

Original Article

Red blood cell distribution width is associated with the presence and severity of myasthenia gravis

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Abstract: Despite the fact that the pathogenesis of myasthenia gravis (MG) has not been fully elucidated, the presence of inflammation and the modulation of the immune response by cytokines could be a key factor in the pathogenesis of MG. The aim of the present study was to investigate the relationship between red blood cell distribution width (RDW) and MG. Venous blood was drawn and hematological parameters were determined in 417 individuals, including 177 patients with MG and 240 healthy controls (HC). In this study, we found that patients with MG had a significantly higher admission RDW than those in the HC group (MG: 13.10 (12.60, 13.80), HC: 12.70 (12.30, 13.20), $P < 0.001$). In addition, our study showed that patients with higher disease activity had higher RDW levels than those with lower disease activity. Moreover, RDW was positively correlated with C-reactive protein (CRP) ($r = 0.609$, $P < 0.001$) and with the degree of disease severity expressed by the Myasthenia Gravis Foundation of America (MGFA) scores ($r = 0.185$, $P = 0.014$). A univariate analysis revealed that the RDW was a risk factor for patients with MG (OR: 1.505; 95% CI: 1.236-1.832; $P < 0.001$). It was further demonstrated by the multivariable logistic regression analysis after adjusting for other potential confounding factors (OR: 2.017; 95% CI: 1.010-4.027; $P = 0.047$). We found that RDW can be regarded as a new informative and inflammatory biomarker to evaluate the systemic inflammatory conditions and disability status in patients with MG.

Keywords: Myasthenia gravis, red blood cell distribution width, inflammatory biomarker, disease severity, Myasthenia Gravis Foundation of America

Introduction

Myasthenia gravis (MG) is an autoimmune-mediated disease of the neuromuscular junction and is clinically characterized by muscle weakness with fatigability [1]. It has been reported that the incidence of MG varies between 1 and 2 and 5 and 15 per 100,000 population [2, 3]. However, the pathogenesis of MG has not been fully elucidated. Previous studies have reported that the presence of inflammation and the modulation of the immune response by cytokines could be key players in MG pathogenesis [4-6].

Red blood cell distribution width (RDW) is a routinely tested value which reflects the variability of circulating red blood cells (RBCs) and has been widely used for the differential diagnosis

of anemia during the past decades. As shown in **Table 1**, in recent years RDW has drawn worldwide attention in the field of inflammation, because it is associated with the presence and severity of numerous diseases, including, for instance, cardiovascular and cerebrovascular diseases [7-9], cancer [10], and autoimmune and inflammatory disease such as multiple sclerosis [11], inflammatory bowel disease (IBD) [12, 13], systemic lupus erythematosus (SLE) [14], and psoriasis vulgaris [15].

To our knowledge, the relationship between the RDW and MG has not been reported in the literature. Knowing that MG is a well-established autoimmune disease and RDW has been reported to be associated with autoimmune disease, we speculated that RDW may be increased in MG and reflect its severity.

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Table 1. The study on RDW

Study	Diseases	Subjects	Country
Tonelli M, et al. 2008 [7]	Coronary Disease	n=4111	Canada
Kim J, et al. 2012 [8]	Acute cerebral infarction	n=847	South Korea
Turcato G, et al. 2017 [9]	Ischemic stroke	n=316	Italy
Koma Y, et al. 2013 [10]	Lung cancer	n=332	Japan
Peng YF, et al. 2015 [11]	Multiple Sclerosis	n=109	China
Cakal B, et al. 2009 [12]	Inflammatory Bowel Disease	n=96	Turkey
Song CS, et al. 2012 [13]	Inflammatory Bowel Disease	n=221	South Korea
Hu ZD, et al. 2013 [14]	Systemic Lupus Erythematosus	n=131	China
Kim DS, et al. 2015 [15]	Psoriasis vulgaris	n=262	South Korea

