Original Article

# Clinical Characteristics of Patients with Diabetic Nephropathy on Maintenance Hemodialysis: A Multicenter Cross-sectional Survey in Anhui Province, Eastern China

**Hu Chen, De-Guang Wang, Liang Yuan, Gui-Ling Liu, Heng-Jie He, Juan Wang, Sen Zhang, Li Hao**

Department of Nephrology, The Second Affiliated Hospital of Anhui Medical University, Hefei, Anhui 230601, China

## Abstract

**Background:** The incidence of diabetic nephropathy (DN) increases year by year. However, clinical characteristics of DN patients on maintenance hemodialysis (MHD) were rarely reported in China. The purpose of this study was to examine the clinical characteristics of the DN patients on MHD in Anhui Province, Eastern China.

**Methods:** The clinical data of MHD patients in the hemodialysis centers of 26 hospitals in Anhui Province from January 1, 2014, to March 31, 2014, were examined. The differences between DN patients and non-DN patients were compared regarding vascular access, nutritional status, mineral and bone disorder, and other indexes.

**Results:** Among the selected 2768 adult MHD patients, 427 had DN. The incidence of hypertension, coronary heart disease, and cerebral thrombus in DN patients was 94.1%, 21.5%, and 15.0%, respectively, which were higher than those in non-DN patients ($P < 0.001$). Category of vascular access for hemodialysis in DN patients was arteriovenous fistula (AVF) (87.4% [373/427]) and tunneled cuffed catheter (TCC) (11.2% [48/427]). The percentage of AVF was significantly lower than that of non-DN patients ($P < 0.001$), and percentage of TCC was significantly higher than that of non-DN patients ($P < 0.001$). Hemoglobin achievement rate in DN patients was 32.0%. The incidence of hypoalbuminemia was 24.7%, significantly higher than that in non-DN patients ($P < 0.001$). The achievement rate of the target range in mineral values was 55.9% in corrected serum calcium level, 30.1% in serum phosphorus level, and 49.3% in intact parathyroid hormone (iPTH) level in DN patients. Compared with non-DN patients, the achievement rate of serum phosphorus was significantly higher in DN patients.

**Conclusions:** DN patients on MHD in Anhui province exhibited different clinical characteristics compared to non-DN hemodialysis patients. They presented higher percentage in TCC use and cardiovascular complication, lower serum albumin and iPTH levels than those in non-DN patients.

**Key words:** Calcium; Diabetic Nephropathy; Hemodialysis; Parathyroid Hormone; Phosphorus

## Introduction

The proportion of global diabetes population is gradually increasing. Previous studies[1,2] revealed total prevalence of diabetes mellitus in Chinese adult population was 11.6%, and about 30%–40% developed into diabetic nephropathy (DN). DN is one of the most important microvascular complications of diabetes mellitus with insidious onset. Its development into end-stage renal disease (ESRD) is 14 times faster than other renal diseases in the absence of effective intervention.[3] Moreover, the mortality is significantly higher in DN patients on maintenance hemodialysis (MHD) than that in non-DN patients.[4,5] The two groups might have different clinical characteristics. The clinical characteristics of DN patients on MHD have been rarely reported. In this study, we examined clinical parameters in both DN and non-DN patients on MHD through data review from 26 hospitals in Anhui

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**Address for correspondence:** Prof. Li Hao, Department of Nephrology, The Second Affiliated Hospital of Anhui Medical University, Hefei, Anhui 230601, China
E-Mail: haoliqilin@163.com



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Province (including 19 tertiary hospitals and 7 secondary hospitals).

## Methods

### Subjects

Twenty-six hospitals in Anhui Province where the number of MHD patients was equal to or above 100 were selected as the study site. We examined the clinical data of adult patients on MHD (age >18 years and dialysis vintage ≥3 months) in participated centers from January 1, 2014, to March 31, 2014. All the participants signed the informed consent. Exclusion criteria were as follows: (1) combined with malignant tumor, active infection, severe liver failure, or liver cirrhosis; (2) acute renal failure, or chronic renal failure of temporary dialysis; and (3) reluctant to participate in the investigation.

