Risk Factors for Major Amputation on Hindfoot Ulcers in Hospitalized Diabetic Patients

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Objective: The purpose of this study was to investigate the risk factors for major amputation in patients hospitalized with diabetic foot ulcers involving the hindfoot.

Approach: Between January 2003 and October 2017, a total of 1,657 diabetic patients were admitted to the diabetic wound center of Korea University Guro Hospital, for the management of foot ulcers. Among the admitted patients, 117 diabetic patients with hindfoot ulcers were included in this study. One hundred and four patients (89%) healed without major amputation, while 13 patients (11%) healed with major amputation. Data related to 88 potential risk factors, including demographics, ulcer condition, vascularity, bioburden, neurology, and serology, were collected from patients in these two groups for comparison.

Results: Among the 88 potential risk factors, 15 showed statistically significant differences between the two groups. In univariate analysis of 88 potential risk factors, nine showed statistically significant differences. In stepwise multiple logistic regression analysis, three of the nine risk factors remained statistically significant. Multivariate-adjusted odds ratios for pulmonary disorders, erythrocyte sedimentation rate (ESR) levels, and total iron-binding capacity (TIBC) levels were 38.525, 1.047, and 0.976, respectively.

Innovation: Compared with forefoot and midfoot ulcers, diabetic foot ulcers involving the hindfoot are at increased risk of major amputation because infection may spread proximal to the ankle. However, large-scale cohort studies that specifically discuss the outcomes and characteristics of diabetic hindfoot ulcers are not widely available.

Conclusion: Risk factors for major amputation in patients hospitalized with diabetic hindfoot ulcers include pulmonary disorders, high levels of ESR, and decreased TIBC levels.

Keywords: diabetic foot, hindfoot, major amputation, risk factor

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INTRODUCTION

DIABETIC FOOT ULCER is a common complication of diabetes. An estimated 10–25% of all patients with diabetes develop foot ulcers in their lifetime.¹ The pathophysiology of diabetic foot ulcer is multifactorial, including peripheral neuropathy, peripheral vascular disease, repetitive trauma, and superimposed foot infection.^{2,3} Dia-

betic foot ulcers frequently lead to lower extremity amputations, ~75% of which are performed in patients with diabetes mellitus.⁴

Major amputations, including above- and below-knee amputations, often lead to significant functional disability, with high rates of postoperative mortality. They are also associated with increased cardiovascular

demand in a subset of patients who already have an increased prevalence of cardiovascular disease.⁵ According to a retrospective study by Aulivola *et al.*,⁶ the overall survival after major amputation ranged from 91.4% at 30 days and 69.7% at 1 year, to 34.7% at 5 years. Therefore, limb salvage is essential for overall stabilization of diabetic foot ulcer patients and prevention of life-threatening outcomes.

CLINICAL PROBLEM ADDRESSED

Compared with forefoot and midfoot ulcers, diabetic foot ulcers involving the hindfoot are at increased risk of major amputation because infection may spread proximal to the ankle. Forefoot ulcers are managed by early surgical intervention such as minor amputation. Although diabetic foot ulcers involving the hindfoot are less frequent, they are associated with poorer prognosis compared with those involving the midfoot or forefoot. The estimated cost of managing the hindfoot ulcer was 1.5-fold higher compared with the midfoot ulcer. Limb salvage in the hindfoot ulcer compared with the midfoot ulcer was attended with a twofold to threefold lower success rate.⁷ The increased rate of the overall major amputation appears to be driven by diabetic foot ulcers associated with the hindfoot.

Several risk factors for major amputation among patients with diabetic foot ulcers have been reported in the literature.^{8–10} However, only few studies involved large cohorts that specifically discussed outcomes and characteristics of hindfoot ulcers.^{8,11,12} In addition, previous studies were mainly conducted at multidisciplinary centers. Management protocols for diabetic foot ulcers vary widely according to hospital policies and guidelines. However, a large-scale study of patients treated with identical management protocol has yet to be reported. Therefore, the purpose of this study was to determine the risk factors for major amputation in patients with diabetic foot ulcers involving the hindfoot, following standard treatment at a referral center for diabetic foot ulcers in Korea.

MATERIALS AND METHODS

Management protocol in brief

We hospitalized patients diagnosed with poorly managed diabetic foot ulcers contraindicated for outpatient clinic-based treatments. Patients with severely infected ulcers that required surgical debridement with systemic intravenous antibiotic therapy, including septic diabetic foot, were also hospitalized. Other criteria for admission included findings of severe vasculopathy warranting im-

mediate angioplasty and situations where outpatient clinic-based debridement was impossible.

