The association between estimated glomerular filtration rate and prognosis in patients with diabetic foot osteomyelitis

Jinghang Zhang | Dong Chen | Xuemei Li | Min Ding | Jun Xu | Meijun Wang | Bai Chang

Abstract
We aimed to explore the association between estimated glomerular filtration rate (eGFR) and prognosis in patients with diabetic foot osteomyelitis (DFO). Three hundred twenty-one DFO inpatients were enrolled and classified into four groups according to the eGFRs as follows: normal (≥90), mildly reduced (60-89), moderately reduced (30-59) and severely reduced (<30). These patients were followed-up for 6 months to observe the outcomes, including ulcer healing and amputation. The associations between eGFR and the outcomes were analysed by univariate and multivariate logistic regression models. Compared with patients with normal eGFR, patients with severely reduced eGFR group had higher risk of healing failure (OR = 4.72, 95% CI: 1.44-15.48), total amputation (OR = 4.50, 95% CI: 1.18-17.13) and minor amputation (OR = 4.05, 95% CI: 1.04-15.87). Severely reduced eGFR in patients with DFO was an independent predictor for amputation and healing failure.

Keywords
diabetic foot osteomyelitis, estimated glomerular filtration rate, prognosis
1 | INTRODUCTION

The diabetes population is increasing in China and worldwide, which has become a global public health problem. The global prevalence of diabetes is estimated to be 9.3% in 2019 and will rise to 10.9% in 2045. In China, the prevalence of diabetes in adults has reached 11.2%. People with diabetes are more likely to foot infection, and about 20% of them will develop diabetic foot ulcer (DFU). Furthermore, a lower limb amputation due to a DFU is carried out every 30 seconds worldwide, with rates being 30 to 40 times higher for diabetic patients than the individuals without diabetes.

Diabetic foot osteomyelitis (DFO) is a moderate to severe infection phase of DFU and has a high amputation and mortality rate. The annual mortality rate of DFU is as high as 11%, while the mortality of amputated patients is even higher than 22%. It has become a hot and difficult point about how to avoid amputation for DFO patients.

Diabetes is also frequently complicated by chronic kidney disease (CKD). Individuals with CKD have an increased risk for DFU. Among patients with DFU, the proportion of CKD is as high as 39.3%. Estimated glomerular filtration rate (eGFR) is a clinically identifiable and intervenable prognostic indicator, which is widely used to evaluate prognosis in patients with DFU. However, there is still no research to observe the association between eGFR and clinical outcomes of DFO patients. Therefore, this study aims to explore the impact of CKD on prognosis of DFO patients according to eGFR.

2 | MATERIALS AND METHODS

2.1 | Study population

A total of 321 DFO patients (224 men and 97 women) diagnosed at Tianjin Medical University Chu Hsien-I Memorial Hospital between December 2019 and January 2021 were prospectively enrolled. All participants provided written informed consent to use their data for research purposes. The research protocol was approved by the ethics committee of Tianjin Medical University Chu Hsien-I Memorial Hospital [DXBYYhMEC2021-26]. This prospective cohort study was conducted in accordance with the Helsinki Declaration. They met the International Working Group on the Diabetic Foot (IWGDF). Exclusion criteria included previous occurrence of DFUs or major amputations, type 1 diabetic foot and acute kidney injury patients. The flow chart is shown in Figure 1.

