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Research Article

Foot Assessment and Risk Factors Classification in Diabetic Nephropathy Patients with Maintenance Hemodialysis

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Abstract

Background: Diabetic nephropathy patients with maintenance hemodialysis have a high incidence of foot ulcers and amputations. This study aims to explore the foot conditions of patients with maintenance dialysis, and screen high-risk groups and strengthen targeted foot care.

Methods: 133 diabetic nephropathy patients were selected from the First affiliated hospital of Jinan university from March 2018 to October 2018, including 63 patients with maintenance Hemodialysis (DN with HD) and 70 patients without dialysis (DN). All patients adopt self-designed foot assessment questionnaire by diabetes specialist, Gavin weighted score of diabetic foot risk factors and Wagner classification for diabetic foot.

Results: The incidence of numbness, abnormal toenail, decreased or absent posterior tibial artery pulse, abnormal temperature sensation and 10g nylon monofilament abnormal in DN with HD patients was significantly higher than that in DN patients (all $P < 0.05$). The Gavin weighted score of diabetic foot risk factors in DN with HD patients was 20.63% in low-risk group, 69.84% in medium-risk group and 9.52% in high-risk group; and that in DN patients was 67.14% for low-risk, 30.00% for medium-risk and 2.86% for high-risk. The difference in distribution between these two groups was statistically significant. In DN with HD group, grade 0 of Wagner classification for diabetic foot was 57 cases, accounting for 90.47%. There were 6 cases with diabetic foot (9.52%), and there were 4 cases of grade 1 (6.35%), 1 case of grade 2 (1.59%) and 1 case of grade 4 (1.59%), respectively. Among the patients with DN, there were 15 cases with normal of Wagner classification for diabetic foot (21.43%) and 51 cases with grade 0 (72.86%). Among 4 cases with diabetic foot (5.71%), there were 3 cases of grade 1, accounting for 4.29%, and 1 case of grade 2, accounting for 1.43%. The difference between these two groups was also statistically significant.

Conclusion: The results of the foot assessment were more severe in diabetic nephropathy patients with maintenance hemodialysis than those in diabetic nephropathy patients without dialysis. Diabetic nephropathy patients with hemodialysis had a larger number of medium-risk groups of diabetic foot. Therefore, it is necessary to strengthen health education and self-care to effectively prevent and treat diabetic foot in diabetic nephropathy patients with maintenance hemodialysis.

Keywords: Diabetic nephropathy; Foot assessment; Hemodialysis; Risk factor

Background

Chronic Kidney Disease (CKD) is a serious public health problem that affects national health in China. One study published in Lancet in 2012 showed that the prevalence of CKD in China was as high as 10.8% [1]. The mortality of end-stage renal disease is high. As one of the main therapeutic methods of renal replacement therapy, hemodialysis can prolong the survival time of patients with end-stage renal disease. However, as the survival time of hemodialysis patients is gradually prolonged, the long-term complications of end-stage renal disease, Chronic Kidney Disease-Mineral and Bone Disorder (CKD-MBD) might leads to calcification, stiff and even necrosis of the foot blood vessels, which seriously affecting the survival rate and quality life of hemodialysis patients [2]. The prevalence of diabetes in China is increasing, and diabetes can lead to a variety of complications, including diabetic

nephropathy and diabetic foot. Meanwhile, the high prevalence and disability rate of diabetic foot cannot be ignored [3].According to research, diabetes is one of the main causes of end-stage renal disease, and is also the main risk factor for vascular calcification. In Europe and the United States, diabetic nephropathy is the first cause of maintenance hemodialysis patients, while in China, the proportion of diabetic nephropathy in maintenance hemodialysis patients is also increasing year by year [4,5]. Hence, this study aims to screen high-risk groups and strengthen targeted foot care by comparing the foot condition of diabetic nephropathy patients with maintenance dialysis and diabetic nephropathy patients without dialysis.

Materials and methods

Study Population

A total of 133 diabetic nephropathy patients were selected from the First affiliated hospital of Jinan university from March 2018 to October 2018, including 63 patients with maintenance hemodialysis and 70 patients without dialysis. Inclusion criteria: patient informed consent and voluntary participation in the study. The exclusion criteria were: blindness or vision loss, lower limb vascular surgery within 3 months, mental illness cannot cooperate. Diabetes mellitus was defined as requiring anti-diabetic drugs or meeting the diagnostic criteria for diabetes mellitus specified by the Chinese Guideline for Diabetes Prevention and Treatment [6].

Assessment Methods

Screening Methods

- The nurse performing the operation was trained by the diabetes management center.
- The foot screening scale was designed by the diabetes management center. The evaluation included gender, age, foot paresthesia, skin color, skin surface (fungal infection, chap, blister, ulcer), foot shape change, toenail abnormalities, dorsal foot artery pulsation, posterior tibial artery pulsation, protective sensation (temperature sensation, fork vibration sensation, nylon wire pressure sensation).