Complete medical history of patients was obtained on admission. General serological tests, including serum blood glucose and inflammatory markers, were performed. The vascularity of the diabetic foot was measured based on transcutaneous partial oxygen tension (TcPO₂), Doppler wave, and toe pressure. Patients with peripheral arterial disease underwent percutaneous transluminal angioplasty (PTA) by interventional cardiologists. Hyperbaric or normobaric oxygen therapy was used as an adjunct to treatment for several clinical conditions associated with tissue hypoxia. Deep tissue culture was performed for the management of wound bioburden. When necessary, intravenous antibiotics were administered empirically, and changed according to the results of culture and sensitivity tests. Serial surgical debridement was performed as needed at bedside or in the operating room according to wound condition. Patients with osteomyelitis were treated with systemic antibiotic therapy for at least 3–6 weeks. Osteomyelitis was diagnosed by magnetic resonance imaging (MRI) and bone biopsy cultures. Neuropathy was evaluated by Semmes-Weinstein monofilament test, pin prick test, temperature test, electromyography (EMG), and nerve conduction velocity tests. Appropriate off-loadings were provided according to ulcer locations. Patients indicated for outpatient treatment were discharged, after receiving specific individual therapeutic footwear.

If wound condition worsened despite treatments based on our protocol for at least 1 month, major amputation was considered to prevent deterioration of their general condition, after efforts to save the limb, including flap surgery. Major amputation was the last resort. Life-threatening conditions associated with severely infected ischemic limbs with a risk of systemic sepsis were also indications for major amputation.

Patients

The study protocol was approved by the Institutional Review Board of our institution. This study was performed in accordance with the Declaration of Helsinki.

This observational and cohort study included the data of 1,657 consecutive patients, who were hospitalized for the management of diabetic foot ulcers at the diabetic wound center of Korea University Guro Hospital between January 2003 and October 2017. The diabetic wound center of the Korea University Guro Hospital is a referral center for patients with diabetic foot ulcers. Among 1,657

Figure 1. A flow diagram of patients included in the study (n =number of patients).

patients, those who met the following inclusion criteria were included in this study: duration of diagnosed diabetes >5 years; ulcer lesion localized at hindfoot; patients without missing data; and patients with a final clinical result of complete healing. Complete healing was defined as a completely epithelialized state without discharge or open lesions. Patients were excluded if they had multiple ulcers of forefoot or midfoot, underwent ongoing treatment, or were lost to follow-up at the time of hospital discharge (Fig. 1).

In total, 1,154 patients (799 males and 355 females) were successfully monitored until complete healing. Of these 1,154 patients, 117 met the inclusion criteria. One hundred and four (89%) of 117 patients healed without major amputations, and 13 (11%) patients healed with major amputation (Table 1). The mean age of the patients was 59.6 ± 11.7 years (range, 27–96 years). The mean duration of diabetic foot ulcers was 7.9 ± 6.5 months and the mean hospitalization period was 21.5 ± 8.1 days.

Evaluation

Patient data were linked to hospital electronic records. Linked data were obtained from Korea University Guro Hospital Admitted Data Collection, which was regularly audited to minimize data inaccuracy. During the admission process, we retained a total of 88 different forms of patient data representing potential risk factors, including demographics, ulcer characteristics, baseline vascularity, wound bioburden, neurology, and serology of all hospitalized patients. To compare demographic and clinical characteristics, 28 variables such as gender,

Table 1. Rate of major amputations according to ulcer locations

	Total Patients	Major Amputation (%)
Forefoot	918	45 (4.9)
Midfoot	119	12 (10.1)
Hindfoot	117	13 (11.1)
Total	1,154	70 (6.1)

age, dialysis, and duration were investigated. Ulcer characteristics, including 16 variables such as location, size, and depth of the ulcer in the major amputation and nonamputation groups, were compared. Results of TcPO₂, toe pressure, Doppler, and computed tomography angiography (CTA) were used to compare vascularity. In addition, 11 variables associated with wound bioburden, 2 variables suggesting neuropathy, and 26 variables of general serology such as hemoglobin A1c, albumin, and glucose were compared between the two groups (Table 2).

All patients showed unilateral involvement except for 10 individuals. Among patients with bilateral involvement, the foot with the larger ulcer was

selected for the analysis. Among patients who were admitted multiple times for different episodes, only the first admission was included in this study.

