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ORIGINAL RESEARCH

The Risk Factors of Hypotension in Patients with End-Stage Chronic Glomerulonephritis During Maintenance Hemodialysis

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Objective: To investigate the risk factors of hypotension during maintenance hemodialysis in patients with end-stage chronic glomerulonephritis.

Methods: A total of 129 patients with end-stage chronic glomerulonephritis on maintenance hemodialysis admitted to our hospital from March 2022 to May 2024 were retrospectively analyzed, and the relevant clinical data of the patients were recorded. Univariate and multivariate logistic regression analysis were performed on various factors that may affect the occurrence of hypotension in patients, and the nomogram model was constructed. The receiver operating characteristic (ROC) curve was used to analyze the predictive risk of hypotension in patients with end-stage chronic glomerulonephritis on maintenance hemodialysis.

Results: A total of 9186 times of dialysis were completed in 129 patients, and 597 times of intradialysis hypotension (IDH) occurred in 46 patients, with an incidence of 6.50%. The patients were divided into IDH group and No-IDH group according to whether they had intradialytic hypotension (IDH). Univariate and multivariate logistic regression analysis showed that ultrafiltration rate, weight growth rate, vascular access type and plasma albumin were independent risk factors for hypotension in patients. A nomogram model was constructed based on the above factors. The area under the curve (AUC) of the nomogram model for predicting intradialytic hypotension (IDH) was 0.862.

Conclusion: Ultrafiltration rate >10 mL/min, weight growth rate >3%, long-term catheter vascular access and low plasma albumin level are independent risk factors for hypotension in patients with end-stage chronic glomerulonephritis undergoing maintenance hemodialysis. The nomogram model based on these factors has a high application value in identifying patients at high risk of hypotension.

Keywords: chronic glomerulonephritis, end-stage renal disease, maintenance hemodialysis, hypotension, risk factors

Introduction

End-stage chronic glomerulonephritis is the end-stage of the development of chronic kidney disease, characterized by irreversible loss of glomerular filtration function.[1] In recent years, the number of End-stage chronic glomerulonephritis patients has been increasing year by year worldwide, and its high disability rate, high mortality rate and heavy medical burden have become an important challenge in the field of public health.[2] As the main renal replacement therapy for End-stage chronic glomerulonephritis patients, maintenance hemodialysis can effectively remove metabolic waste and regulate water and electrolyte balance. However, the incidence of related complications in the treatment process is high, which significantly affects the prognosis of patients.[3,4] Among them, intradialysis hypotension (IDH) is one of the most common acute complications in the process of hemodialysis, and its incidence can be as high as 20%-30%. Studies have found that the occurrence of IDH is closely related to serious clinical outcomes such as cardiovascular events and fistula dysfunction.[5,6]

Studies have shown that when the systolic blood pressure of patients is lower than 90mmHg, the blood flow velocity in the internal fistula vessel decreases rapidly, the blood viscosity increases, and the risk of platelet aggregation and thrombosis increases.[7] In addition, repeated vascular endothelial injury caused by hypotension can further accelerate

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intimal hyperplasia and intravascular stenosis, especially in patients with diabetes mellitus or elderly patients.[8,9] Clinical investigations have shown that hypotension is an independent risk factor for the occlusion of arteriovenous fistula in maintenance hemodialysis patients. In addition, long-term recurrent IDH can also aggravate myocardial ischemia, leading to increased hospitalization rates and all-cause mortality.[10,11]

At present, the risk factors for IDH are not completely clear. Some scholars have shown that the occurrence of IDH is related to many factors such as ultrafiltration speed, improper setting of dialysate sodium concentration, drug factors (such as excessive use of antihypertensive drugs), malnutrition and autonomic nervous system dysfunction.[12,13] However, the interaction between factors and their weights still need to be further quantified. Especially for patients with end-stage chronic glomerulonephritis, the inflammatory state or vascular stiffness caused by the primary disease can further amplify the risk of IDH.[14,15] Therefore, it is of great significance to analyze the risk factors of hypotension in patients with end-stage chronic glomerulonephritis during maintenance hemodialysis for early identification of high-risk patients and development of personalized intervention strategies.

Materials and Methods

Clinical Data

A total of 129 patients with end-stage chronic glomerulonephritis on maintenance hemodialysis who were admitted to Shanghai Sixth People's Hospital between March 2022 and May 2024 were enrolled in this retrospective study. The study was approved by the Ethics Committee of Shanghai Sixth People's Hospital (Approval No. 2022-KY-018). The requirement for informed consent was waived by the ethics committee due to the retrospective nature of the study and the use of anonymized data. Patient confidentiality was strictly protected, and all data were handled in accordance with institutional guidelines. This study was conducted in full compliance with the ethical principles of the Declaration of Helsinki.