The incidence of DN and non-DN leading cause of MHD was 29.5% (8.9%–50.0%) and 70.6% (50.0%–91.1%), respectively, according to relevant literature.[6-8] We calculated the minimum sample size of 1998 that conformed the requirement of the design ($\alpha = 0.05$). This study was approved by the Institutional Review Board of the Second Hospital of Anhui Medical University.

### Data collection

Doctors, nurses, and graduate students who participated in the investigation were trained twice and then required to complete the relevant questionnaire. The content of the questionnaire included general demographic characteristics, laboratory examination, clinical manifestation, and medications. The questionnaire was mainly based on the content of "Chronic Kidney Disease Patient Database" (http://ckd.edc-china.com.cn/login.jsp) with some minor necessary alteration. We applied it after experts' argumentation, and it took about 30 min to finish.

According to the odd or even number, the subjects of this study were divided into two groups. The laboratory examination indexes and drugs use between the two groups were calculated by Spearman correlation analysis, and the results showed that the indexes indicated a positive correlation between the two groups (the correlation coefficient between 0.713 and 0.826). Kaiser-Meyer-Olkin value was 0.886 by the confirmatory factor analysis, and $P < 0.001$ by Bartlett sphericity test. Therefore, we can do factor analysis. We extracted three principal component factors of complications, laboratory tests, and drug use and analyzed the factor of maximum variance rotation. Finally, we calculated that the cumulative variance contribution rate was 73.643% (factor loading value was between 0.702 and 0.824). It explained and verified that the questionnaire used in this research had good reliability and validity.

Fasting venous blood was drawn before dialysis. Serum levels of albumin, calcium, and phosphorus were measured by the biochemical analyzer. Intact parathyroid hormone (iPTH) concentration were detected by immunoradiometric or immunochemiluminometric assays. All laboratory tests were completed by clinical laboratories participated in this study. Hospitals were unable to complete the iPTH test, the specimens were sent to Hefei Kingmed Center (Kingmed Diagnostics, Inc., Hefei, China) for clinical laboratory test. Corrected calcium was as the sum of total calcium (mmol/L) + 0.2 × (4 – serum albumin (g/L)/10).

### Related guidelines and definition

#### Serum calcium, phosphate, and intact parathyroid hormone

According to the *Kidney Disease: Improving Global Outcomes (KDIGO) guidelines*[9] in 2009, MHD patients with corrected serum calcium from 2.13 to 2.50 mmol/L, phosphate from 0.81 to 1.45 mmol/L, and iPTH from 2 to 9 times the upper limit of normal (150–600 ng/L in this study) were considered optimal.

#### Anemia

According to the *KDIGO Clinical Practice Guideline for Anemia*[10] in 2012: male hemoglobin (Hb) <130 g/L, female Hb <120 g/L, or Hb is in normal range, but drugs like erythropoietin have been used to correct anemia; diagnostic criteria for Chinese anemia: male Hb <120 g/L, female Hb <110 g/L, or Hb is in normal range, but drugs like erythropoietin have been used to correct anemia.

#### Hemoglobin therapeutic target

According to the *Chinese experts' consensus and recommendations on renal anemia* in 2014:[11] Hb therapeutic target: Hb ≥110 g/L.

#### Hypoalbuminemia

Serum albumin <35 g/L.

#### Therapeutic strategies

For patients with high calcium, low phosphorus, and low iPTH, if they stop taking calcium, phosphorus binder, and Vitamin D active drugs, the process is considered as treatment; if they still take calcium, phosphate binder, and Vitamin D active drugs, the process is considered an improper treatment. For patients with low calcium, high phosphorus, and high iPTH, if they still take calcium, phosphorus binder, and Vitamin D active drugs, the process is considered as treatment; if they stop taking calcium, phosphate binder and Vitamin D active drugs, the process is considered an improper treatment.