Screening Tools

Diabetic foot screen pack, including the following tools

a. A 128 Hz tuning fork with a scale was used to check vibration sensation. The 128 Hz tuning fork after excitation was vertically placed on the first phalangeal process of the patient with appropriate pressure until the patient's sensory vibration disappeared. The scale of the tuning fork when the patient's sensory vibration disappeared was observed. If the threshold value > 5 was positive, the vibration sensation was normal; if the threshold value < 5 was negative, the vibration sensation was abnormal.

b. Tip - Therm (Germany) cool thermal sensation checker, it has a metal at one end and a polyester at the other. Use both ends perpendicular to sufficient back skin respectively, ask a patient "Cold and hot". If there is no sensation or no abnormality, the temperature sensation will decrease or disappear.

c. Semmes Weinstein 5.07 (10 g) nylon monofilament, is the gold standard for detection of foot ulcer risk factors [7], the WHO and the International Diabetes Federation (IDF) recommend its widely used in clinical practice [8]. Before the test, place the nylon filament on the tester's hand to let the subject know how the filament feels. The test sites were 10, including the dorsum of the foot, the ventral part of the first, second, third and fifth toes, the lower part of the foot bottom corresponding to the toes, the middle part of the foot bottom, and the heel. If the patient can feel more than 8 sites, the sense of touch is considered to be normal, only 1 ~ 7 sites is decreased, and 0 points is disappeared.

Diabetic Foot Risk Factor Classification Scale

Gavin weighted score of diabetic foot risk factors was used to screen the high-risk group of diabetic nephropathy patients Table 1 [9].

Diabetic foot risk factors	Gavin weighted score
Vascular lesions	1
Foot deformity	2
Protective anesthesia	3
History of heart disease and/or smoking	1
History of diabetes > 10 years	2
Diabetic nephropathy or retinopathy	1
Previous foot ulcers or amputations	3

Table 1: Gavin weighted score of diabetic foot risk factors.

According to the cumulative score, 1 ~ 3 was classified as low-risk group, 4 ~ 8 as medium-risk group, and 9- 13 as high-risk group. Meanwhile, the Wagner classification for diabetic foot was used to grade diabetic foot Table 2 [10]. Among them, the vascular lesions were judged by palpating the dorsal foot artery and the posterior tibial artery and asking whether the patient had rest pain and intermittent claudication. Protective anesthesia using 10 g nylon monofilament and temperature sense check.

Grade	Clinical manifestations
0	Risk factors for foot ulcers, no ulcers at present
1	Surface ulcer, no clinical infection
2	Deeper ulcers, often with soft tissue inflammation, without abscess or bone infection
3	Deep infection with bone lesions or abscesses
4	Localized gangrene (toe, heel, or forefoot)
5	The whole foot gangrene

Table 2: Wagner classification for diabetic foot.

Statistical Analysis

Continuous variables are presented as the mean±Standard Deviation (SD), while non-parametric variables are presented as the median and interquartile ranges. Categorical variables are expressed as the frequency and percentage. Non-parametric test was used to compare continuous variables between groups, where appropriate. Differences between categorical variables were analyzed using a chi-square test or double-tailed Fisher's exact test, depending on applicability. All values are two-tailed, and $P < 0.05$ was considered statistically significant. Data were analyzed using IBM SPSS Statistics version 25.0 for Windows (IBM, Armonk, NY, USA).

Results

- The age of diabetic nephropathy patients with hemodialysis (DN with HD) was smaller than that of Diabetic Nephropathy patients without dialysis (DN) ($P < 0.05$), and there were no statistical differences in gender, age of diabetes, smoking and drinking (Table 3).

	DN with HD （N=63）	DN (N=70）	Total (N=133）	P
Age (years)	61.89±13.33	70.80±10.58	66.98±9.44	< 0.001
Male: female ratio	37:26:00	35:35:00	72:61	0.313
Age of dialysis (years)	4（2-5）	/	/	/
Age of diabetes (years)	12（7-15）	11 (6-14)	12 (7-14)	0.658
Smoking (N/%)	10/15.87%	15/21.43%	25/18.80%	0.413
Drinking (N/%)	7/11.11%	12/17.14%	19/14.99%	0.321
DN: Diabetic Nephropathy; HD: Hemodialysis; Age of dialysis and age of diabetes were expressed as median and interquartile distance. P value for analysis of comparison between DN with HD patients and DN patients.				

Table 3: Differences of demographic and clinical characteristics.