Inclusion and Exclusion Criteria

Inclusion criteria: ① Patients met the diagnostic criteria of chronic glomerulonephritis, and end-stage renal disease was confirmed by pathological or clinical comprehensive evaluation; ② Aged from 18 to 75 years old, receiving regular hemodialysis for more than 3 months; ③ Patients had stable dialysis regimen and complete clinical data.

Exclusion criteria: ① patients with end-stage renal disease caused by non-chronic glomerulonephritis, such as polycystic kidney disease, hypertensive renal injury, diabetic nephropathy, etc.; ② Patients with severe cardiac dysfunction (NYHA class III–IV), liver failure (Child-Pugh class C), malignant tumor or active infection (such as tuberculosis, sepsis, etc).; ③ patients with mental disease or cognitive dysfunction; ④ Acute stroke, acute myocardial infarction or severe trauma requiring emergency intervention in the past 3 months; ⑤ long-term use of vasoactive drugs (eg, norepinephrine, dopamine) or recent adjustment of the dose of antihypertensive drugs (within 1 week); ⑥ poor dialysis compliance (eg, frequent treatment interruptions or failure to complete ultrafiltration targets as planned); ⑦ Malignant tumor.

Data Collection

General data of patients were collected from the blood purification information management system of the department, including age, gender, dialysis age, vascular access mode, diabetes mellitus, hypertension, coronary heart disease, weight growth rate, pre-dialysis systolic blood pressure, pre-dialysis diastolic blood pressure, hemoglobin (Hb), albumin, blood urea nitrogen, serum creatinine, intact parathyroid hormone (iPTH) and ultrafiltration rate.

Research Methods

IDH group included patients whose systolic blood pressure decreased more than 20mmHg or mean arterial blood pressure decreased more than 10mmHg during dialysis, accompanied by symptoms of hypotension, and nurses' intervention measures were recorded according to the doctor's advice. Otherwise, they were included in the No-IDH group.

Statistical Analysis

SPSS 27.0 was used for statistical analysis, *t* test was used for comparison of measurement data, and $\chi 2$ test was used for comparison of count data. Univariate and multivariate logistic regression analyses were used to analyze the factors that may affect the occurrence of IDH, and $P<0.05$ was considered statistically significant.

Results

Occurrence of IDH

A total of 129 patients were enrolled in this study, and a total of 9186 times of dialysis were completed, of which 46 patients had 597 times of intradialytic hypotension, with an incidence of 6.50%. According to whether IDH occurred during dialysis, there were 46 patients in IDH group and 83 patients in No-IDH group.

Univariate Analysis of IDH

The results of univariate analysis showed that. There were No significant differences in age, gender, diabetes, hypertension, coronary heart disease, systolic blood pressure before dialysis, diastolic blood pressure before dialysis, blood urea nitrogen and serum creatinine between IDH group and no-IDH group (P>0.05), while the dialysis age, vascular access type, weight growth rate, Hb, albumin, iPTH and ultrafiltration rate were significantly different (P<0.05) between the two groups. The difference was statistically significant (P<0.05), as shown in Table 1.

Table 1 Univariate Analysis of IDH Occurrence

Factors	IDH Group (n=46)	No-IDH Group (n=83)	t/χ^2	*P*
Age (years, $\bar{x} \pm s$)	58.29±8.30	56.68±9.21	0.984	0.327
Dialysis duration (years, $\bar{x} \pm s$)	4.64±1.29	3.59±1.06	4.981	0.000
Gender				
Male	27	47	0.052	0.820
Female	19	36		
Vascular access type				
Long-term catheter	25	17	15.459	0.000
Autogenous arteriovenous fistulas	21	66		
Diabetes				
Is	19	37	0.129	0.719
No	27	46		
Hypertension				
Is	31	60	0.342	0.559
No	15	23		
Coronary heart disease				
Is	14	22	0.227	0.634
No	32	61		
Body mass growth rate				
≤3%	16	49	6.964	0.008
>3%	30	34		
Predialysis systolic blood pressure (mmHg, $\bar{x} \pm s$)	134.98±24.03	136.59±16.94	0.444	0.658
Diastolic blood pressure (mmHg, $\bar{x} \pm s$) before dialysis	78.95±14.23	80.17±17.53	0.404	0.687
Hb (g/L, $\bar{x} \pm s$)	101.28±13.40	110.38±15.42	3.360	0.001
Albumin (g/L, $\bar{x} \pm s$)	33.59±5.94	39.42±6.12	5.237	0.000
Blood urea nitrogen (mmol/L, $\bar{x} \pm s$)	25.62±6.04	24.03±7.22	1.267	0.207
Serum creatinine (μmol/L, $\bar{x} \pm s$)	989.60±256.17	1027.58±310.65	0.706	0.481

(*Continued*)

Table 1 (Continued).