2.2 | Definition and measurement of exposure, outcomes and impact factors

eGFR was calculated following the EPI equation. Patients were divided into four groups as follows: normal eGFR: ≥90 mL/min/1.73 m², mildly reduced eGFR: 60 to 89 mL/min/1.73 m², moderately reduced eGFR: 30 to 59 mL/min/1.73 m² and severely reduced eGFR: <30 mL/min/1.73 m². DFO was based on probing-to-bone test positive, abnormal plain x-ray and abnormal laboratory testing (including erythrocyte sedimentation rate, high-sensitivity C-reactive protein and procalcitonin). Peripheral arterial disease (PAD) was defined as the presence of stenosis or occlusion of lower limb arteries indicated by Doppler ultrasound. Infection degree was defined according to the classification system of Infectious Diseases Society of America (IDSA). If osteomyelitis is demonstrated in the absence of ≥2 signs/symptoms of local or systemic inflammation, classify the foot as either moderate infection (if <2 systemic inflammatory response syndrome criteria) or severe infection (if ≥2 systemic inflammatory response syndrome criteria) (including: temperature, >38°C or <36°C; heart rate, >90 beats/minute; respiratory rate, >20 breaths/minute or PaCO₂ < 4.3 kPa; white blood cell count >12 000/mm³). DFO healing was determined by complete epithelialisation on the wound without major amputation. The definition of amputations as follows: a minor amputation was defined as any amputation distal to the ankle joint; a major amputation was defined as any amputation up to or proximal to the ankle joint, and a toe amputation was defined as the level of amputation lower than the metatarsophalangeal joint. Other impacted factors, including demographic data, duration of diabetes, HbA1c, albumin (ALB) and other biochemical data. The outcome information was collected from the medical records of inpatients in our department. If the patient cannot be contacted due to foot treatment elsewhere, it is obtained by calling him. All the treatments are based on the guidelines for diabetic foot treatments recommended by the International Working Group on the Diabetic Foot (IWGDF).
subjects after a 10-hours overnight fast: HbA1c, BP, ALB, TC, TG, LDL-C and HDL-C. HbA1c was measured using high-performance liquid chromatography. BP was measured after 15 minutes of rest. Smoker was identified as having smoked more than 100 cigarettes in their lifetime. History of CHD was confirmed by medical records or defined by history of angina or myocardial infarction, any positive cardiac stress test result or pathological signs on coronary angiography. History of stroke was defined as any event of neurological deficit with or without sequela.

### 2.3 Statistical analysis

All clinical and laboratory data were analysed using the Statistical Package for Social Sciences (SPSS) statistical software version 23.0. Quantitative variables were expressed as means ± SD or median (range) according to their distribution, and the one-way ANOVA or Kruskal-Wallis test was used to make comparisons among groups. Qualitative variables were expressed as percentages, and comparisons were made using the \( \chi^2 \) test. To analyse the association between reduced eGFR and healing and amputation, odd ratios (OR) with 95% confidence intervals were first calculated using logistic univariate models. Then, the following factors: age, sex, HbA1c, duration of diabetes, CHDs, SBP, TG, PAD and infection degree were included as confounders to ascertain OR for healing and amputation in multivariate logistic regression models step by step. A P-value < .05 was considered statistically significant.

### 3 RESULTS

#### 3.1 Baseline characteristics

The baseline characteristics of the 321 patients with DFO stratified by eGFR are summarised in the Table 1. Two patients who died during follow-up were excluded. Overall, the mean age was 63.10 ± 11.64 years, and 69.8% of the patients were male. The median diabetes duration was 15 (IQR = 10-20) years. HbA1c level averaged 8.80 ± 2.05%. Two hundred thirty-seven (73.8%) patients received insulin therapy to control blood glucose. Eighty-six (26.8%) patients received angiotensin converting enzyme inhibitors (ACEI)/angiotensin receptor blocker (ARB) agents treatment. Among them, 159 individuals (49.5%) had normal eGFR, 84 individuals (26.2%) had mildly reduced eGFR, 57 individuals (17.8%) had moderately reduced eGFR and 21 individuals (6.5%) had severely reduced eGFR. There were significant differences in age, HbA1c, stroke, CHD, SBP, TG, PAD and infection degree among the four groups (\( P < .05 \)).

