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Original Article

Analysis of the Relationships between Mean Red Blood Cell Volume, Red Blood Cell Distribution Width and Hypotension in Patients with Hemodialysis

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Abstract

Background: We aimed to explore and analyze the relationships between mean corpuscular volume (MCV), red blood cell distribution width (RDW) and hypotension in patients with hemodialysis.

Methods: The clinical data of 163 patients from the Xinghua People's Hospital, Taizhou, China with hemodialysis were retrospectively analyzed. The incidence of hypotension was counted and the levels of MCV and RDW were compared between the patients with and without hemodialysis. MCV and RDW were analyzed as possible influencing factors of hypotension. Receiver operating characteristic curve (ROC) was drawn to analyze the effect of MCV and RDW on the risk assessment of hypotension in patients with hemodialysis.

Results: MCV in patients with hypotension was significantly lower than those without hypotension ($P < 0.05$), and RDW was higher than those without hypotension ($P < 0.05$). The constituent ratio of higher age (>60), diabetic nephropathy, maintenance hemodialysis, MCV < 80fl, RDW > 14.8%, malnutrition, anemia, ultrafiltration rate, diet during dialysis, coronary heart disease, atrial fibrillation and antihypertensive drugs before dialysis were higher in patients with hypotension than those without hypotension ($P < 0.05$). The sensitivity, specificity and AUC of the combination of MCV and RDW were higher than those of the single assessment. MCV is lower in patients with hypotension and RDW is higher than those in patients without hypotension.

Conclusion: MCV combined with RDW has a good evaluation effect.

Keywords: Red blood cell; Hemodialysis; Hypotension

Introduction

Hemodialysis is one of the renal replacement therapies commonly used in patients with acute or chronic renal failure clinically. Through hemodialysis, the blood of patients with chronic renal failure can be drained out of the body. After treatment by dialyzer, the metabolic waste in the body is cleared by the principles of diffusion, ultra-filtration, adsorption and convection to maintain the balance of acid, base and electrolyte, and remove excessive water. Finally, the purified blood is returned to the body (1).

The incidence of hypotension in patients with hemodialysis is high, about 20%~30%, which is prone to the elderly with diabetes or cardiovascular disease (2). Once it occurs, patients may have dizziness, pale complexion and other symptoms. Severe patients may have dyspnea or even transient loss of consciousness and other symptoms, with serious harm, which can affect the treatment process (3). Among patients with hemodialysis, nutritional status, anemia and the risk of complications can be evaluated according to the changes of blood routine indexes, in which prolonged hemodialysis can lead to elevated MCV and is associated with malnutrition and anemia (4). Meanwhile, malnutrition and anemia can increase the risk of hypotension in patients with hemodialysis (5).

Hence, it is assumed that MCV is related to the occurrence of hypotension. RDW also showed significant elevated blood pressure in patients with hemodialysis (6), which is also coincident with the occurrence of hypotension.

In order to further explore the relationship between MCV, RDW and hypotension in patients with hemodialysis, this study designed the retrospective analysis reported as follows.

Materials and Methods

Clinical Data

After the approval of the hospital Ethics Committee, the clinical data of 163 patients with hemodialysis were reviewed. They were admitted in the Xinghua People's Hospital, Taizhou, China from Mar 2017 to May 2019.

Inclusion criteria: ①Patients met the hemodialysis treatment indication; ② Patients who received hemodialysis treatment; ③ Patients with hemodialysis treatment time ≥ 2 weeks, as well as complete clinical data; ④ Patients who have agreed to a study of their medical records with their family. Exclusion criteria: ① Patients with primary hypotension; ② Patients who have not been cleared that whether there was hypotension in hemodialysis treatment; ③ Patients who were transferred to other hospitals; ④ Patients who voluntarily gave up treatment themselves and/or their families; ⑤ Patients who died within 48 h after admission. There were 66 females and 97 males, aged 44~81 yr old, with the average age of (58.96±8.15) yr old. There were 53 patients with obesity. Protopathy types: 64 cases of glomerular nephritis, 70 cases of diabetic nephropathy, 19 cases of hypertensive renal impairment, 10 other cases, 78 cases of maintenance hemodialysis, 69 cases of malnutrition, 67 cases of anemia, 38 cases of ultra-filtration rate, 48 cases of diet during dialysis, 34 cases with coronary heart disease, 29 cases with atrial fibrillation, 24 cases of antihypertensive drugs before dialysis.