Statistical analyses

Data of all 88 variables in patients treated successfully with major amputations were compared with those without major amputations and statistical significance was examined. Mann-Whitney *U*-tests were used to compare quantitative variables between the two groups. With regard to categorical variables, Chi-square tests were used, except for ambulation status, smoking status, neuropathic symptoms, location and depth of ulcer, MRI findings,

Table 2. Risk factors analyzed in this study

Risk Factor (p-Value)			
Demographics	Gender (1.000) Age (0.709) DM duration (0.538) Ambulation (0.948) Neuropathic Sx. (0.058) Dialysis (0.174) Dialysis duration (0.210) Smoking (0.354) Previous Hx. of DMF Tx. (0.645)	Foot deformity Charcot deformity (0.389) Claw toe (1.000) Hammer/mallet toe (1.000) Hallux valgus (1.000) High arch foot (0.356) Comorbidities Cardiac disorder (0.304) Hypertension (0.387) Pulmonary disorder (0.020) ^a Renal disorder (0.111)	Comorbidities (continued) GI disorder (1.000) Hepatobiliary disorder (1.000) Ophthalmic disorder (0.286) CNS disorder (0.441) Arthritis (1.000) Musculoskeletal disorder (1.000) Genitourinary disorder (0.609) Metabolic disorder (0.356) Malignant tumor (0.515) Other comorbidities (0.352)
Ulcer characteristics	Cause Trauma (0.069) Burn (1.000) Pressure (0.195) Spontaneous (1.000) Duration (0.049) ^a Side (0.327) Size (0.011) ^a Previous Treatment at other hospital (1.000)	Depth Dermis (1.000) Subcutaneous tissue (0.542) Tendon/Joint (1.000) Bone (0.871) Inflammatory sign (0.316)	Location Dorsal foot (0.514) Plantar foot (0.056) Border (0.337)
Vascularity	TcPO ₂ (0.111) CTA ATA stenosis (0.994) PoTA stenosis (0.528)	Toe pressure (1.000)	Doppler (0.615)
Wound bioburden	Serology WBC (0.009) ^a ESR (0.001) ^a CRP (<0.001) ^a Procalcitonin (<0.001) ^a	MRI No infection (0.589) Cellulitis (0.108) Bone marrow edema (0.280) Osteomyelitis (0.316)	Tissue culture No growth (0.100) Growth, soft tissue (0.043) ^a Growth, bone (0.738)
Neurology	Monofilament test (0.012) ^a	EMG and NCV (1.000)	
General serology	HbA1c (0.432) LDL (0.339) Albumin (0.011) ^a Creatinine (0.410) FBS (0.282) Vitamin E α (0.117) Fe (0.119) Cu (0.144) TIBC (<0.001) ^a	Cholesterol (0.402) Hb (0.048) ^a Protein (0.039) ^a ALT (0.007) ^a Vitamin A (0.625) Vitamin E β (0.885) Mg (0.644) Platelet (0.142) 2-h postprandial blood sugar (0.454)	HDL (0.919) Glucose (0.597) BUN (0.869) AST (0.907) Vitamin C (0.356) Vitamin E γ (0.803) Zn (0.052) Ferritin (0.001) ^a

^a*p* < 0.05.

ALT, alanine aminotransferase; AST, aspartate aminotransferase; ATA, anterior tibial artery; BUN, blood urea nitrogen; CNS, central nervous system; CRP, C-reactive protein; CTA, computed tomography angiography; DM, diabetes mellitus; EMG, electromyography; ESR, erythrocyte sedimentation rate; FBS, fasting blood sugar; GI, gastrointestinal; HDL, high-density lipoprotein; LDL, low-density lipoprotein; MRI, magnetic resonance imaging; NCV, nerve conduction velocity; PoTA, posterior tibial artery; TcPO₂, transcutaneous partial oxygen tension; TIBC, total iron-binding capacity; WBC, white blood cell.

and EMG findings. Fisher's exact tests were used to analyze these seven variables due to the statistically limited data for these variables.

Univariate logistic regression analysis and odds ratios (OR) with 95% confidence interval (CI) were used to analyze the association between the risk of major amputation and the aforementioned 88 variables. Statistically significant variables identified in univariate regression analysis were used to perform stepwise multivariate logistic regression. A p -value of <0.05 was considered statistically significant. The data were analyzed using the IBM SPSS version 21 software package (SPSS, Chicago, IL).