#### 3.2 Wound healing

A total of 293 patients without major amputation were followed up. Two hundred twenty-four (76.5%) attained ulcer healing by the end of the follow-up. At the end of follow-up, the healing rate of the normal group was 81.5% (123/151), the healing rate was lower in reduced eGFR group, with 78.4% (58/74), 70.6% (36/51) and 41.2% (7/17) in the mildly, moderately and severely reduced eGFR groups, respectively.
|                          | Total | eGFR (mL/min/1.73 m²) |  ≥90 | 60-89 | 30-59 | <30 | P          |
|--------------------------|-------|-----------------------|------|-------|-------|-----|-----------|
| n                        | 321   |                       | 159  | 84    | 57    | 21  |           |
| Male (%)                 | 224 (69.8) |                   | 105 (66) | 61 (72.6) | 43 (75.4) | 15 (71.4) | .52 |
| Age (y)                  | 63.1 ± 11.65 |           | 60.29 ± 11.66 | 67.71 ± 10.74 | 65.26 ± 10.98 | 60 ± 10.19 | <.01 |
| Diabetes duration (y)    | 15 (10,20) |           | 14 (10,22) | 20 (10,25) | 20 (10,22) | 20 (11,26.5) | .09 |
| HbA1c (%)                | 8.81 ± 2.05 |           | 9.14 ± 2.19 | 8.67 ± 1.92 | 8.39 ± 1.64 | 8.08 ± 2.09 | <.05 |
| PAD (%)                  | 247 (76.9) |           | 112 (70.4) | 62 (73.8) | 54 (94.7) | 19 (90.5) | <.01 |
| Infection degree (%)     |       | Moderate infection   |       |       |       |   | <.01 |
|                         |       | 203 (63.2) | 119 (74.8) | 48 (57.1) | 27 (47.4) | 9 (42.9) |   |
|                         |       | Severe infection    |       |       |       |   | <.01 |
|                         |       | 118 (36.8) | 40 (25.2) | 36 (42.9) | 30 (52.6) | 12 (57.1) |   |
| CHD (%)                  | 129 (40.2) |           | 41 (25.8) | 39 (46.4) | 32 (56.1) | 17 (81) | <.01 |
| Stroke (%)               | 83 (25.9) |           | 27 (17.0) | 27 (32.1) | 23 (40.4) | 6 (28.6) | <.01 |
| SBP (mmHg)               | 136.6 ± 18.58 |           | 133.34 ± 17.16 | 137.02 ± 10.74 | 144.39 ± 10.98 | 138.71 ± 10.19 | <.01 |
| DBP (mmHg)               | 77.44 ± 11.87 |           | 77.66 ± 11.62 | 76.62 ± 11.78 | 78.46 ± 13.38 | 76.29 ± 10.10 | .78 |
| Smoking (%)              | 140 (43.6) |           | 70 (44.0) | 35 (41.7) | 28 (49.1) | 7 (33.3) | .63 |
| ALB (g/L)                | 33.72 ± 5.24 |           | 34.25 ± 5.04 | 34 ± 4.64 | 32.52 ± 6.11 | 32.15 ± 6.02 | .08 |
| TC (mmol/L)              | 4.35 ± 1.25 |           | 4.42 ± 1.28 | 4.17 ± 1.18 | 4.53 ± 1.25 | 4.1 ± 1.20 | .24 |
| TG (mmol/L)              | 1.26 (0.98,1.73) |           | 1.20 (0.94,1.68) | 1.14 (0.89,1.46) | 1.63 (1.14,1.98) | 1.45 (1.19,2.09) | <.01 |
| LDL (mmol/L)             | 3.02 ± 0.97 |           | 3.06 ± 0.98 | 2.87 ± 0.97 | 3.16 ± 0.95 | 2.89 ± 0.91 | .27 |
| HDL (mmol/L)             | 0.86 ± 0.24 |           | 0.88 ± 0.26 | 0.87 ± 0.25 | 0.84 ± 0.21 | 0.74 ± 0.19 | .08 |
| ACEI/ARB (%)             | 86 (26.8) |           | 40 (25.2) | 29 (34.5) | 15 (26.3) | 2 (9.52) | .11 |
| Insulin use (%)          | 237 (73.8) |           | 113 (71.1) | 64 (76.2) | 44 (77.2) | 16 (76.2) | .74 |

Abbreviations: ALB, albumin; CHD, coronary heart disease; DBP, diastolic blood pressure; HbA1c, glycated haemoglobin A1c; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; PAD, peripheral artery disease; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides.
group respectively ($\chi^2 = 14.98; P < .01$). Furthermore, comparing the mildly, moderately and severely reduced group with the normal group, the risk ratio (RR) of healing in the severely reduced eGFR group was $0.505$ (95% CI: 0.29-0.90) ($\chi^2 = 14.16; P < .01$). However, there was no significant difference between the mildly/moderately reduced eGFR group and the normal eGFR group (Detailed in Figure 2A).