Methods

Study population

All patients in this study with MG were hospitalized from February 2009 to March 2015 in the First Affiliated Hospital of Wenzhou Medical University and had definite MG according to the standard clinical diagnostic criteria of Drachman [16]. Patients were excluded if they had one of the following diseases/situations: 1) other autoimmune diseases, 2) malignancies 3) hematologic diseases, 4) blood transfusion, 5) lymphoproliferative disorders, 6) infections, 7) anemia, 8) hepatosplenic diseases, 9) missing data of RDW [17, 18]. Finally, 177 patients with myasthenia gravis (MG) were included in the study. Moreover, the severity of MG (**Table 2**) was assessed based on the widely accepted Myasthenia Gravis Foundation of America (MGFA) clinical classification on admission [19]. According to the clinical classification, patients with MG were divided into two subgroups: mild disease activity (I, II and III) and severe disease activity (IV and V).

240 healthy individuals, who underwent a health examination between January 2012 and August 2017 in the First Affiliated Hospital of Wenzhou Medical University, were enrolled as controls. Healthy individuals whose RDW data were missing before enrollment were excluded.

Ethical approval was granted by the Ethics Committee of the First Affiliated Hospital of Wenzhou Medical University.

Clinical and laboratory measurements

Blood samples were drawn by venipuncture in the morning after overnight fasting on admission and were used for the analysis of bi-

ochemical measurements by a Clinical Analyzer Beckman Coulter AU5831 (Beckman Coulter, California, U.S.). The following hematological parameters were obtained: red blood cell distribution width (RDW), white blood cell count (WBC), hemoglobin (Hb), red blood cells (RBC), plate-

let count, mean corpuscular volume (MCV), C-reactive protein (CRP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin (Tbil), direct bilirubin (Dbil), indirect bilirubin (Ibil), total protein, albumin, fasting blood glucose (FBG), blood urine nitrogen (BUN), creatinine, uric acid (UA), total cholesterol (TC), triglyceride (TG), high density lipoprotein-cholesterol (HDL-C) and low density lipoprotein-cholesterol (LDL-C).

In addition, MGFA scores (given as 1-5 and corresponding to I-V) were used to estimate the disease disability based on the clinical symptoms and laboratory test results recorded in the medical records [20].

Statistical analysis

The statistical software Statistical Program for Social Sciences (version 21.0, SPSS Inc, Chicago, IL, USA) and MedCalc 11.4.2 (MedCalc Software, Mariakerke, Belgium) were used for all statistical analyses in our study. The comparisons of the data with the normal distribution between two groups were performed using an independent Student's *t* test. Otherwise, the Mann Whitney U-test was used. The comparisons among groups were performed by a Kruskal-Wallis test. Enumeration data were expressed as numbers and percentiles and compared by a chi-squared test. Correlations between two variables were evaluated using the Spearman approach. Also, factors with $P \leq 0.10$ in the univariate analysis were included into the multivariate analyses as independent variables. The influence of RDW on MG was estimated by binary logistic regression analysis, after adjusting for some potential confounding variables. The results were expressed as adjusted odds ratios (ORs) (95% confidence intervals [CIs]). All *P* values are 2-sided and

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Table 2. MGFA clinical classification [19]

Class I	Any ocular muscle weakness May have weakness of eye closure All other muscle strength is normal
Class II	Mild weakness affecting other than ocular muscles May also have ocular muscle weakness of any severity
IIa	Predominantly affecting limb, axial muscles, or both May also have lesser involvement of oropharyngeal muscles
IIb	Predominantly affecting oropharyngeal, respiratory muscles, or both May also have lesser or equal involvement of limb, axial muscles, or both
Class III	Moderate weakness affecting other than ocular muscles May also have ocular muscle weakness of any severity
IIIa	Predominantly affecting limb, axial muscles, or both May also have lesser involvement of oropharyngeal muscles
IIIb	Predominantly affecting oropharyngeal, respiratory muscles, or both May also have lesser or equal involvement of limb, axial muscles, or both
Class IV	Severe weakness affecting other than ocular muscles May also have ocular muscle weakness of any severity
IVa	Predominantly affecting limb and/or axial muscles May also have lesser involvement of oropharyngeal muscles
IVb	Predominantly affecting oropharyngeal, respiratory muscles, or both May also have lesser or equal involvement of limb, axial muscles, or both
Class V	Defined by intubation, with or without mechanical ventilation, except, when used during routine postoperative management. The use of a feeding tube without intubation places the patient in class IVb