Methods

Criteria for determining hypotension

According to the complications of hemodialysis (7), the systolic blood pressure in hemodialysis therapy decreased at least 20 mmHg, or the mean arterial pressure in hemodialysis treatment decreased at least 10 mmHg, accompanied by dizziness, irritability, anxiety, yawning, pale complexion, nausea, vomiting, rapid heart rate, abdominal discomfort, cold sweat and other symptoms. In severe cases, dyspnea, muscle spasms, blackness loss of transient consciousness can occur.

MCV and RDW detection: peripheral venous blood was extracted from all patients during hemodialysis treatment with XFA6100 blood routine analyzer produced by Plang Medical Devices Co., Ltd.

The analysis of influencing factors of hypotension in hemodialysis treatment: The factors that may affect hypotension in hemodialysis treatment were summarized as independent variables, including gender, age, obesity (body mass index >25 kg/m^2), protopathy type, maintenance hemodialysis, MCV, RDW, malnutrition, anemia, ultra-filtration rate, diet during dialysis, accompanied by coronary heart disease, atrial fibrillation and antihypertensive drugs before dialysis. The occurrence of hemodialysis in the treatment of hypotension was used as dependent variables. The independent variables were assigned values to analyze the influencing factors of hypotension (Table 1).

Table 1: Independent variable assignment results

Independent variables	*Assignment*	*Independent variables*	*Assignment*
Gender	Female=0, male=1	Malnutrition	No=0, yes=1
Age	≤60 yr old=0, >60 yr old=1	Anemia	No =0, yes=1
Obesity	No =0, yes =1	too fast ultra-filtration	No =0, yes =1
Type of protopathy disease	glomerular nephritis=0, diabetic nephropathy =1, hypertensive renal impairment=2, other =3	diet during dialysis	No =0, yes =1
Maintenance hemodialysis	No =0, yes =1	Coronary heart disease	No =0, yes =1
MCV	80~98 fl=0,<801,>90 fl=2	Atrial fibrillation	No =0, yes =1
RDW	11.6%~14.8%=0，＜11.6%=1，＞14.8%=2	antihypertensive drugs before dialysis	No =0, yes =1

Observation Indicators

Comparison of MCV and RDW levels between patients with and without hypotension;
Analysis of MCV and RDW as possible influencing factors of hypotension;
Analysis MCV and RDW assessment of the risk of hypotension in patients with hemodialysis.

Statistical Analysis

SPSS 22 (Chicago, IL, USA) software was used for statistical analysis. The measurement data were compared by *t* test, the counting data were compared by χ^2 test, and the influencing factors were analyzed by Logistic multiple regression analysis. MCV and RDW assessment of hypotension risk was measured by the area under the curve (AUC) of the receiver operating characteristic (ROC). $P<0.05$ was statistically significant.

Results

Comparison of MCV and RDW levels between patients with and without hypotension

There were 40 patients with hypotension in this group, with the incidence of 24.54%. The MCV of patients with hypotension was significantly lower than that of non-occurrence ($P<0.05$). And the RDW was significantly higher than that of non-occurrence ($P<0.05$) (Table 2).