### Statistical analysis

The skewed distribution measurement was represented by median (quartile) and compared by Wilcoxon rank sum test. The normal distribution measurement was expressed as mean ± standard deviation (SD), and compared with independent sample *t*-test between DN and non-DN groups. The qualitative data were compared using the Chi-square test and Mann–Whitney test. Data were analyzed using the Statistical Package for Social Sciences (SPSS), version 13.0 (SPSS Inc., Chicago, IL, USA). $P < 0.05$ was considered statistically significant.

## Results

### Demographic and baseline clinical data

A total of 26 hospitals (including 19 tertiary hospitals and 7 secondary hospitals) in Anhui province participated in

this study. Three thousand copies of questionnaire were distributed, and 2774 copies were recovered. The response rate was 92.5%. Among 2768 recovered copies with age >18 years, 2079 (75.1%) copies contained albumin and serum calcium data, 2461 (88.9%) copies contained serum phosphorus data, and 2163 (78.1%) copies contained iPTH data.

Among the 2768 adult cases, 1647 were male, and 427 were primary DN. In these primary DN patients, male accounted for 59.5% (254/427), with mean age of 61.3 ± 11.5 years and average dialysis vintage of 31.4 ± 26.3 months. The other 2341 cases were non-DN diseases, including chronic glomerulonephritis (58.9% [1379/2341]), hypertensive nephrosclerosis (22.1% [518/2341]), polycystic kidney (4.7% [111/2341]), obstructive nephropathy (2.4% [56/2341]), drug-induced renal damage (1.8% [41/2341]), gout nephropathy (1.4% [33/2341]), system lupus erythematosus (1.1% [26/2341]), chronic pyelonephritis (0.6% [15/2341]), Henoch–Schonlein purpura nephritis (0.4% [9/2341]), and the others (6.5% [153/2341]). The age of DN patients was significantly higher than those of non-DN patients ($P < 0.001$), and their average dialysis vintage was significantly lower than that of non-DN patients ($P < 0.001$) [Table 1].

## Comparison of complications

The incidence of hypertension, coronary heart disease, and cerebral thrombus of DN patients was 94.1%, 21.5%, and 15.0%, respectively, which were all significantly higher than that of non-DN patients ($P < 0.001$). There was no significant difference between DN and non-DN patients regarding cerebral hemorrhage, heart failure, stubborn itch, continuous bone pain, bone deformities, figure dwarf (>3 cm), and muscle atrophy ($P > 0.05$), as shown in Table 2.

## Category of vascular access

The category of vascular access in DN patients on MHD in Anhui Province were arteriovenous fistula (AVF) (87.4% [373/427]), tunneled cuffed catheter (TCC) (11.2% [48/427]), temporary venous catheter (1.2% [5/427]), and arteriovenous direct puncture (0.2% [1/427]). Percentage of AVF was lower than those in non-DN patients ($P < 0.001$), and TCC percentage was higher than those in non-DN patients ($P < 0.001$), as shown in Figure 1.

## Nutritional status and anemia

Based on KDIGO guidelines for anemia in 2012 and the diagnostic criteria for Chinese anemia, the incidence of anemia in DN patients was 98.5% and 98.1%, respectively; Hb achievement rate was not significantly different between DN and non-DN patients. There was significantly higher incidence of hypoalbuminemia (24.7%) in DN patients than those in non-DN patients (16.1%, $P < 0.001$) as shown in Tables 1 and 3.

## Mineral bone disorder status

Based on KDIGO guidelines, the achievement rate of corrected serum calcium, serum phosphorus, and iPTH levels in DN patients on MHD in Anhui Province was 55.9%,