Abbreviations: MG, myasthenia gravis; MGFA, Myasthenia Gravis Foundation of America.

atelets (MG: 211.19±57.85, HC: 238.19±56.61, P<0.001), total bilirubin (Tbil) (MG: 10.50 (8.00, 14.00), HC: 11.00 (9.00, 15.00), P=0.032), indirect bilirubin (Ibil) (MG: 7.00 (6.00, 10.00), HC: 10.00 (8.00, 13.00), P<0.001), total protein (MG: 69.62±6.04, HC: 74.36±4.17, P<0.001), albumin (MG: 40.54±4.14, HC: 46.57±2.74, P<0.001), fasting blood glucose (FBG) (MG: 4.60 (4.13, 5.28), HC: 5.50 (5.10, 5.80), P<0.001), creatinine (MG: 57.00 (48.00, 69.00), HC: 60.50 (51.00, 74.75), P=0.026), uric acid (UA) (MG: 292.84±95.44, HC: 336.61±87.62, P<0.001), total cholesterol (TC) (MG: 4.70±1.17, HC: 4.99±1.03, P=0.008), high density

p-values less than 0.05 were considered statistically significant.

Results

Clinical characteristic of the study subjects

The clinical characteristics and laboratory findings of 177 MG patients and 240 healthy controls are shown in **Table 3**. There were no significant differences between the two groups in age, gender, systolic blood pressure (SBP), diastolic blood pressure (DBP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), blood urine nitrogen (BUN), triglyceride (TG), or low density lipoprotein-cholesterol (LDL-C). Furthermore, WBC count (MG: 6.61 (5.30, 8.99), HC: 5.92 (4.97, 6.86), P<0.001) and direct bilirubin (Dbil) (MG: 4.00 (3.00, 5.00), HC: 3.00 (3.00, 4.00), P<0.001) were significantly increased in the MG patients, but body mass index (BMI) (MG: 22.75±3.50, HC: 23.48±3.25, P=0.049), hemoglobin (Hb) (MG: 133.00 (124.00, 146.00), HC: 142.00 (130.25, 157.00), P<0.001), red blood cells (RBC) (MG: 4.37±0.46, HC: 4.80±0.47, P<0.001), pl-

lipoprotein-cholesterol (HDL-C) (MG: 1.23 (1.00, 1.46), HC: 1.31 (1.10, 1.61), P=0.001) were significantly decreased.

RDW in MG patients and healthy controls

As was illustrated in **Figure 1**, the MG patients had significantly higher RDW than the patients in the HC group (MG: 13.10 (12.60, 13.80), HC: 12.70 (12.30, 13.20), P<0.001). We found that the RDW of patients with a long disease duration (>1 year) were mildly larger than the RDW in patients with a short disease duration (≤1 year). However, there is no significant difference (disease duration >1 year: 13.20 (12.70, 13.98), ≤1 year: 13.00 (12.50, 13.70), P=0.061) (**Table 4**). Moreover, the RDW in patients with early-onset MG (age at onset ≤50 years) were not significantly lower than those in patients with late-onset MG (age at onset >50 years) (age at onset ≤50 years: 13.10 (12.60, 13.80), >50 years: 13.10 (12.63, 13.80), P=0.712) (**Table 4**). In our study, there were no significant differences between class IIa, IIIa, IVa (absence of bulbar involvement) and class IIb, IIIb, IVb (presence of bulbar involvement)

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Table 3. Clinical characteristic of the subjects