Table 2: Comparison of MCV and RDW levels between patients with and without hypotension

Occurrence of hypotension	*Number of cases*	*MCV (fl)*	*RDW(%)*
Occurrence	40	62.54±7.82	16.35±1.36
Non-occurrence	123	89.83±8.15	13.22±1.42
t value		18.576	12.233
P value		0.000	0.000

Analysis of risk factors for hypotension

There was no statistically significant difference in the constituent ratio of gender and obesity between hypotension patients and non-occurrence. The constituent ratio of higher age (> 60 yr old), diabetic nephropathy, maintenance hemodialysis, MCVP >80 fl, RDW>14.8%, malnutrition, anemia, ultra-filtration rate, diet during dialysis, coronary heart disease, atrial fibrillation, antihypertensive drugs before dialysis was higher in patients with hypotension than those without hypotension (Table 3).

Table 3: Comparison of constituent ratio of possible influencing factors in patients with and without hypotension

Possible influencing factors	*Occurrence (n=40)*	*Non-occurrence (n=123)*	χ^2 *value*	*P value*
Gender				
Female	17（42.50）	49（39.84）	0.089	0.766
Male	23（57.50）	74（61.16）		
Age				
>60 yr old	35（87.50）	41（33.33）	35.586	0.000
≤60 yr old	5（12.50）	82（66.67）		
Obesity				
Yes	15（37.50）	38（30.89）	0.600	0.438
No	25（62.50）	85（69.11）		
Type of protopathy				
Glomerular nephritis	12（30.00）	52（42.28）	4.586	0.031
Diabetic nephropathy	23（57.50）	47（38.21）		
Hypertensive renal impairment	3（7.50）	16（13.01）		
Other	2（5.00）	8（6.50）		
Maintenance hemodialysis				
Yes	26（65.00）	52（42.28）	6.246	0.012
No	14（35.00）	71（57.72）		
MCV (fl)				
80~98	10（25.00）	92（74.80）	30.873	0.000
＜80	26（65.00）	16（13.01）		
＞90	4（10.00）	15（12.20）		
RDW (%)				
11.6%~14.8%	8（20.00）	86（69.92）	25.371	0.000
＜11.6%	2（5.00）	12（9.76）		
＞14.8%	30（75.00）	15（12.20）		
Malnutrition				
Yes	29（72.50）	40（32.52）	19.763	0.000
No	11（27.50）	83（67.48）		
Anemia				
Yes	25（62.50）	32（26.02）	17.667	0.000
No	15（37.50）	91（73.98）		
Ultra-filtration rate				
Yes	16（40.00）	22（17.89）	8.256	0.004
No	24（60.00）	101（82.11）		
Diet during dialysis				
Yes	18（45.00）	30（24.39）	6.171	0.013
No	22（55.00）	93（75.61）		
Coronary heart disease				
Yes	18（45.00）	16（13.01）	18.714	0.000
No	22（55.00）	107（86.99）		
Atrial fibrillation				
Yes	16（40.00）	13（10.57）	17.875	0.000
No	24（60.00）	110（89.43）		
Antihypertensive drugs before dialysis				
Yes	13（32.50）	11（8.94）	13.340	0.000
No	27（67.50）	112（91.06）		

Logistic multiple regression analysis showed that age > 60 yr old, diabetic nephropathy, maintenance hemodialysis, MCV<80 fl, RDW>14.8%, malnutrition, anemia, ultra-filtration rate, diet during dialysis, accompanied by coronary heart disease, atrial fibrillation, and antihypertensive drugs before dialysis were independent risk factors for hemodialysis hypotension (Table 4).