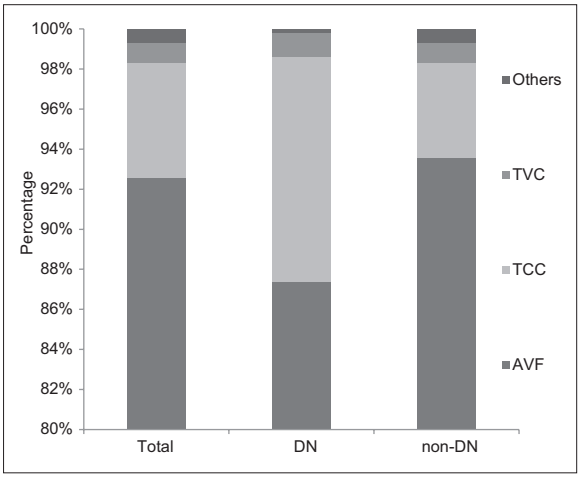


**Figure 1:** Comparison of vascular access types of DN and non-DN patients. DN: Diabetic nephropathy; AVF: Arteriovenous fistula; TCC: Tunneled cuffed catheter; TVC: Temporary venous catheter.

**Table 1: Demographic and baseline clinical data of DN and non-DN patients**

| Variables | Total ($n$ = 2768) | DN ($n$ = 427) | Non-DN ($n$ = 2341) | Statistics | $P$ |
|---|---|---|---|---|---|
| Age (years) | 53.5 ± 14.3 | 61.3 ± 11.5 | 52.1 ± 14.3 | 14.659* | <0.001 |
| Male, $n$ (%) | 1658 (59.9) | 254 (59.5) | 1404 (60.0) | 0.036† | 0.849 |
| Dialysis vintage (months) | 45.5 ± 39.1 | 31.4 ± 26.3 | 48.0 ± 40.5 | −10.709* | <0.001 |
| Smoking history, $n$ (%) | 924 (33.4) | 149 (34.9) | 775 (33.1) | 0.520† | 0.471 |
| Drinking history, $n$ (%) | 205 (7.4) | 15 (3.5) | 190 (8.1) | 11.159† | <0.001 |
| Tertiary hospitals, $n$ (%) | 2038 (73.6) | 368 (86.2) | 1670 (71.3) | 40.989† | <0.001 |
| Hb (g/L) | 99.2 ± 21.5 | 99.6 ± 20.6 | 99.2 ± 21.6 | 0.351* | 0.726 |
| Albumin (g/L) | 39.7 ± 5.9 | 38.4 ± 6.1 | 40.0 ± 5.9 | −4.735* | <0.001 |
| Hypoalbuminemia, $n$ (%) | 368 (17.6) | 90 (24.7) | 278 (16.1) | 15.432† | <0.001 |
| Creatinine (μmol/L) | 917.1 ± 305.7 | 786.9 ± 357.9 | 941.2 ± 288.8 | −9.548* | <0.001 |
| Blood urea nitrogen (mmol/L) | 24.9 ± 8.7 | 23.3 ± 8.4 | 25.2 ± 8.8 | −4.232* | <0.001 |
| Uric acid (mmol/L) | 432.6 ± 127.8 | 407.5 ± 123.5 | 437.3 ± 128.0 | −4.115* | <0.001 |
| Corrected calcium (mmol/L) | 2.21 ± 0.34 | 2.20 ± 0.33 | 2.21 ± 0.35 | −0.715* | 0.475 |
| Phosphorus (mmol/L) | 1.92 ± 0.62 | 1.71 ± 0.58 | 1.95 ± 0.62 | −7.791* | <0.001 |
| iPTH (ng/L) | 280.0 (123.0, 554.0) | 204.0 (81.0, 407.0) | 293.0 (137.0, 599.8) | −6.848‡ | <0.001 |

*$t$ values; †$\chi^2$ values; ‡$Z$ values. Data showed as $n$ (%), mean ± SD, or median (quartile). SD: Standard deviation; DN: Diabetic nephropathy; Hb: Hemoglobin; iPTH: Intact parathyroid hormone.