	MG		HC		P
	n	Result	n	Result	
Age (Years)	177	44.93±16.85	240	43.68±10.37	0.387
Sex (F/M)	177	96/81	240	118/122	0.306
BMI (kg/m ²)	145	22.75±3.50	200	23.48±3.25	0.049
SBP (mmHg)	177	129.65±17.84	233	126.59±17.18	0.080
DBP (mmHg)	177	80.69±11.74	233	79.35±11.45	0.247
Smoking (Yes/No)	177	38/139	-	-	-
WBC (×10 ⁹ /L)	177	6.61 (5.30, 8.99)	240	5.92 (4.97, 6.86)	<0.001
Hb (g/L)	177	133.00 (124.00, 146.00)	240	142.00 (130.25, 157.00)	<0.001
RBC (×10 ¹² /L)	177	4.37±0.46	240	4.80±0.47	<0.001
Platelet (×10 ⁹ /L)	177	211.19±57.85	240	238.19±56.61	<0.001
MCV (fl)	177	90.45±5.43	-	-	-
CRP (mg/L)	35	3.44 (1.69, 7.00)	-	-	-
ALT (IU/L)	176	20.00 (14.00, 33.00)	240	21.00 (14.00, 34.00)	0.777
AST (IU/L)	176	20.00 (16.25, 26.75)	240	20.00 (17.00, 26.00)	0.626
Tbil (μmol/L)	170	10.50 (8.00, 14.00)	235	11.00 (9.00, 15.00)	0.032
Dbil (μmol/L)	157	4.00 (3.00, 5.00)	163	3.00 (3.00, 4.00)	<0.001
Ibil (μmol/L)	157	7.00 (6.00, 10.00)	164	10.00 (8.00, 13.00)	<0.001
Total protein (g/L)	177	69.62±6.04	240	74.36±4.17	<0.001
Albumin (g/L)	177	40.54±4.14	240	46.57±2.74	<0.001
FBG (mmol/L)	164	4.60 (4.13, 5.28)	240	5.50 (5.10, 5.80)	<0.001
BUN (mmol/L)	175	4.90 (3.90, 5.80)	240	5.00 (4.30, 5.90)	0.369
Creatinine (mmol/L)	175	57.00 (48.00, 69.00)	240	60.50 (51.00, 74.75)	0.026
UA (μmol /L)	175	292.84±95.44	240	336.61±87.62	<0.001
TC (mmol/L)	174	4.70±1.17	240	4.99±1.03	0.008
TG (mmol/L)	174	1.30 (0.87, 1.77)	240	1.23 (0.85, 1.77)	0.621
HDL-C (mmol/L)	174	1.23 (1.00, 1.46)	240	1.31 (1.10, 1.61)	0.001
LDL-C (mmol/L)	174	2.77±0.90	237	2.85±0.79	0.322

Abbreviations: MG, myasthenia gravis; HC, healthy controls; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; WBC, white blood cell; Hb, hemoglobin; RBC, red blood cells; MCV, mean corpuscular volume; CRP, C-reactive protein; ALT, alanine aminotransferase; AST, aspartate aminotransferase; Tbil, total bilirubin; Dbil, direct bilirubin; Ibil, indirect bilirubin; FBG, fasting blood glucose; BUN, blood urine nitrogen; UA, uric acid; TC, total cholesterol; TG, triglyceride; HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein-cholesterol.

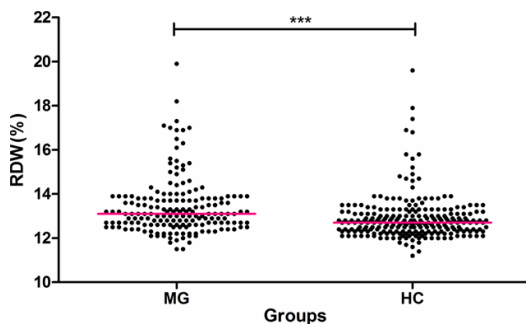


Figure 1. RDW in patients with MG and HC. MG, myasthenia gravis; HC, healthy controls; ***P<0.001. Note: horizontal lines represent the median values and data were analyzed by Mann-Whitney U test.

(class IIa, IIIa, IVa: 13.05 (12.70, 13.80), class IIb, IIIb, IVb: 13.05 (12.60, 13.90), P=0.993) (Table 4). In addition, we also found that there were no significant differences between the RDW of patients with thymoma shown on MRI or computed tomography and patients without thymoma (nonthymoma: 13.10 (12.60, 13.85), thymoma: 13.00 (12.60, 13.65), P=0.582) (Table 4).