The results of the univariate and multivariate logistic regression models for estimating the relationship between eGFR and ulcer healing failure in patients with DFO are listed in Table 2. In univariate regression model (model 1), the risk of healing failure was higher in the severely reduced eGFR group, with OR of $6.28$ (95% CI: 2.2-17.92), but there was no significant difference in the mild to moderate decreased eGFR group ($P < .05$). After further adjusting gender and age, there was still no significant difference in the mildly and moderately reduced eGFR group. Further adjusting for HbA1c, diabetes duration, CHD, stroke, SBP, TG, PAD and infection degree, the difference was still statistically significant in the severely reduced eGFR group ($P = .01$) (shown in Table 2).

3.3 | Total amputation

During the follow-up, 65.1% (209/321) patients underwent amputations. The total amputation rate of the normal group was 58.5% (93/159), the total amputation rate was higher in reduced eGFR group, with 67.9% (57/84), 71.9% (41/57) and 85.7% (19/21) in the mildly, moderately and severely reduced group, respectively ($\chi^2 = 8.44; P = .04$). Furthermore, comparing the mildly, moderately and severely reduced group with the normal group, the RR of total amputation in the severely reduced eGFR group was $1.47$ (95%CI:1.18-1.82) ($\chi^2 = 5.82; P = .02$). No significant difference was found between the mildly/moderately reduced eGFR group and the normal eGFR group (Figure 2B).

Whether in univariate regression analysis or the model after adjusting gender and age, we can see patients with severely reduced eGFR have a higher risk of amputation, and the difference is statistically significant. There was no significant difference between the mildly/moderately reduced eGFR group and the normal eGFR group. By adjusting the confounding factors of diabetes duration and HbA1c, we found that moderately and severely reduced eGFR were all associated with the risk of total amputation, and the difference was statistically significant. Finally, after adjusting all the confounding factors, we found that severely reduced eGFR was independently associated with total amputation rate, and the OR was $4.50$ (95% CI: 1.18-17.13, $P = .03$). (Table 3).

3.4 | Minor amputation

Of all patients who underwent amputation, 187 (89.5%) underwent minor amputation and 22 (10.5%) underwent major amputation. Because of the small major amputation population, in order to avoid statistical bias, we further conducted the regression analysis for minor
amputation. No matter in univariate regression analysis or the model after adjusting gender and age (model 2), reduced eGFR did not correlate with the minor amputation. After further adjusting all other confounding factors, we found that the severely reduced eGFR was independently associated with minor amputation, and the OR was 4.05 (95% CI: 1.04-15.87, \( P = .04 \)). This is consistent with the result of total amputation (Table 3).

### DISCUSSION

A large number of studies have revealed that DFU patients may have adverse outcomes when combined with renal insufficiency, especially in patients with severe renal dysfunction or dialysis.\(^{19-21}\) A retrospective study\(^{22}\) about the long-term diabetic complications as predictors of foot ulcers healing failure revealed that eGFR <60 mL/min/1.73 m\(^2\) was an independent risk factor for

### TABLE 2

| eGFR (mL/min/1.73 m\(^2\)) | 60-89 (n = 84) | 30-59 (n = 57) | <30 (n = 21) |
|----------------------------|----------------|----------------|-------------|
| **Outcomes**               | 60-89 (n = 84) | 30-59 (n = 57) | <30 (n = 21) |
| Healing failure            |                |                |             |
| Model 1 Reference          | 1.21 (0.61-2.41)| 1.83 (0.88-3.79)| 6.28 (2.20-17.92)| \(<.01\)
| Model 2 Reference          | 1.06 (0.52-2.17)| 1.67 (0.79-3.53)| 6.19 (2.15-17.85)| \(<.01\)
| Model 3 Reference          | 1.02 (0.50-2.11)| 1.56 (0.73-3.32)| 5.21 (1.78-15.25)| \(<.01\)
| Model 4 Reference          | 0.97 (0.46-2.03)| 1.11 (0.49-2.50)| 3.98 (1.28-12.42)| \(0.02\)
| Model 5 Reference          | 1.06 (0.50-2.27)| 1.26 (0.542.95)| 4.72 (1.44-15.48)| \(0.01\)