RESULTS

In comparative analysis of the major amputation group and nonamputation group, 15 of 88 potential risk factors showed statistically significant differences (Table 2). In univariate analysis, significant differences were observed for 9 of 88 potential risk factors. In stepwise multiple logistic analysis, three factors remained statistically significant among the nine factors. Multivariate-adjusted ORs in the stepwise logistic regression model for pulmonary disorders, erythrocyte sedimentation rate (ESR) levels, and total iron-binding capacity (TIBC) levels were 38.525 (95% CI: 2.053–723.010; $p=0.015$), 1.047 (95% CI: 1.001–1.095; $p=0.046$), and 0.976 (95% CI: 0.956–0.996; $p=0.021$), respectively (Table 3).

DISCUSSION

Few studies reported the major amputation rates of diabetic hindfoot ulcers. In the European Study Group on Diabetes and the Lower Extremity

(EURODIALE) study reported by Pickwell *et al.*,¹³ ulcer location had a significant effect on the outcome. Major amputations were performed more frequently for heel ulcers compared with those of the midfoot and forefoot ulcers; mortality was the highest in patients with heel ulcers. Chipchase *et al.*¹¹ have reported that 7.1% of diabetic patients with heel ulcers were resolved by major amputation, while 19.5% were unhealed at the time of patient's death. Orneholm *et al.*⁸ reported an amputation rate of 8.6% at a multidisciplinary diabetes foot clinic (tertiary center) in Sweden. The percentage of patients with major amputations in our study appeared to be higher than in previous studies. The reason might be because hospitalized patients enrolled in this study had relatively more severe ulcers. For example, 50% (58/117) of patients had osteomyelitis. Faglia *et al.*¹⁴ reported that major amputation was performed in 52% of diabetic patients with osteomyelitis of the heel.

In addition to adequate treatment, identification of risk factors for diabetic hindfoot ulcers is essential to prevent major amputation. In our study, univariate and multivariate stepwise logistic regression analyses showed that nine and three items, respectively, were risk factors for major amputation in patients with diabetic foot ulcers involving the hindfoot.

Pulmonary disorder (OR = 38.525, $p=0.015$) was a factor predicting major amputation in the stepwise multivariate analysis. Pulmonary disorder is an independent risk factor for tissue hypoxia and ischemia, endothelial vasomotor alterations, acceleration of platelet aggregation, and inhibition of collagen synthesis.¹⁵ We administered normobaric or hyperbaric oxygen therapy to hospitalized

Table 3. Results of univariate and stepwise multiple logistic analyses

Factors	Univariate Analysis			Stepwise Logistic Regression		
	OR	95% CI	p-Value	OR	95% CI	p-Value
Demographics						
Comorbidities						
Pulmonary disorder	6.160	1.511–25.118	0.011	38.525	2.053–723.01	0.015
Ulcer characteristics						
Size	1.013	1.002–1.024	0.017			
Wound bioburden						
Serology (standard value)						
WBC (7,100–11,000/ μ L)	1.201	1.071–1.347	0.002			
ESR (0–10 mm/h)	1.038	1.012–1.064	0.004	1.047	1.001–1.095	0.046
CRP (0–5 mg/L)	1.008	1.003–1.013	<0.001			
General serology (standard value)						
Albumin (3.3–5.1 g/dL)	0.244	0.064–0.926	0.038			
ALT (10–44 IU/L)	0.874	0.781–0.977	0.018			
Ferritin (30–400 ng/mL)	1.001	1.000–1.002	0.008			
TIBC (250–450 μ g/dL)	0.974	0.959–0.990	0.001	0.976	0.956–0.996	0.021

CI, confidence interval; OR, odds ratios.

patients. However, oxygen delivery to diabetic foot ulcers may be difficult in patients with pulmonary disorders such as tuberculosis, chronic obstructive pulmonary disease, and pneumonia, despite the use of the oxygen therapy. Such a condition certainly elevates the risk of major amputation in patients.