- The incidence of numbness, abnormal toenail, decreased or absent posterior tibial artery pulse, abnormal temperature sensation and 10g nylon monofilament abnormal in DN with HD patients was significantly higher than that in DN patients (all $P < 0.05$). There were no statistically significant differences in pain, abnormal skin color, callose incidence, decreased or absent dorsalis pedis artery pulse and tuning fork abnormal (Table 4).

	DN with HD（N=63）	DN (N=70）	Total（N=133）	P
Numbness (N/%)	44/69.84%	30/42.86%	74/55.64%	0.002
Pain (N/%)	2/3.17%	7/10.00%	9/6.77%	0.223
Abnormal skin color (N/%)	9/14.29%	11/15.71%	20/15.04%	0.818

Callose (N/%)	8/12.70%	6/2.99%	14/10.53%	0.439
Abnormal toenail (N/%)	11/17.46%	4/5.71%	15/11.28%	0.032
Decreased or absent dorsalis pedis artery pulse (N/%)	17/26.98%	13/18.57%	30/22.56%	0.246
Decreased or absent posterior tibial artery pulse (N/%)	23/36.50%	14/20.00%	37/27.82%	0.034
Temperature sensation abnormal (N/%)	30/47.62%	15/21.43%	45/33.83%	0.001
10g nylon monofilament abnormal (N/%)	16/25.40%	8/11.43%	24/18.05%	0.036
Tuning fork abnormal (N/%)	3/4.76%	6/8.57%	9/6.77%	0.382
DN: Diabetic Nephropathy; HD: hemodialysis; P value for analysis of comparison between DN with HD patients and DN patients.				

Table 4: Foot assessment.

- The Gavin weighted score of diabetic foot risk factors in DN with HD patients was 20.63% in low-risk group, 69.84% in medium-risk group and 9.52% in high-risk group. And the probability distribution of Gavin weighted score of diabetic foot risk factors in DN patients was 67.14% for low-risk, 30.00% for medium-risk and 2.86% for high-risk. The difference in distribution between these two groups was statistically significant Figure 1.

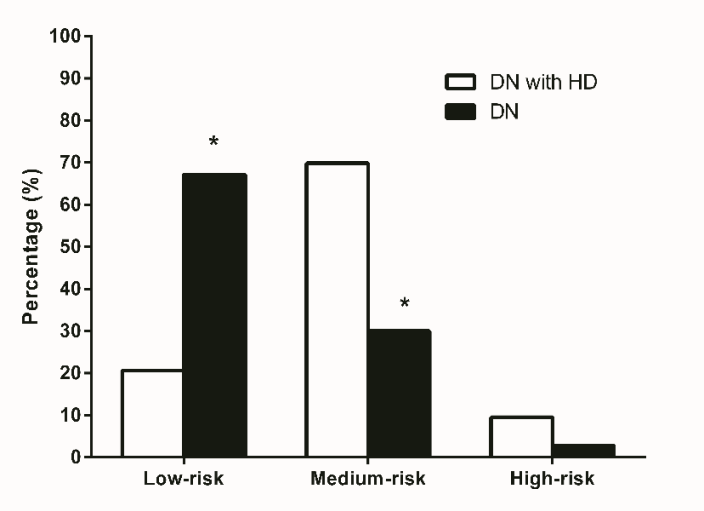

Figure 1: Comparison of the Gavin weighted score of diabetic foot risk factors (*indicated comparison between DN with HD patients and DN patients, $p < 0.05$).

- In DN with HD group, grade 0 of Wagner classification for diabetic foot was 57 cases, accounting for 90.47%. There were 6 cases with diabetic foot (9.52%), and there were 4 cases of grade 1 (6.35%), 1 case of grade 2 (1.59%) and 1 case of grade 4 (1.59%), respectively. Among the patients with DN, there were 15 cases with normal of Wagner classification for diabetic foot (21.43%) and 51 cases with grade 0 (72.86%). Among 4 cases with diabetic foot (5.71%), there were 3 cases of grade 1, accounting for 4.29%, and 1 case of grade 2, accounting for 1.43%. The difference between these two groups was statistically significant Figure 2.

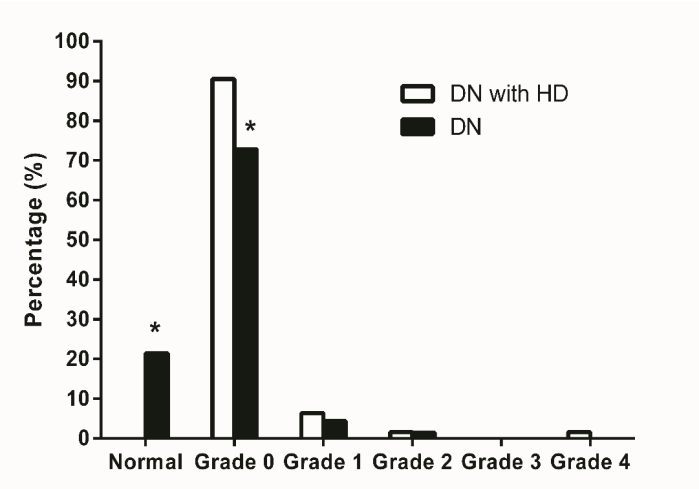

Figure 2: Comparison of the Wagner classification for diabetic foot (*indicated comparison between DN with HD patients and DN patients, $p < 0.05$)