RDW could differentiate MG patients from healthy controls

The cut-off value of the RDW for predicting the presence of MG was determined to be 13 (%). A

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Table 4. RDW in patients with MG

Variables	Result	T/F/Z/ χ^2	P
Duration of disease (years)		-1.876	0.061
≤ 1 (n=124)	13.00 (12.50, 13.70)		
> 1 (n=52)	13.20 (12.70, 13.98)		
Age of onset (years)		-0.370	0.712
≤ 50 (n=113)	13.10 (12.60, 13.80)		
> 50 (n=64)	13.10 (12.63, 13.80)		
MGFA		11.800	0.019
I (n=67)	13.00 (12.50, 13.70)		
II (n=51)	13.10 (12.50, 13.80)		
III (n=30)	13.00 (12.68, 13.95)		
IV (n=15)	13.00 (12.70, 13.90)		
V (n=14)	13.95 (13.43, 15.23)		
MGFA		-0.011	0.993
IIa, IIIa, IVa (n=40)	13.05 (12.70, 13.80)		
IIb, IIIb, IVb (n=56)	13.05 (12.60, 13.90)		
Thymus histology		-0.551	0.582
Nonthymoma (n=105)	13.10 (12.60, 13.85)		
Thymoma (n=69)	13.00 (12.60, 13.65)		

Abbreviations: RDW, red blood cell distribution width; MG, myasthenia gravis; MGFA, Myasthenia Gravis Foundation of America.

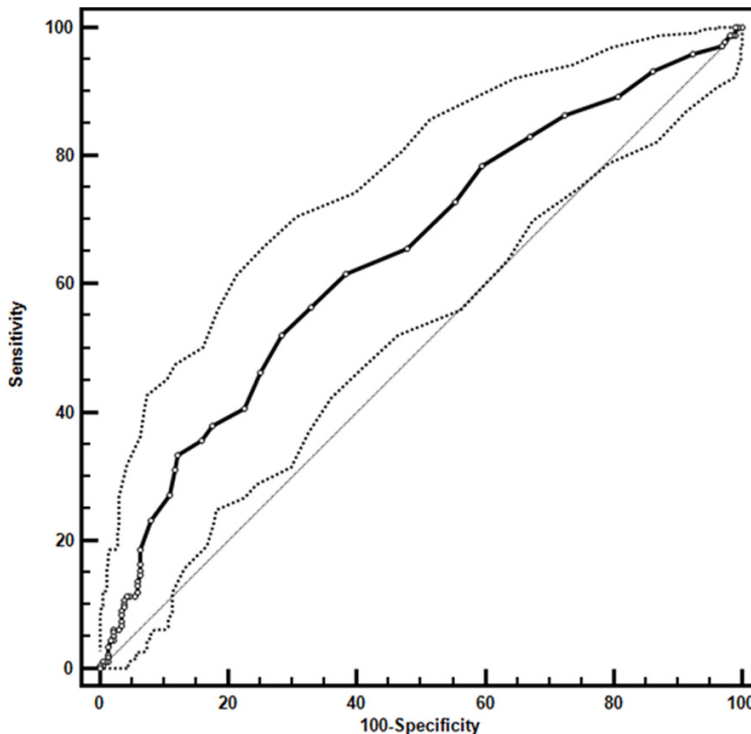


Figure 2. Receiver operating characteristic curves of RDW for differentiating MG patients from healthy controls. Area under the curve 0.648, 95% CI: 0.600 to 0.694, cut-off value 13 (%) with sensitivity 51.98%, specificity 71.67%.

receiver operator characteristic curve (ROC) analysis revealed a 0.648 area under the curve (0.600-0.694 CI), a 51.98% sensitivity, and a 71.67% specificity with the cut-off value (**Figure 2**). The ROC curves revealed that RDW had high discriminative ability for differentiating MG patients from healthy controls.