Table 4: Logistic Multiple regression analysis

Risk factors	*β*	*SE*	*Wald* χ^2	*P*	*OR*	*CI 95%*
Age > 60 yr old	1.862	0.412	20.425	0.000	6.437	1.682~7.801
Diabetic nephropathy	1.753	0.453	14.975	0.001	5.772	1.896~6.753
Maintenance hemodialysis	1.996	0.477	17.510	0.000	7.360	1.302~9.064
MCV<80 fl	2.015	0.405	24.754	0.000	7.501	2.311~8.451
RDW>14.8%	2.023	0.463	19.091	0.000	7.561	1.525~7.864
Malnutrition	1.697	0.440	14.875	0.001	5.458	1.656~9.025
Anemia	1.874	0.369	25.792	0.000	6.514	1.458~7.541
Ultra-filtration rate	1.669	0.352	22.482	0.000	5.307	1.802~5.951
Diet during dialysis	1.457	0.383	14.472	0.003	4.293	1.595~5.673
Coronary heart disease	1.972	0.475	17.236	0.000	7.185	2.258~8.511
Atrial fibrillation	1.851	0.415	19.894	0.000	6.366	2.305~7.295
Antihypertensive drugs before dialysis	1.696	0.412	16.946	0.000	5.452	1.951~6.241

Analysis of the role of MCV and RDW in assessing the risk of hypotension

The optimal cutoff points for the risk of hypotension in MCV and RDW assessment were 70.15 fl and 16.02%. The sensitivity, specificity and AUC of the combination were higher than those of the single assessment (Table 5, Fig. 1).

Table 5: Role of MCV and RDW in the risk assessment of hypotension

Indicators	*Optional cut-off point*	*Sensitivity*	*Specificity*	*AUC*	*95% CI*
MCV	70.15 fl	80.00% (32/40)	89.43%(110/123)	0.671	0.545~0.702
RDW	16.02%	87.50% (35/40)	93.50%(115/123)	0.789	0.683~0.815
MCV and RDW	——	92.50% (37/40)	98.37%(121/123)	0.902	0.707~0.915

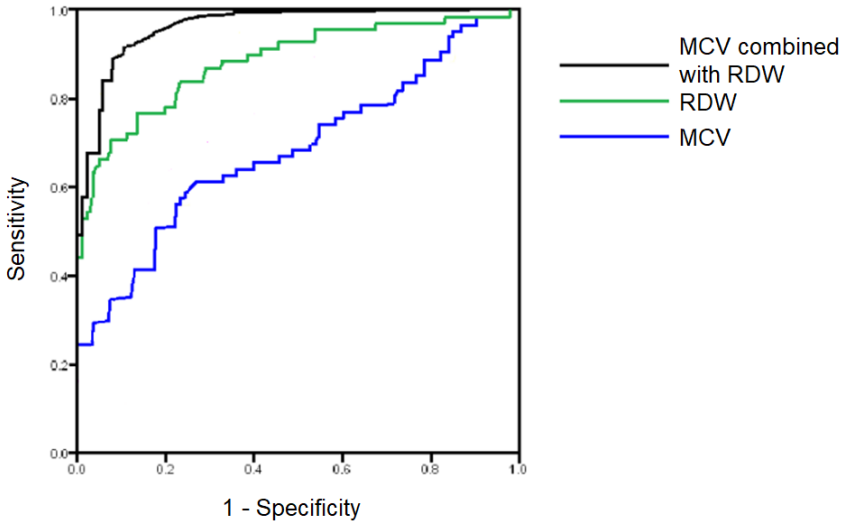

Fig. 1: Role of MCV and RDW in the risk assessment of hypotension

Discussion

During the treatment of patients with hemodialysis, the decrease of effective blood volume can lead to hypotension, which causes serious harm to the patients and increases the risk of poor prognosis, especially cardiovascular events. The ultra-filtration rate and refilling rate of patients with hemodialysis should be balanced as far as possible (8). If ultra-filtration rate increases, the effective blood volume decreases and the risk of hypotension increases. If the two can balance, they can effectively filter out excessive water and reduce the probability of hypotension. There were a variety of factors affecting the balance between the two, and the risk of hypotension in hemodialysis patients was still relatively high, with a lack of effective laboratory evaluation indicators. Therefore, it was very important to explore the risk factors of hypotension in patients with hemodialysis, as well as sensitive and specific evaluation indicators.