Factors	IDH Group (n=46)	No-IDH Group (n=83)	t/χ^2	*P*
iPTH				
<300 pg/L	33 (71.74)	38 (45.78)	8.058	0.005
≥300 pg/L	13 (28.26)	45 (54.22)		
Ultrafiltration rate				
≤10 mL/min	16 (34.78)	57 (68.67)	13.839	0.000
>10 mL/min	30 (65.22)	26 (31.33)		

Multivariate Logistic Regression Analysis of IDH

The factors with statistical significance in the above univariate analysis were assigned and shown in Table 2. The results of multivariate analysis showed that ultrafiltration rate, weight growth rate, vascular access type and plasma albumin were independent risk factors affecting the occurrence of hypotension (P<0.05), as shown in Table 3.

Nomogram Model Construction

Based on the above results, a nomogram model was constructed, as shown in Figure 1.

ROC Curve Analysis of Predictive Value of Nomogram Model

The area under the ROC curve of the nomogram model for predicting IDH was 0.862 (P<0.05, 95% CI: 0.797–0.927) in patients with end-stage chronic glomerulonephritis undergoing maintenance hemodialysis, as shown in Figure 2.

Discussion

For patients with end-stage chronic glomerulonephritis, when patients enter maintenance hemodialysis, hypotension is one of the most common acute complications in the treatment process. The occurrence of hypotension not only seriously affects the dialysis adequacy of patients, but also may lead to an increased risk of cardiovascular events and even threaten the quality of life of patients.[16,17] Studies have confirmed that the mechanism of intradialytic hypotension is complex, involving the interaction of multiple factors such as volume load, cardiovascular function, autonomic nervous regulation,

Table 2 Assignment of Independent Variables

Independent Variables	Assignment
Dialysis age	Continuous variables
Vascular access type	Autogenous arteriovenous fistula =0; Long-term catheter =1
Body mass growth rate	≤3%=0; > 3% = 1
Hb	Continuous variables
Albumin	Continuous variables
iPTH	≥300 pg/L=0; <300 pg/L=1
Ultrafiltration rate	≤10 mL/min=0; >10 mL/min=1

Table 3 Multivariate Logistic Regression Analysis Affecting the Occurrence of IDH

Important Factors	b	S.E	$\bar{x}$	P	OR	95% CI
Ultrafiltration rate	1.598	0.417	14.685	0.000	4.943	2.183 ~ 11.193
Body Mass Growth rate	1.619	0.602	7.233	0.007	5.048	1.551 ~ 16.427
Types of Vascular access	1.429	0.659	4.702	0.030	4.175	1.147 ~ 15.190
Albumin	1.447	0.673	4.623	0.032	4.250	1.136 ~ 15.896