30.1%, and 49.3%, respectively. For the achievement rates of corrected calcium, serum phosphorus and iPTH levels in DN and non-DN patients were ordinal variables, they were compared using Mann-Whitney test [Table 4]. The rates at each density level between DN and non-DN groups were then compared using the Chi-square test. Compared with non-DN patients, the achievement rate of serum phosphorus in DN patients was significantly higher ($\chi^2 = 19.595$, $P < 0.001$), whereas those of corrected serum calcium and iPTH did not show significant difference ($\chi^2 = 2.784$, $P = 0.095$; $\chi^2 = 0.338$, $P = 0.561$). The incidence of low iPTH was 39.8%, which was significantly higher than that of non-DN patients ($P < 0.001$). Treatment conditions of low corrected serum calcium, hyperphosphatemia, and secondary hyperparathyroidism did not show significant differences between the two groups ($P > 0.05$), as shown in Table 5.

## Discussion

This study was a multicenter cross-sectional survey in Anhui Province, Eastern China, involving clinical characteristics of 2768 adult patients in hemodialysis centers of 26 hospitals in Anhui Province. There were 427 primary DN cases, which accounted for 15.4%. In our country, DN is the second leading cause of ESRD;[12] however, DN is the third leading cause of ESRD in Anhui Province. The incidence of DN is increasing with the improvement of living standard and the change of lifestyle. In the western world, DN has become the leading cause of ESRD, and accounts for approximately 50% of diseases that induce ESRD in the developed countries.[7,8] Thus, it is necessary to pay great attention to DN.

**Table 2: Comparison of complications between DN and non-DN patients, *n* (%)**

| Complications | Total (*n* = 2768) | DN (*n* = 427) | Non-DN (*n* = 2341) | $\chi^2$ | *P* |
|---|---|---|---|---|---|
| Hypertension | 2396 (86.6) | 402 (94.1) | 1994 (85.2) | 24.966 | <0.001 |
| Coronary heart disease | 269 (9.7) | 92 (21.5) | 177 (7.6) | 50.499 | <0.001 |
| Cerebral thrombus | 172 (6.2) | 64 (15.0) | 108 (4.6) | 66.700 | <0.001 |
| Cerebral hemorrhage | 57 (2.1) | 14 (3.3) | 43 (1.8) | 3.723 | 0.054 |
| Heart failure in nearly 3 months | 182 (6.6) | 34 (8.0) | 148 (6.3) | 1.582 | 0.208 |
| Stubborn itch | 1197 (43.2) | 190 (44.5) | 1007 (43.0) | 0.323 | 0.570 |
| Continuous bone pain | 405 (14.6) | 69 (16.2) | 336 (14.4) | 0.943 | 0.331 |
| Bone deformities | 37 (1.3) | 4 (0.9) | 33 (1.4) | 0.612 | 0.434 |
| Figure dwarf (>3 cm) | 92 (3.3) | 17 (4.0) | 75 (3.2) | 0.679 | 0.410 |
| Muscle weakness with atrophy | 299 (10.8) | 56 (13.1) | 243 (10.4) | 2.803 | 0.094 |

DN: Diabetic nephropathy.

**Table 3: Comparison of incidence of anemia and Hb achievement rate between DN and non-DN patients, *n* (%)**

| Variables | Total (*n* = 2768) | DN (*n* = 427) | Non-DN (*n* = 2341) | $\chi^2$ | *P* |
|---|---|---|---|---|---|
| Incidence of anemia | | | | | |
| KDIGO guidelines in 2012 | 2635 (98.8) | 407 (98.5) | 2228 (98.8) | 0.264 | 0.608 |
| Diagnostic criteria for Chinese anemia | 2623 (98.4) | 405 (98.1) | 2218 (98.4) | 0.249 | 0.618 |
| Hb achievement rate | | | | 0.047 | 0.837 |
| Hb <110 g/L | 1803 (67.6) | 281 (68.0) | 1522 (67.5) | | |
| Hb ≥110 g/L | 864 (32.4) | 132 (32.0) | 732 (32.5) | | |

KDIGO: Kidney Disease: Improving Global Outcomes; Hb: Hemoglobin; DN: Diabetic nephropathy.