### TABLE 3

| eGFR (mL/min/1.73 m\(^2\)) | 60-89 (n = 84) | 30-59 (n = 57) | <30 (n = 21) |
|----------------------------|----------------|----------------|-------------|
| **Outcomes**               | 60-89 (n = 84) | 30-59 (n = 57) | <30 (n = 21) |
| Total amputation            |                |                |             |
| Model 1 Reference          | 1.50 (0.86-2.61)| 1.82 (0.94-3.51)| 4.26 (1.21-15.05)| \(0.02\)
| Model 2 Reference          | 1.66 (0.93-2.97)| 1.94 (0.99-3.80)| 4.25 (1.20-15.05)| \(0.03\)
| Model 3 Reference          | 1.70 (0.95-3.05)| 2.02 (1.03-3.98)| 4.59 (1.28-16.41)| \(0.02\)
| Model 4 Reference          | 1.74 (0.96-3.16)| 2.46 (1.18-5.13)| 5.17 (1.38-19.32)| \(0.02\)
| Model 5 Reference          | 1.64 (0.89-3.02)| 2.18 (1.02-4.66)| 4.50 (1.18-17.13)| \(0.03\)

### TABLE 3

| eGFR (mL/min/1.73 m\(^2\)) | 60-89 (n = 84) | 30-59 (n = 57) | <30 (n = 21) |
|----------------------------|----------------|----------------|-------------|
| **Outcomes**               | 60-89 (n = 84) | 30-59 (n = 57) | <30 (n = 21) |
| Minor amputation           |                |                |             |
| Model 1 Reference          | 1.35 (0.76-2.38)| 1.62 (0.83-3.18)| 3.46 (0.96-12.53)| \(0.06\)
| Model 2 Reference          | 1.52 (0.84-2.75)| 1.78 (0.89-3.53)| 3.61 (0.99-13.13)| \(0.05\)
| Model 3 Reference          | 1.56 (0.86-2.83)| 1.85 (0.93-3.70)| 3.96 (1.08-14.55)| \(0.04\)
| Model 4 Reference          | 1.61 (0.88-2.97)| 2.11 (0.99-4.51)| 4.43 (1.15-17.04)| \(0.03\)
| Model 5 Reference          | 1.55 (0.83-2.91)| 2.07 (0.95-4.51)| 4.05 (1.04-15.87)| \(0.04\)

Abbreviations: CI, confidence intervals; Model 1, univariate analysis; Model 2, adjusted for age, sex; Model 3, adjusted for age, sex, HbA1c, diabetes duration; Model 4, adjusted for age, sex, HbA1c, diabetes duration, CVD, stroke, SBP, TG; Model 5, adjusted for age, sex, HbA1c, diabetes duration, CVD, stroke, SBP, TG, PAD, infection degree; OR, odd ratio.
Poor wound healing. However, among patients with DFUs, patients with DFO are more complicated and worse prognosis than those without osteomyelitis.23,24

At present, there are few studies on renal function and prognosis of DFO. Some research25 found that high urine albumin-creatinine ratio was associated with poor clinical outcomes in patients with DFO. However, there is no research on eGFR and prognosis of DFO patients.

The current study analysed the association between eGFR and healing/amputation of DFO patients. The results demonstrated that severely reduced eGFR was an independent predictor of healing failure in DFO patients. In our study, 23.5% of patients failed to heal, and the healing rate gradually decreased with the decline of eGFR. The present study found that DFO patients who had a severely reduced eGFR (<30 mL/min/1.73 m²) had a high risk for healing failure (OR = 4.72, P = .01). This was consistent with the previous studies.12,26 Zubair et al26 reported that wound healing was associated with the decrease in creatinine clearance rate in patients with DFUs. He et al12 revealed that a moderate or severe decrease in eGFR was an independent predictor of poor outcomes in DFU patients.

DFU healing is a complex and multi-factor process. Infection and limb ischemia are common factors affecting wound healing. In this study, we demonstrated that severely reduced eGFR was an independent predictor of healing failure in DFO patients. The increased albumin excretion rate could induce peripheral edema, tissue oxygenation and inflammation may be worsened by tissue edema in eGFR-reduced patients.27,28 Anaemia is the most common complication of CKD, which is another factor involved in the healing failure of DFU, as it can also reduce the tissues’ oxygen supply.29 Hypertension caused by renal insufficiency may lead to endothelial dysfunction, worsening of the lower limb ischemia, which harms the process of wound healing.29