Serum TIBC level (OR=0.976, $p=0.021$) was also found to be a predictive factor for major amputation in the stepwise multivariate analysis. In univariate analysis, serum ferritin (OR=1.001, $p=0.008$) was found to be a predictive factor for major amputation. Previous studies have shown that anemia associated with low hemoglobin level was a risk factor for major amputation in diabetic foot ulcers.^{10,15,16} Severe anemia with low hemoglobin levels may contribute to wound hypoxia, thus adversely affecting wound healing.¹⁵ Traditionally, anemic patients have been divided into two groups: "iron deficiency anemia" and "anemia of chronic inflammation."¹⁷ In anemia of chronic inflammation, ferritin is normal or high, while TIBC is low as iron is segregated by macrophages and stored as ferritin following failure to deliver iron from the reticuloendothelial system to the bone marrow. We found that TIBC and ferritin rather than hemoglobin levels were risk factors for major amputation in diabetic hindfoot ulcers.

Serum ESR level (OR=1.047, $p=0.046$) was also a significant risk factor in the stepwise logistic regression. In addition, serum white blood cell (WBC) and C-reactive protein (CRP) levels were risk factors for major amputation in univariate analysis. ESR appears to be the best biomarker to diagnose diabetic foot osteomyelitis.^{18,19} Other inflammatory markers such as CRP and procalcitonin might be used in acute phase of the disease. However, they revert to normal level typically within a week of treatment.^{18,20} Therefore, ESR may be useful for monitoring response to therapy as it tends to normalize more slowly.²¹ Furthermore, a prospective study by Michail *et al.*,²¹ involving 27 patients with diabetic foot osteomyelitis, demonstrated that ESR can be used in the follow-up of osteomyelitis to monitor treatment response instead of other serum inflammatory markers such as WBC, CRP, and procalcitonin. In our previous study, the mean values of ESR in infectious and noninfectious diabetic foot patients were found to be 90 ± 35 mm/hr and 55 ± 34 mm/hr, respectively.²² Furthermore, the sensitivity of ESR was significantly higher compared with WBC or CRP. Although inflammatory markers such as WBC, ESR, CRP, and procalcitonin have been disputed as predictive factors for major amputation, higher ESR levels might predict a higher chance of major amputation in diabetic hindfoot ulcers.

Ulcer size, serum albumin, and alanine aminotransferase (ALT) levels were also risk factors for major amputation in diabetic hindfoot ulcers, according to the univariate analysis. First, the ulcer size (OR=1.013, $p=0.017$) was a significant risk factor for major amputation in hindfoot ulcers since large ulcers may increase the contact area with bones, thus increasing the risk of osteomyelitis in diabetic hindfoot. Second, serum albumin (OR=0.244, $p=0.038$) was an additional predictive factor for major amputation. A low serum albumin level implies poor nutrition, which could delay wound healing. In addition, serum albumin can be reduced during episodes of metabolic stress, such as sepsis. Third, serum ALT level (OR=0.874, $p=0.018$) was also a risk factor for major amputation. A review of medical literatures revealed that uremia, diabetes, malnutrition, and alcoholic disease were associated with low ALT activity,²³ for unknown reasons. Further investigations are needed.

In contrast of others' observation, our data showed that nephropathy,⁸ peripheral arterial disease,²⁴ and osteomyelitis^{25,26} were not risk factors for major amputation in diabetic hindfoot ulcers. A previous study suggested that nephropathy and high creatinine levels were risk factors for major amputation in diabetic hindfoot ulcers.⁸ However, our data revealed that nephropathy, dialysis, and serum creatinine level were not risk factors in univariate analysis ($p=0.120$, $p=0.172$, and $p=0.953$, respectively) because we referred patients who underwent dialysis or showed high creatinine levels to the Department of Nephrology, according to our management protocol. Experienced nephrologists at our hospital successfully managed the poor renal condition of our patients.

Furthermore, the presence of peripheral arterial disease has also been cited as a risk factor for major amputation in diabetic hindfoot ulcers.^{8,12,24} We evaluated the vascular status of every hospitalized patient and patients with peripheral arterial disease, who underwent PTA. Our previous study demonstrated that PTA significantly increased TcPO₂ in ischemic diabetic feet.²⁷ We believe that PTA may increase tissue oxygenation in diabetic hindfoot ulcers compared with those involving forefoot or midfoot.

Previous studies suggested that osteomyelitis was a risk factor for major amputation in diabetic foot ulcers.^{12,24-26} However, our data showed that osteomyelitis was not a risk factor for major amputation because we treated foot infections aggressively by frequent serial surgical debridement with at least 3-6 weeks of systemic antibiotic therapy based on results of tissue culture, according

to our management protocol. In addition, treatment with systematic antibiotics might be more effective for hindfoot than for other distal areas.