The association of RDW with MG severity

As shown in **Figure 5**, patients with higher disease activity had larger RDW levels than those with lower disease activity. The median of RDW increased from HC to severe disease activity: 12.7%, 13.0% and 13.5%, respectively. Furthermore, RDW was positively correlated with the degree of disease severity expressed by the MGFA scores ($r=0.185$, $P=0.014$) (**Figure 4**). Moreover, the levels of RDW in patients with myasthenic crisis (MC) were significantly higher than those without MC (**Figure 3**).

Correlations between RDW and clinical laboratory findings in patients with MG

As shown in **Figure 6**, RDW was positively correlated with CRP ($r=0.609$, $P<0.001$). Also, RDW negatively correlated with Hb ($r=-0.158$, $P=0.036$) (**Figure 7**).

RDW was independently associated with MG

A multivariable logistic regression analysis was performed to estimate whether the RDW was independently associated with MG. As shown in **Table 5**,

RDW is associated with the presence and severity of MG

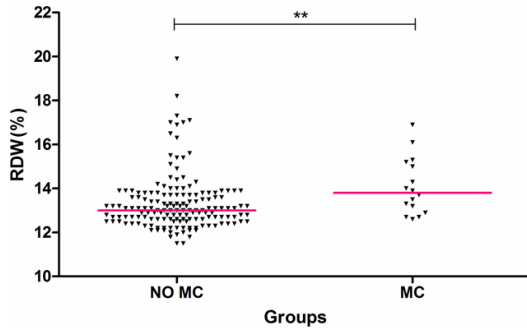


Figure 3. Relationship between RDW and MC. MC, Myasthenic crisis; **P<0.01. Note: horizontal lines represent the median values and data were analyzed by Mann-Whitney U test.

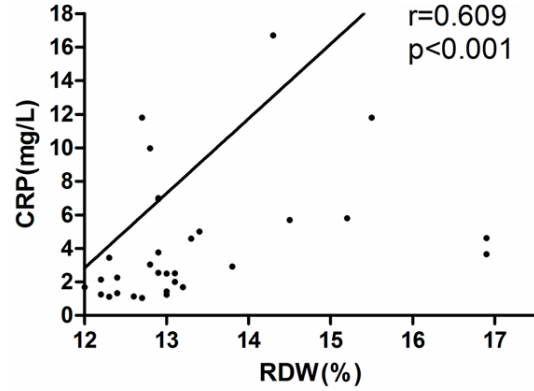


Figure 6. Correlations between RDW and CRP in patients with MG. RDW, red blood cell distribution width; MG, myasthenia gravis; CRP, C-reactive protein.

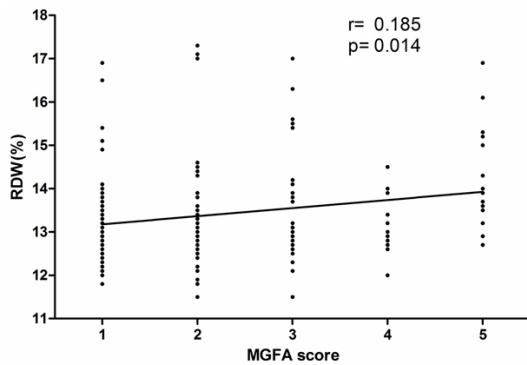


Figure 4. Scatter plot indicating a correlation between RDW and MGFA score in patients with MG. RDW, red cell distribution width; MGFA, Myasthenia Gravis Foundation of America; MG, myasthenia gravis.

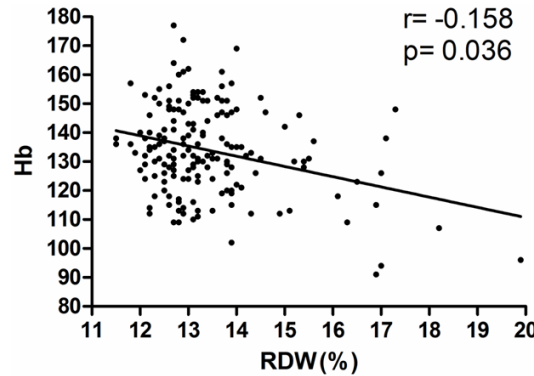


Figure 7. Correlations between RDW and Hb in patients with MG. RDW, red blood cell distribution width; MG, myasthenia gravis; Hb, hemoglobin.