Several studies19,21,30,31 revealed that renal insufficiency (eGFR <60 mL/min/1.73 m²) was a risk factor for amputation in DFU patients. Our study confirms that severe reduced eGFR is associated with amputation risk after adjusting the confounders, including the PAD and infection degree (OR = 4.50, P = .03). Different from previous studies, this study further analysed the association between eGFR and the risk of minor amputation in DFU patients. The results revealed that the risk of minor amputation increased by 4.05 times when the eGFR <30 mL/min/1.73 m², which was consistent with the overall amputation. Impaired immune defences of patients with renal failure make the wound more likely to infection, especially the infection of bone tissue. Antibiotic treatment is important for DFO patients. The decline of renal function may represent a limiting factor for antibiotic treatment. This leads to the failure of antibiotic treatment and increases the risk of amputation.32

There were several limitations in our study. First, the sample size was small. Second, the follow-up was short, so we cannot observe the long-term adverse outcomes.

In conclusion, severely reduced eGFR is strongly associated with poor prognoses in DFO patients. The results from this study highlight the need for clinician to protect the renal function in the management of DFU patients.

ACKNOWLEDGEMENTS

The authors are thankful for the medical staff of Chu Hsien-I Memorial Hospital & Tianjin Institute of Endocrinology, Tianjin Medical University, Tianjin China. This work was supported by the National Natural Science Foundation of China (81973614) and The Science &Technology Development Fund of Tianjin Education Commission for Higher Education (2018KJ047).

CONFLICT OF INTEREST

The authors state that they have no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

REFERENCES

1. Boulton AJ, Vileikyte L, Ragnarson-Tennwall G, Apelqvist J. The global burden of diabetic foot disease. Lancet. 2005; 366(9498):1719-1724.
2. Saeedi P, Petersohn I, Salpea P, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: results from the international diabetes federation diabetes atlas, 9 (th) edition. Diabetes Res Clin Pract. 2019;157:107843.
3. Li Y, Teng D, Shi X, et al. Prevalence of diabetes recorded in mainland China using 2018 diagnostic criteria from the American Diabetes Association: national cross sectional study. BMJ (Clin Res Ed). 2020;369:m997.
4. Lavery LA, Armstrong DG, Murdoch DP, Peters EJ, Lipsky BA. Validation of the Infectious Diseases Society of America’s diabetic foot infection classification system. Clin Infect Dis. 2007;44(4):562-565.
5. Ferreira RC. Diabetic foot. Part 1: ulcers and infections. Rev Bras Ortop. 2020;55(4):389-396.
6. Chen D, Wang M, Shang X, et al. Development and validation of an incidence risk prediction model for early foot ulcer in diabet es based on a high evidence systematic review and meta-analysis. Diabetes Res Clin Pract. 2021;180:109040.
7. Singh N, Armstrong DG, Lipsky BA. Preventing foot ulcers in patients with diabetes. JAMA. 2005;293(2):217-228.
8. Ndosi M, Wright-Hughes A, Brown S, et al. Prognosis of the infected diabetic foot ulcer: a 12-month prospective observational study. Diabet Med. 2018;35(1):78-88.
9. Jiang Y, Ran X, Jia L, et al. Epidemiology of type 2 diabetic foot problems and predictive factors for amputation in China. Int J Low Extrem Wounds. 2015;14(1):19-27.
10. Fortington LV, Geertzen JH, van Netten JJ, Postema K, Rommers GM, Dijkstra PU. Short and long term mortality rates after a lower limb amputation. *Eur J Vasc Endovasc Surg*. 2013;46(1):124-131.

11. Margolis DJ, Hofstad O, Feldman HI. Association between renal failure and foot ulcer or lower-extremity amputation in patients with diabetes. *Diabetes Care*. 2008;31(7):1331-1336.

12. He Y, Qian H, Xu L, et al. Association between estimated glomerular filtration rate and outcomes in patients with diabetic foot ulcers: a 3-year follow-up study. *Eur J Endocrinol*. 2017;177(1):41-50.

13. Orimoto Y, Ohta T, Ishibashi H, et al. The prognosis of patients on hemodialysis with foot lesions. *J Vasc Surg*. 2013;58(5):1291-1299.

