8)	8.8, 9.2 (2.8)		10.5 to 12.3	<.005
Erythrocyte sedimentation rate	65.5, 68.8 (34.8)	18, 30.1 (25.8)		51.8 to 66	<.001
C-reactive protein	7.6, 10.8 (9.4)	2.2, 4.0 (4.6)		7.3 to 10.7	<.001
Glycated hemoglobin >8%	70 (84.3)	0			
Glomerular filtration rate <60	16 (19.3)	1 (3.2)	7.2	0.9 to 56.5	<.05
Albumin	3.5, 3.4 (0.5)	3.9, 3.9 (0.8)		3.3 to 3.6	<.005
Prealbumin	12.7, 13.7 (6.6)	26.9, 21.8 (7.8)		12.2 to 16	<.05
Prior treatment	13 (15.7)	7 (22.6)	0.6	0.2 to 1.8	.39
Osteomyelitis	31 (37.3)	2 (6.5)	8.6	1.9 to 38.8	.001
Number of surgeries	2, 2.7 (1.3)	2, 1.3 (0.8)		2.1 to 2.5	<.001
0	4 (4.8)	7 (22.6)	0.2	0.1 to 0.6	<.005
1 to 2	40 (48.2)	24 (77.4)	0.3	0.1 to 0.7	.005
>3	39 (47)	0	5.8	1.6 to 21.4	<.005
Total (1 to 3)	79 (95.2)	24 (77.4)			
Outcomes					
Healed/no amputation	43 (51.8)	29 (93.5)	0.1	0 to 0.3	<.001
Toe/ray amputation	13 (16)	2 (6.5)	2.7	0.6 to 12.7	.2
Midfoot amputation	18 (21.7)	0			
Leg amputation	9 (10.8)	0			
Total amputation	40 (48.2)	2 (6.5)	13.5	3 to 60.2	<.001
Length of hospitalization (d)					
Osteomyelitis	15, 18.1 (10.9)	34.5 (17.5)		15 to 23.2	<.05
Soft tissue infection	12.5, 15.1 (10.3)	5, 5.7 (3.2)		9.6 to 13.8	<.001
Total	13, 16.2 (10.6)	5, 7.5 (9.0)		11.9 to 15.9	<.001

Descriptive variables are n (%); continuous variables are median, mean (standard deviation).
Abbreviation: CI, confidence interval.

Discussion

Most of the available data regarding puncture wounds is described primarily in children with *Pseudomonas* OM (9,15–22). The current literature on puncture wounds in adults with and without diabetes is >20 years old (2,5–8,22,23). Our study highlights differences in clinical presentation, treatment, outcomes, and severity of puncture wound infections in patients with and without diabetes.

There is a striking difference in the clinical presentation in patients with and without diabetes. Infected puncture wounds in patients with diabetes tend to be more severe, with a higher proportion of OM and leukocytosis (7,24). In our study, 3 patients without diabetes took 120 days before seeking medical care, causing the average time to seek treatment to increase. However, the median time for patients without diabetes to present to the emergency room for treatment was 3 days as opposed to 7 days in patients with diabetes. In 1995, Lavery et al (7) reported on patients with puncture wounds and noted that patients with diabetes took ~3 days longer before seeking medical care than patients without diabetes. Our hypothesis is that due to sensory neuropathy and impaired pain response, patients with DM do not manifest traditional symptoms of infections, resulting in a delay in presentation. As previously described by Lavery et al (7), 92% of patients with diabetes had neuropathy, and their main complaint in the emergency department was not pain, but rather not feeling well and local signs of infection. The main complaint of people without diabetes was pain.

Lavery and colleagues (7,24) looked at 77 patients with diabetes and 69 patients without diabetes with an infected puncture wound and found that patients with diabetes had significantly more episodes of OM (35% versus 13%). Laughlin et al (9) reported similar rate of OM (16%) in patients without diabetes. Our rate of OM in patients with diabetes is similar to Lavery at 37.3%. However, we have a lower incidence of OM (6.5%) in patients without diabetes. This could be because both the Laughlin and Lavery studies had higher numbers of subjects without diabetes than ours.

We found that patients with diabetes required significantly more surgical procedures than patients without diabetes. No patient without diabetes required >2 surgeries; patients with diabetes had ≤6 surgeries for management of the infection. This is consistent with Armstrong et al (2), who reported that the requirement of multiple operations in patients with diabetes was 5 times higher than in patients without diabetes.

There are several limitations to this study. The first limitation is its retrospective nature. It relies on the accuracy of the medical records, and is vulnerable to errors in data collection. Measurement bias is possible because other experienced physicians may use a different operational definition of disease processes. Because this cohort of patients was treated at a safety net hospital, selection bias is also a possibility, because our hospital serves a low-income population with a large minority population. Performance and chronological bias are also possible.

In summary, we found that patients with diabetes who experienced puncture wounds of the foot had worse outcomes than patients without diabetes. The worse outcomes potentially may be explained by a significant delay in treatment as a result of peripheral neuropathy. Because of the low number of patients without diabetes, this study may be underpowered to detect other significant differences between the 2 groups. Further research with higher numbers of subjects in both groups would provide more accurate data on the differences between the groups.

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