**Table 4: Comparison of achievement rates of corrected calcium, serum phosphorus and iPTH between DN and non-DN patients, *n* (%)**

| Variables | Total (*n* = 2768) | DN (*n* = 427) | Non-DN (*n* = 2341) | *Z* | *P* |
|---|---|---|---|---|---|
| Corrected calcium | | | | 0.266 | 0.790 |
| <2.13 mmol/L | 686 (33.0) | 115 (31.7) | 571 (33.3) | | |
| 2.13–2.50 mmol/L | 1080 (51.9) | 203 (55.9) | 877 (51.1) | | |
| >2.50 mmol/L | 313 (15.1) | 45 (12.4) | 268 (15.6) | | |
| Phosphorus | | | | 8.077 | <0.001 |
| <0.81 mmol/L | 39 (1.6) | 14 (3.6) | 25 (1.2) | | |
| 0.81–1.45 mmol/L | 533 (21.7) | 118 (30.1) | 415 (20.1) | | |
| >1.45 mmol/L | 1889 (76.8) | 260 (66.3) | 1629 (78.7) | | |
| iPTH | | | | 6.199 | <0.001 |
| <150 ng/L | 637 (29.4) | 138 (39.8) | 499 (27.5) | | |
| 150–600 ng/L | 1035 (47.9) | 171 (49.3) | 864 (47.6) | | |
| >600 ng/L | 491 (22.7) | 38 (11.0) | 453 (24.9) | | |

iPTH: Intact parathyroid hormone; DN: Diabetic nephropathy.

**Table 5: Comparison of treatment status of MBD between DN and non-DN patients***

| Variables | Number of noncompliance, *n* | | Treatment rate, *n* (%) | | Improper treatment, *n* (%) | | $\chi^2$ | *P* |
|---|---|---|---|---|---|---|---|---|
| | DN | Non-DN | DN | Non-DN | DN | Non-DN | | |
| Corrected calcium | | | | | | | | |
| <2.13 mmol/L | 115 | 571 | 65 (56.5) | 303 (53.1) | 50 (43.5) | 268 (46.9) | 0.460 | 0.498 |
| >2.50 mmol/L | 45 | 268 | 30 (66.7) | 124 (46.3) | 15 (33.3) | 144 (53.7) | 6.414 | 0.011 |
| Phosphorus | | | | | | | | |
| <0.81 mmol/L | 14 | 25 | 8 (57.1) | 12 (48.0) | 6 (42.9) | 13 (52.0) | 0.300 | 0.584 |
| >1.45 mmol/L | 260 | 1629 | 130 (50.0) | 870 (53.4) | 130 (50.0) | 759 (46.6) | 1.045 | 0.307 |
| iPTH | | | | | | | | |
| <150 ng/L | 138 | 499 | 44 (31.9) | 149 (29.9) | 94 (68.1) | 350 (70.1) | 0.210 | 0.647 |
| >600 ng/L | 38 | 453 | 24 (63.2) | 310 (68.4) | 14 (36.8) | 143 (31.6) | 0.448 | 0.503 |

*For patients with high calcium, low phosphorus and low iPTH; if they stop taking calcium, phosphorus binder and Vitamin D active drugs, the process is considered as treatment; if they still take calcium, phosphate binder and Vitamin D active drugs, the process is considered as improper treatment; For patients with low calcium, high phosphorus and high iPTH, if they still take calcium, phosphorus binder and Vitamin D active drugs, the process is considered as treatment; if they stop taking calcium, phosphate binder and Vitamin D active drugs, the process is considered as improper treatment. MBD: Mineral and bone disorder; iPTH: Intact parathyroid hormone; DN: Diabetic nephropathy.

ESRD patients inevitably require renal replacement therapy, and vascular access is the lifeline of patients on MHD. AVF has fewer complications than the central venous catheter.[13] The guidelines suggest that AVF should be used at the rate of 85% or more when dialysis starts.[14] This study showed that the usage rate of AVF in DN patients on MHD was only 87.4%, significantly lower than those in non-DN patients, and the usage rate of TCC was 11.2%, significantly higher than those in non-DN patients. The success rate of AVF for DN patients is low resulting from high blood pressure and high blood glucose. DN patients have many cardiovascular complications. This study found that the incidences of hypertension, coronary heart disease, and cerebral thrombosis in patients with DN were significantly higher than those in non-DN patients. As a result, it is not easy to facilitate the maturity and thrombosis of internal fistula, thus causing internal fistula occlusion.