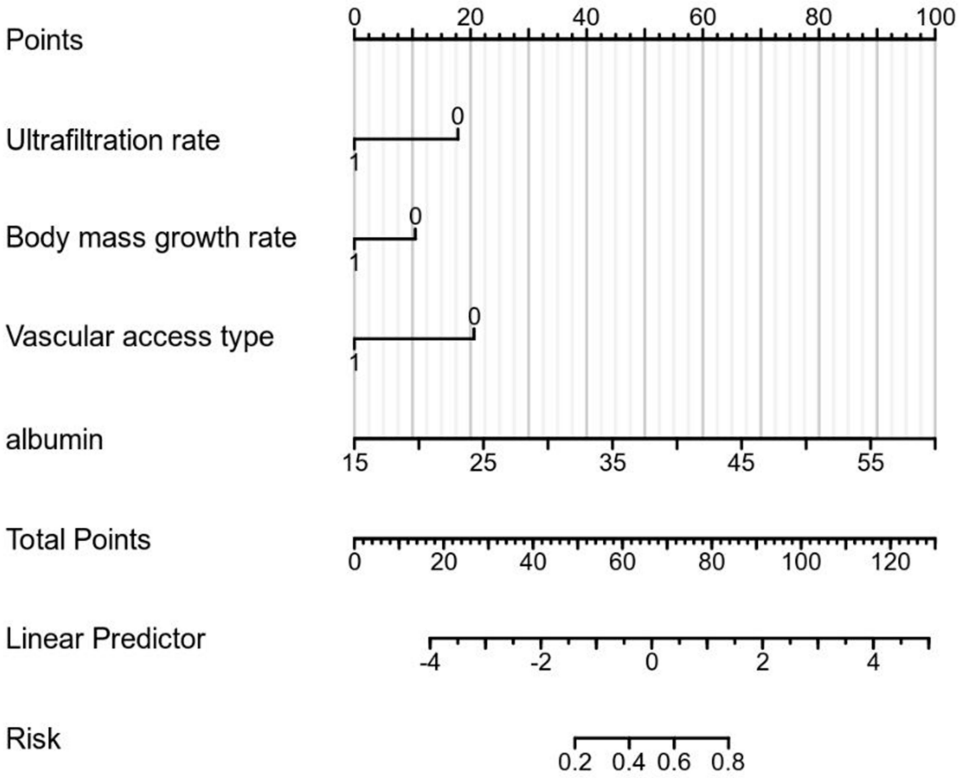

Figure 1 Construction of the nomogram model.

and dialysis parameter settings.[18] With the progress of blood purification technology, although the management strategies of hypotension have been continuously improved, the incidence of hypotension remains high, suggesting that further refinement of risk factor stratification and establishment of individualized prediction models are needed. Current studies mostly focus on the analysis of single factor or specific population, but the weight of risk factors may be different in patients with different etiologies in different regions. How to screen key indicators and build efficient prediction tools based on clinical practice is still the key direction of clinical research.[19,20]

In recent years, the research on the risk factors of intradialysis hypotension (IDH) has gradually developed from a single dimension to a multi-dimensional integration. Volume management related indicators (such as ultrafiltration rate and weight growth rate) are widely considered to be the core influencing factors, and their mechanism is closely related to the decrease of effective circulating blood volume caused by insufficient vascular refilling capacity.[21,22] The functional status of cardiovascular system (such as left ventricular hypertrophy and arteriosclerosis) and nutritional metabolic indicators (such as plasma albumin level) have also been confirmed to be involved in the occurrence of hypotension, but the strength of their role varies in different studies.[23,24] For example, some scholars have proposed that the type of vascular access (such as long-term catheter) may indirectly increase the risk of hypotension by affecting hemodynamic stability, but this conclusion has not been consistently verified in most studies.[25,26] In addition, although nomogram models have shown potential in disease risk prediction, most of the existing studies are based on small samples or single-center data, and the universality and clinical practicability of the models still need to be further verified.

Through retrospective analysis of 129 patients, it was clear that ultrafiltration rate >10 mL/min, weight growth rate >3%, long-term catheter as vascular access and low plasma albumin level were independent risk factors for intradialytic hypotension. First of all, ultrafiltration rate and body mass growth rate, as a direct reflection of volume load, are highly consistent with the conclusions of previous studies.[27,28] For example, ultrafiltration rates that are too fast (eg, >10-15 mL/kg/h) have been shown to significantly increase the risk of hypotension in several studies, and the risk found in this study was significantly increased when the threshold was reduced to 10 mL/min, suggesting that patients with end-stage chronic glomerulonephritis