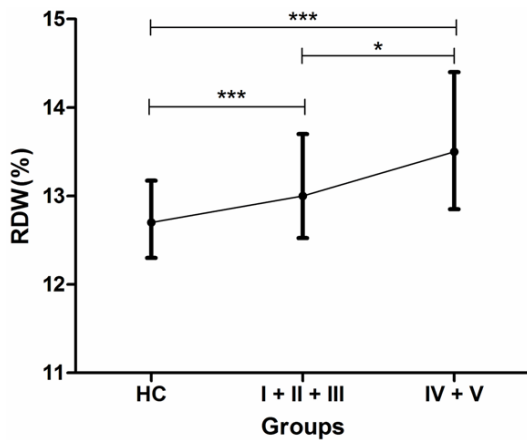


Figure 5. RDW in HC and two subgroups according to the MGFA Clinical Classification. RDW, red cell distribution width; HC, healthy controls; MGFA, Myasthenia Gravis Foundation of America; *P<0.05, ***P<0.001. Bar represents median and interquartile range.

a univariate analysis revealed that the RDW was a risk factor for patients with MG (OR: 1.505; 95% CI: 1.236-1.832; P<0.001). It was further demonstrated by the multivariable logistic regression analysis after adjusting for other potential confounding factors (OR: 2.017; 95% CI: 1.010-4.027; P=0.047).

Discussion

Our study showed that patients with MG had a significantly higher admission RDW than the patients in the HC group. Moreover, in this study, we demonstrated that patients with higher disease activity had higher RDW levels than those with lower disease activity. Moreover, RDW was positively correlated with the degree of disease severity expressed by the MGFA scores (r=0.185, P=0.014). Furthermore, a

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Table 5. Adjusted odds ratio (OR) for RDW

Characteristics	Univariable			Multivariable		
	OR	95% CI	P	OR	95% CI	P
Sex	0.816	0.553-1.204	0.306			
Age	1.007	0.992-1.022	0.349			
BMI (kg/m ²)	0.936	0.877-1.000	0.051			0.418
SBP (mmHg)	1.010	0.999-1.022	0.081			0.562
DBP (mmHg)	1.010	0.993-1.027	0.247			
RDW	1.505	1.236-1.832	<0.001	2.017	1.010-4.027	0.047
WBC	1.242	1.140-1.352	<0.001	1.545	1.115-2.141	0.009
Hb	0.965	0.953-0.978	<0.001			0.892
RBC	0.146	0.090-0.238	<0.001	0.097	0.012-0.748	0.025
PLT	0.992	0.988-0.995	<0.001	0.990	0.980-1.000	0.048
ALT (IU/L)	1.000	0.994-1.007	0.945			
AST (IU/L)	1.004	0.995-1.015	0.379			
Tbil (µmol/L)	0.967	0.928-1.007	0.106			
Dbil (µmol/L)	1.370	1.165-1.611	<0.001	2.756	1.763-4.308	<0.001
Ibil (µmol/L)	0.828	0.774-0.886	<0.001	0.692	0.576-0.832	<0.001
Total protein (g/L)	0.825	0.786-0.866	<0.001			0.529
Albumin (g/L)	0.582	0.524-0.645	<0.001	0.646	0.506-0.826	<0.001
FBG (mmol/L)	0.571	0.451-0.723	<0.001			0.114
BUN (mmol/L)	1.034	0.906-1.180	0.618			
Creatinine (mmol/L)	0.990	0.978-1.002	0.114			
UA (µmol /L)	0.995	0.992-0.997	<0.001			0.340
TC (mmol/L)	0.777	0.643-0.938	0.009	2.253	1.118-4.543	0.023
TG (mmol/L)	0.936	0.753-1.162	0.548			
HDL-C (mmol/L)	0.429	0.248-0.741	0.002	0.020	0.003-0.153	<0.001
LDL-C (mmol/L)	0.887	0.699-1.125	0.322			