These study findings indicated that major amputations in diabetic hindfoot ulcers were associated with pulmonary disorder, high levels of ESR, and decreased TIBC levels. First, pulmonary disorder was the strongest predictor for major amputation in patients with diabetic hindfoot ulcers. Thus, diabetic patients with pulmonary disorders may not have adequate tissue oxygenation in wound beds for wound healing. Second, the leading cause associated with ESR elevation is infection.²⁸ Wound infection *per se* can delay wound healing. In addition, pneumonia is known to be a leading infectious cause underlying the high levels of ESR.²⁹ As mentioned above, pneumonia, one of the representative pulmonary disorders, may impair oxygen supply in wound beds, leading to delayed wound healing. Third, diabetic patients with decreased TIBC levels were commonly associated with chronic inflammation. In addition, TIBC levels suggested the levels of transferrin, and transferrin has been known to be an antioxidant. Therefore, decreased TIBC levels probably contributed to decreased antioxidant status.³⁰ Consequently, inadequate tissue oxygenation, infection, chronic inflammation, and decreased antioxidant levels provide a theoretical basis underlying the increased risk of major amputation.

The study findings suggest that it is imperative to investigate diabetic hindfoot ulcer patients for pulmonary disorders, high ESR, or low TIBC levels. Appropriate evaluation and treatment of high-risk comorbidities such as pulmonary disorder, infection, and chronic inflammation may reduce the risk of major amputation. Pulmonary function testing and chest computed tomography are simple, safe, and inexpensive modalities, and are indicated for screening of pulmonary disorders. Maintaining ESR and TIBC levels within normal limits is a therapeutic strategy to prevent major amputations. In particular, frequent monitoring of patients with high ESR or low TIBC levels is necessary for a timely response and appropriate treatment of infection and chronic inflammation.

The three items that were noted as risk factors in our study might be genetic in nature. Primary ciliary dyskinesia, an autosomal recessive genetic pulmonary disorder that causes defects in the action of cilia lining in the respiratory tract, may increase the risk.³¹ Autoimmune disorders such as rheumatoid arthritis, polymyalgia rheumatic, systemic lupus erythematosus, and giant cell arteritis are common genetic inflammatory disorders associated with ESR elevation.³² Hereditary hemochromatosis is

the most common inherited disorder of iron metabolism involving an abnormal increase in intestinal iron absorption associated with decreased TIBC levels.³³ In addition, the prognosis of individuals with diabetes may also vary depending on socioeconomic status such as income, education, occupation, and insurance. However, our databases lacked comprehensive information associated with genetic and socioeconomic factors. Therefore, further studies based on accurate data related to genetic and socioeconomic factors for major amputation in diabetic patients with hindfoot ulcers are needed.

Our study had all limitations inherent to retrospective studies. For example, patient compliance that could affect the outcomes was not considered. Our patient population was entirely Korean. A selection bias may exist because our hospital is a tertiary referral center for complex diabetic foot ulcers. Therefore, results of this study might not be applicable to the general population or primary care centers. In addition, this study focused only on baseline data at the time of admission. Individual responses to treatment were not considered.

In summary, we have determined the risk factors for major amputation involving hindfoot ulcers in hospitalized diabetic patients. Although our knowledge is not comprehensive to ensure prevention of major amputations in diabetic patients at high risk, these risk factors may facilitate physicians engaged in the assessment of patients needing hospitalization and prompt treatment.

INNOVATION

This study might be the first large-scale cohort study that specifically investigated the risk factors for major amputation in diabetic patients with hindfoot ulcers. Risk factors for major amputation among hospitalized diabetic hindfoot patients were pulmonary disorders, high levels of ESR, and decreased TIBC levels.

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KEY FINDINGS

- Hindfoot ulcers in diabetic patients are closely associated with major amputation; however, few studies have determined the risk factors for major amputation.
- This study was designed to determine the risk factors for major amputation in diabetic hindfoot ulcers.
- Risk factors were pulmonary disorders, high levels of ESR, and decreased TIBC levels.

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Abbreviations and Acronyms

ALT = alanine aminotransferase
CI = confidence interval
CRP = C-reactive protein

CTA = computed tomography angiography
EMG = electromyography
ESR = erythrocyte sedimentation rate
MRI = magnetic resonance imaging
OR = odds ratios
PTA = percutaneous transluminal angioplasty
TcPO₂ = transcutaneous partial oxygen tension
TIBC = total iron-binding capacity
WBC = white blood cell