14. Bus SA, Lavery LA, Monteiro-Soares M, et al. Guidelines on the prevention of foot ulcers in persons with diabetes (IWGDF 2019 update). *Diabetes Metab Rev*. 2020;36(Suppl 1):e3269.

15. Levey AS, Stevens LA, Schmid CH, et al. A new equation to estimate glomerular filtration rate. *Ann Intern Med*. 2009;150(9):604-612.

16. Lipsky BA, Senneville É, Abbas ZG, et al. Guidelines on the diagnosis and treatment of foot infection in persons with diabetes (IWGDF 2019 update). *Diabetes Metab Rev*. 2020;36(Suppl 1):e3280.

17. Morbach S, Furchert H, Gröblinghoff U, et al. Long-term prognosis of diabetic foot patients and their limbs: amputation and death over the course of a decade. *Diabetes Care*. 2012;35(10):2021-2027.

18. Morbach S, Lutale JK, Viswanathan V, et al. Regional differences in risk factors and clinical presentation of diabetic foot lesions. *Diabet Med*. 2004;21(1):91-95.

19. Lee JH, Yoon JS, Lee HW, et al. Risk factors affecting amputation in diabetic foot. *Yeungnam Univ J Med*. 2020;37(4):314-320.

20. Wolf G, Müller N, Busch M, et al. Diabetic foot syndrome and renal function in type 1 and 2 diabetes mellitus show close association. *Nephrol Dial Transplant*. 2009;24(6):1896-1901.

21. Salim M. Clinical outcomes among patients with chronic kidney disease hospitalized with diabetic foot disorders: a nationwide retrospective study. *Endocrinol Diabetes Metab*. 2021;4(3):e00277.

22. Caruso P, Longo M, Gicchino M, et al. Long-term diabetic complications as predictors of foot ulcers healing failure: a retrospective study in a tertiary-care center. *Diabetes Res Clin Pract*. 2020;163:108147.

23. Grennan D. Diabetic foot ulcers. *JAMA*. 2019;321(1):114.

24. Wukich DK, Hobizal KB, Brooks MM. Severity of diabetic foot infection and rate of limb salvage. *Foot Ankle Int*. 2013;34(3):351-358.

25. Yang J, Huang J, Wei S, et al. Urine albumin-creatinine ratio is associated with prognosis in patients with diabetic foot osteomyelitis. *Diabetes Res Clin Pract*. 2021;180:109043.

26. Zubair M, Malik A, Ahmad J. The impact of creatinine clearance on the outcome of diabetic foot ulcers in north Indian tertiary care hospital. *Diabetes Metab Syndr*. 2011;5(3):120-125.

27. Ndi A, Lavery LA, Boulton AJ. Diabetic foot disease in people with advanced nephropathy and those on renal dialysis. *Curr Diab Rep*. 2010;10(4):283-290.

28. Gohel MS, Windhaber RA, Tarlton JF, Whyman MR, Poskitt KR. The relationship between cytokine concentrations and wound healing in chronic venous ulceration. *J Vasc Surg*. 2008;48(5):1272-1277.

29. Barrett EJ, Liu Z, Khamaisi M, et al. Diabetic microvascular disease: an Endocrine Society scientific statement. *J Clin Endocrinol Metab*. 2017;102(12):4343-4410.

30. Ghanassia E, Villon L, Thuan Dit Dieudonné JF, Boegner C, Avignon A, Sultan A. Long-term outcome and disability of diabetic patients hospitalized for diabetic foot ulcers: a 6.5-year follow-up study. *Diabetes Care*. 2008;31(7):1288-1292.

31. Miyajima S, Shirai A, Yamamoto S, Okada N, Matsushita T. Risk factors for major limb amputations in diabetic foot gangrene patients. *Diabetes Res Clin Pract*. 2006;71(3):272-279.

32. Roberts DM, Sevastos J, Carland JE, Stocker SL, Lea-Henry TN. Clinical pharmacokinetics in kidney disease: application to rational design of dosing regimens. *Clin J Am Soc Nephrol*. 2018;13(8):1254-1263.

How to cite this article: Zhang J, Chen D, Li X, et al. The association between estimated glomerular filtration rate and prognosis in patients with diabetic foot osteomyelitis. *Int Wound J*. 2022;19(7):1650-1657. doi:10.1111/iwj.13765