Abbreviations: OR, odds ratio; CI, confidence interval; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; RDW, red blood cell distribution width; WBC, white blood cell; Hb, hemoglobin; RBC, red blood cells; PLT, platelet; ALT, alanine aminotransferase; AST, aspartate aminotransferase; Tbil, total bilirubin; Dbil, direct bilirubin; Ibil, indirect bilirubin; FBG, fasting blood glucose; BUN, blood urine nitrogen; UA, uric acid; TC, total cholesterol; TG, triglyceride; HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein-cholesterol.

multivariable logistic regression analysis was performed to show that the RDW was independently associated with MG. Last but not least, we found that RDW was positively correlated with CRP ($r=0.609$, $P<0.001$).

Myasthenia gravis (MG) is an autoimmune disease of the neuromuscular junction characterized by muscle weakness with fatigability [1]. There is mounting evidence that the presence of inflammation and the modulation of the immune response by cytokines contribute to the pathogenesis of MG [4-6]. The Th1 cells and Th17 cells can secrete pro-inflammatory cytokines such as interferon- γ (IFN- γ) (Th1) and IL-17 (Th17) [21, 22]. On the other hand, Th2 cells can secrete anti-inflammatory cytokines such as IL-4, and Treg cells are also thought to

be anti-inflammatory for having the ability to suppress certain immune responses. Furthermore, it has been demonstrated that the balance of T helper type 1 (Th1), Th2, Th17 and regulatory T (Treg) subsets of CD4+ helper T cells are reorganized by increasing Th1, Th17 subsets and decreasing Th2, Treg subsets during the development of EAMG [23].

RDW, a routinely tested value, which reflects the variability of circulating red blood cells (RBCs), has recently been proven to be an inflammatory indicator and is associated with the presence and severity of various autoimmune disease [11-14]. Indeed, a multitude of articles suggest that inflammation contributes to increasing the level of RDW by affecting erythrocyte heterogeneity [13, 24, 25]. An ear-

RDW is associated with the presence and severity of MG

lier study proved that RDW values in patients with multiple sclerosis (MS) were significantly higher than the healthy controls, and elevated RDW values are associated with the EDSS score in patients with MS [11]. In addition, the results suggest that RDW may be a useful marker to estimate disability status and treatment effectiveness in patients with MS [11]. Moreover, RDW has been proposed as a reliable, simple, and inexpensive marker for the assessment of disease activity in patients with IBD [12, 13]. In addition, a previous study demonstrated that RDW could be a useful index for disease activity assessment for SLE patients without hematological complications [14]. Considering there is no ideal serum inflammatory marker for predicting the presence and severity of MG, we aimed to investigate whether RDW could be a qualified marker for predicting the presence and activity of MG.

We found that the RDW in patients with MG was significantly higher than in patients in the health control group. In addition, RDW was positively correlated with the degree of disease severity expressed by the MGFA scores ($r=0.185$, $P=0.014$), and the RDW was independently associated with MG. Moreover, we showed that there was a significantly positive correlation between the RDW and CRP in patients with MG ($r=0.609$, $P<0.001$). Therefore, based on the above observations, there is reason to speculate that RDW, as an inexpensive and available test, can be considered a new informative and Inflammatory biomarker to estimate the systemic inflammatory conditions and disability status in patients with MG.

There are some limitations to the present study. Firstly, this is only a single center retrospective study. In addition, the sample size of our study was relatively small, and the detailed mechanisms associating RDW with MG remain unclear. Despite these limitations, this is the first study showing that red blood cell distribution width (RDW) is associated with the presence and severity of myasthenia gravis (MG).

Conclusion

In conclusion, we demonstrated for the first time that RDW, as an inexpensive and available test on admission, can be considered as a new informative and inflammatory biomarker to

estimate the systemic inflammatory conditions and disability status in patients with MG.

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Disclosure of conflict of interest

None.

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