In this report, a total of 40 patients had hypotension during hemodialysis, with the incidence of hypotension of 24.54%, suggesting that patients with hemodialysis do have a higher risk of hypotension. Additionally, the MCV of patients with hypotension in this study was significantly lower than those without hypotension. The RDW of patients with hypotension was significantly higher than those without hypotension. It can be seen that MCV was generally low and RDW was generally high in patients with hypotension during hemodialysis treatment, indicating that the abnormality of MCV and RDW may be related to hypotension in patients with hemodialysis. In further risk factor analysis, the proportion of patients with hypotension, MCV<80 fl, RDW>14.8%, was significantly higher than those without hypotension. Logistic multiple regression analysis confirmed that they are independent risk factors of hypotension, showing that both can increase the risk. Red blood cell is an important blood cell, which can transport oxygen to various tissue parts of the body, and transport metabolite carbon dioxide out of the body. It is an indispensable component in the body. Changes in erythrocyte volume can directly affect its transport function. In malnutrition, anemia and other diseases, there were also significant changes in MCV. During hemodialysis in patients with acute and chronic renal failure, red blood cells in blood circulation can be affected by renal tubular filtrate pH, osmotic pressure and other MCV changes. They are related to the severity of the disease, which can be used to predict poor prognosis (9). In addition, there was a close relationship between MCV and liver function damage, and the abnormal decrease of its level means that the risk

of debilitating syndrome and hypotension may significantly increase. RDW is one of the important parameters to reflect the heterogeneity of red blood cell volume. The high accuracy and simple measurement method can reflect the degree of inflammation, the higher the level of this index, the more serious the damage of red blood cell (10, 11).

Inflammatory factors can induce ion channel dysfunction on erythrocyte membrane, leading to high calcium and sodium state, as well as the changes of cell volume and resting potential, so as to accelerate erythrocyte apoptosis (12). The activated body slightly inflammatory state of patients with hemodialysis can enhance oxidative stress damage. Coupled with the lack of active vitamin D3, it can lead to higher RDW and cause systemic vascular atherosclerosis, resulting in declining in vascular elasticity and reducing the tolerance of the body for blood dialysis (13). It can be speculated that higher RDW is likely to induce hypotension through time approaches. Consequently, among patients with hemodialysis, it is suggested to strengthen the monitoring of MCV, RDW in patients with hemodialysis. By this method, the occurrence of hypotension can be evaluated. The two indicators should be actively regulated when abnormal, in order to control the incidence of hypotension.

Furthermore, the analysis of the risk factors for hypotension in patients with hemodialysis in this study shows that high age (> 60 yr old), diabetic nephropathy, maintenance hemodialysis, malnutrition, anemia, ultra-filtration rate, diet during dialysis, coronary heart disease, atrial fibrillation, and antihypertensive drugs before dialysis were all risk factors, consistent with previous reports in China and abroad (14-16). According to the results of the above analysis, it is suggested that the prevention and control of the above risk factors should be strengthened in patients with hemodialysis, to actively control blood sugar levels, adjust hemodialysis programmes, improve nutritional status and correct anemia. The ultra-filtration rate should be set reasonably. Food should be avoided as far as possible during dialysis, especially for patients aged >60 yr old accompanied by coronary heart disease and atrial fibrillation. The prevention and control of hypotension should be strengthened to avoid antihypertensive drugs before dialysis.

Conclusion

The risk of hypotension in patients with hemodialysis was high. The MCV of patients with hypotension was generally low and the RDW was generally high. Both of them were risk factors for the occurrence of hypotension. The efficacy of combined application was significantly higher than that of single application in the evaluation of hypotension. Besides, high age (>60 yr old), diabetic nephropathy, maintenance hemodialysis, malnutrition, anemia, ultra-filtration rate, diet during dialysis, accompanied by coronary heart disease, atrial fibrillation, antihypertensive drugs before dialysis are independent risk factors for hypotension in such patients. It is necessary to strengthen prevention and control of the above factors, actively control the risk of hypotension, and ensure the smooth progress of hemodialysis.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict interest

The authors declare that there is no conflict of interest.

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