There was no significant difference between DN and non-DN patients in the incidence of anemia and Hb success rate, which might be related to the wide use of erythropoietin. The levels of serum albumin and phosphorus reflect the nutritional status of patients to some extent. This study found that the level of serum albumin and phosphorus in DN patients was significantly lower than those in non-DN patients. The results may be related to the factors below. The dietary intake of DN patients is restricted for a long time, and the prevalent gastrointestinal dysfunction leads to the decrease of protein absorption. In addition, there is a large amount of proteinuria in ESRD patients with DN, that further aggravates the malnutrition of patients.

KDIGO[15] first proposed the concept of CKD-mineral bone disorder (MBD) in 2006, which argues that MBD will cause metabolism disorder of calcium, phosphorus and iPTH, renal osteodystrophy, and ectopic calcification. Many studies[16-18] show that MBD increases the mortality in patients on MHD. This study applied the KDIGO guidelines. Our results showed that the achievement rates of corrected serum calcium, serum phosphorus, and iPTH in DN patients on MHD were 55.9%, 30.1%, and 49.3%, respectively. The achievement rate of serum phosphorus was significantly higher than that of non-DN patients. The incidence of hypophosphatemia was 3.6% in DN patient, significantly higher than that of non-DN patients. Our results showed a higher incidence of low iPTH level in DN patients than that in non-DN patients. However, there was no significant difference in drug use. It implied sustained low iPTH indicating the presence of low-turnover renal bone disease. Wahl *et al*.[19] found that the level of iPTH in patients with renal insufficiency caused by diabetes was significantly lower than that in patients with renal insufficiency caused by other primary diseases. The result might be caused by the factors below. First, a study[20] showed that the iPTH level of DN patients with poor glucose control was lower than that of the patients with ideal blood glucose control. Thus, we speculate that high blood glucose of DN patients may inhibit the secretion of iPTH, although its mechanism is not clear. Some scholars[21] believed that high blood glucose might inhibit the secretion by inhibiting PTH synthesis and depleting PTH storage pool of parathyroid cell. Second, Lu *et al*.[22] reported that the content of serum alkaline phosphatase and iPTH are low in DN patients on MHD, so they are susceptible to low-turnover renal bone disease. Ni and Zhou[23] suggested that diabetes and malnutrition play an important role in low-turnover renal bone disease. This study also found that the age and incidence of malnutrition in DN patients were significantly higher than those in non-DN patients. Thus, the occurrence and development of low-turnover renal bone disease in DN patients is highly suspected in low iPTH status. Third, the parathyroid tissue is less stimulated since malnutrition and low level of serum phosphorus in DN patients, thus leading to the decrease of iPTH secretion. Fourth, excessive emphasis is placed on the achievement rate of calcium and phosphorus clinically, so Vitamin D receptor agonists are overused. This study

found that the MHD patients who had low iPTH levels still used Vitamin D agonists (69.7%). Therefore, the improper treatment is a possible cause of low iPTH.

Our study had several limitations. First, laboratory tests were not performed in one central laboratory. Therefore, the possible variation exists between laboratories. Second, the definitions of DN, hypertension, coronary heart disease, cerebral thrombus, cerebral hemorrhage, and heart failure were based on early diagnosis, and no further steps were taken to confirm the diagnosis. Finally, we lacked the follow-up between non-DN patients and DN patients regarding long-term prognosis and the endpoint events.

In conclusion, DN patients on MHD present different clinical circumstances compared to non-DN patients. Accordingly, clinical management in DN hemodialysis patients needs more individual modification than that in non-DN hemodialysis patients.


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## Conflicts of interest

There are no conflicts of interest.

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