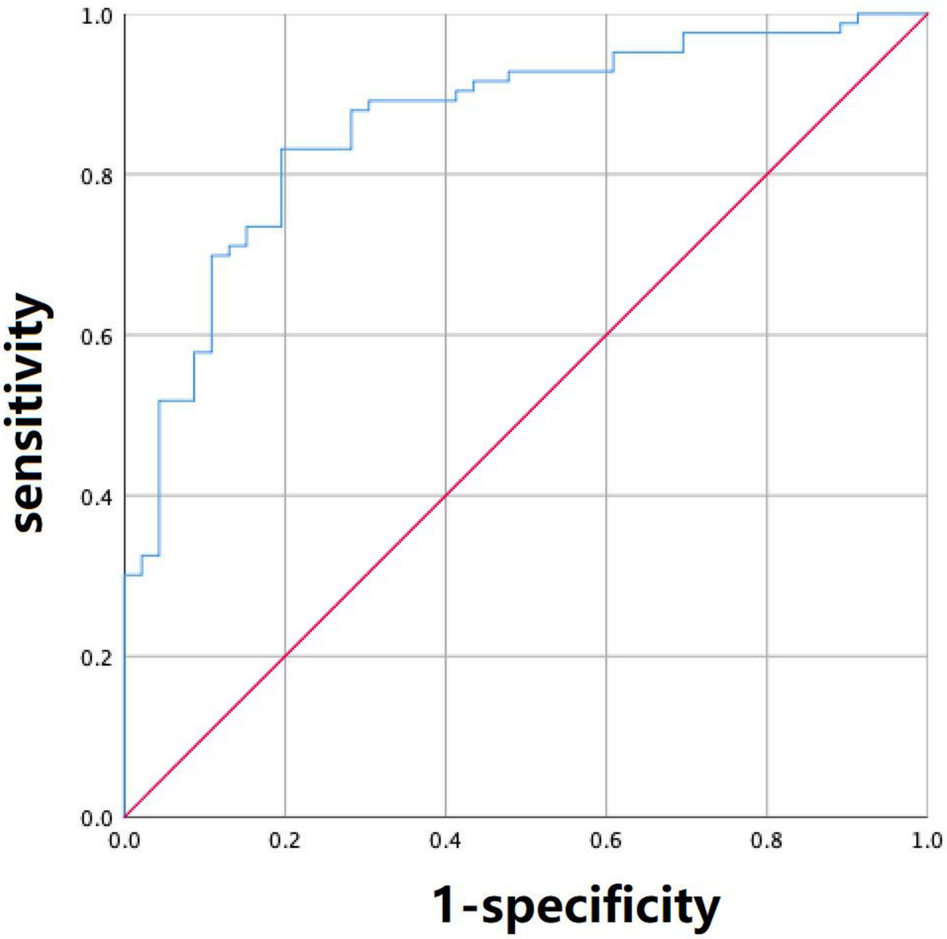

Figure 2 ROC curve analysis of predictive value of nomogram model.

may have a worse tolerance to volume fluctuations and need to restrict the ultrafiltration rate more severely.[29,30] Second, a weight gain rate of >3% leads to excessive interdialytic fluid retention, forcing an increase in the total volume of ultrafiltration, and further exacerbating the imbalance between the rate of vascular refilling and the rate of ultrafiltration. This finding is consistent with clinical guidelines that emphasize limiting interdialytic weight gain (<3% is generally recommended).[31] Third, the association between long-term use of catheters as vascular access and the risk of hypotension may be related to their hemodynamic properties. Compared with autogenous arteriovenous fistulas, catheters are prone to induce turbulence and increased blood flow resistance, leading to a decrease in cardiac preload. At the same time, catheter-related infection or fibrous sheath formation may exacerbate inflammation and impair the compensatory ability of vasoconstriction.[32] This finding is consistent with the conclusions of a small number of studies, but more mechanism studies are needed to further verify. Finally, low plasma albumin level reflects malnutrition and inflammation, which may reduce plasma colloid osmotic pressure, aggravate tissue edema, and reduce effective circulating blood volume. At the same time, the release of inflammatory factors (such as IL-6 and TNF-α) can induce nitric oxide-mediated vasodilation, and the above pathophysiological processes together promote hypotension.[33] In this study, multivariate analysis was used to confirm its independent predictive value, which provides a basis for clinical nutritional intervention.

However, this study still has some limitations. First, the sample size is small and the single-center retrospective design may cause selection bias, which limits the extrapolation of the conclusions. In addition, although the nomogram model showed high predictive efficiency (AUC=0.862), it has not been externally validated, and its clinical applicability needs to be further confirmed by prospective multicenter studies. In the future, hemodynamic monitoring techniques such as bioelectrical impedance analysis can be dynamically combined to volume status assessment, and genomic or

metabolomics indicators can be integrated to improve prediction accuracy. In summary, the prediction model based on the key risk factors in this study provides a practical tool for risk stratification of intradialysis hypotension in patients with end-stage chronic glomerulonephritis. However, its reliability needs to be verified by a larger sample and a wider population to guide the optimization of clinical individualized intervention strategies.

Conclusion and Recommendations

In this retrospective study of patients with end-stage chronic glomerulonephritis undergoing maintenance hemodialysis, we identified that ultrafiltration rate >10 mL/min, interdialytic weight gain >3%, long-term catheter use for vascular access, and low plasma albumin levels were independent risk factors for intradialytic hypotension (IDH). A nomogram model based on these variables demonstrated good predictive performance (AUC=0.862), providing a practical tool for early risk assessment.

However, it is important to emphasize that these findings may not be generalizable to hemodialysis populations with other primary renal diseases such as diabetic nephropathy or nephrosclerosis, which now represent a larger and growing proportion of end-stage renal disease cases. Given the declining prevalence of chronic glomerulonephritis in many regions, the utility of this analysis may be limited to similar clinical populations.

Therefore, further multicenter, prospective studies involving diverse etiologies of end-stage renal disease are needed to validate and expand the applicability of our model. Clinicians should integrate individualized ultrafiltration strategies and nutritional interventions into patient care to reduce the incidence of IDH in susceptible populations.

Disclosure

The authors report no conflicts of interest in this work.

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