Discussion

The foot assessment results of DN with HD patients were not optimistic. This study showed the incidence of numbness, abnormal toenail, decreased or absent posterior tibial artery pulse, abnormal temperature sensation and 10g nylon monofilament abnormal in DN with HD patients was significantly higher than that in DN patients (all $P < 0.05$). In DN with HD patients, the Gavin weighted score of risk factors for diabetic foot in the

low-risk group was 20.63%, that in the medium-risk group was 69.84%, and that in the high-risk group was 9.52%. In patients with DN, the percentage of low-risk was 67.14%, that of medium-risk was 30.00%, and that of high-risk was 2.86%. There was a difference in the Gavin weighted score of risk factors for diabetic foot between the two groups ($P < 0.05$). In DN with HD group, 57 cases (90.47%) accounting for grade 0 of the Wagner classification for diabetic foot were assigned, and 6 cases (9.52%) had diabetic foot.

Among DN patients, 15 cases were normal (21.43%) in the Wagner classification for diabetic foot， 51 cases (72.86%) in grade 0, and 4 cases (5.71%) of diabetic foot. The differences of the Wagner classification for diabetic foot between the two groups were also statistically significant. This is similar to previous studies [11,12]. High risk diabetic foot refers to patients with diabetes who do not have active ulcers, but have peripheral neuropathy, accompanied or not accompanied by foot malformations or peripheral artery diseases, or have a history of foot ulcers, or have a history of lower limb or foot amputation (or partial amputation) [13]. The diabetic foot assessment tool/grading system was originally proposed by the international diabetic foot working group and has been adopted by most countries in the world [3]. The previous study had shown that patients in the high-risk group are 34 times more likely to develop foot ulcers than those in the low-risk group, and patients in the high-risk group are 17 times more likely to have amputations [14]. And one prospective study indicated that the occurrence and development of diabetic foot ulcers can be predicted by the diabetic foot risk factor grading system [15]. Early identification of high-risk diabetic foot and the adoption of foot hierarchical management can effectively reduce the incidence of foot ulcers and amputation rate in diabetic patients.

Three-level hierarchical management of the high-risk diabetic foot risk factor grading system can transform the high-risk diabetic foot into medium-and low-risk ones [14]. The foot assessment results of DN with HD patients were more severe than that in DN patients, however, in hemodialysis center, medical staff and patients tend to concentrate on the control of dry weight, blood pressure and related complications of hemodialysis patients and ignored the foot risk caused by high blood glucose and vascular calcification lesions. This study found that both Gavin weighted score of diabetic foot risk factors and Wagner classification for diabetic foot in DN with HD patients are more serious than DN patients. This suggested that after diabetic nephropathy entered the stage of hemodialysis, the occurrence probability of diabetic foot was significantly increased, which might be related to the longer course of diabetic disease, greater fluctuation of blood pressure during dialysis, and different degrees of calcium and phosphorus metabolic disorder in most patients.

Therefore, we should pay attention to the hemodialysis patients foot lesions, prevent and delay the occurrence and development of diabetic foot. At the same time, for hemodialysis patients, it is necessary to strengthen the foot health education, conduct specialized standardized nursing guidance, enhance the patients' sense of self-protection, reduce the foot injury, so as to avoid the occurrence of foot lesions. The hemodialysis center can arrange professional nurses to regularly evaluate the patients' feet, make individualized plans according to the different evaluation results of patients, and provide one-on-one health guidance to patients, jointly formulate goals and plans, establish archives, and urge patients to implement the plans and complete the goals.

This study has some advantages and limitations. First of all, we conducted a comprehensive foot assessment and risk stratification for diabetic nephropathy patients with hemodialysis, and put forward suggestions for the management of diabetic foot. Secondly, foot evaluation, as a non-invasive index, has a high predictive value for diabetic foot and is suitable for clinical application. Limitations include the following points: our sample size is relatively small; due to only one center are included, multicenter data and follow-up studies are necessary; and as an observational study, we cannot conclude causation, so more basic research is needed. Therefore, with the development of dialysis technology, since the age of dialysis patients increases gradually, the foot lesions caused by vascular calcification and diabetes are worthy of our attention, so personalized health education and systematic diabetic foot management should be strengthened.

Competing interests: The authors declare that they have no competing interests.

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