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C-reactive protein/albumin ratio as a prognostic biomarker in myasthenia gravis

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ABSTRACT

Aims: Limited research has explored novel inflammatory targets in myasthenia gravis (MG). This study aimed to investigate the role of the C-reactive protein (CRP)/albumin ratio (CAR) in disease activity and prognosis in MG patients.

Methods: CRP, albumin, and CAR levels were compared between MG patients and healthy controls. The relationships of these parameters with MG activities of daily living (MG-ADL) scores and mortality were examined.

Results: Sixty-six patients and 51 controls participated. CRP and CAR levels were significantly higher in the patient group (p=0.002, 0.003). No significant difference was found in albumin levels (p=0.154). A positive correlation was observed between the MG-ADL stage and both CRP and CAR levels (p=0.000 for both), with these markers increasing as MG-ADL worsened. A negative correlation was found between the MG-ADL stage and albumin (p=0.003). CRP, CAR, and albumin levels were significantly associated with mortality (p=0.000, 0.000, 0.005).

Conclusion: Elevated CRP and CAR levels in MG patients suggest acute inflammation contributing to clinical decline. Albumin's decrease with worsening MG-ADL suggests its value as a prognostic marker rather than a diagnostic. CAR proved to be a stronger marker than albumin for disease diagnosis, severity monitoring, and mortality prediction. Our findings could help illuminate inflammatory mechanisms in MG and other neuromuscular diseases.

Keywords: Myasthenia gravis, C-reactive protein, albumin

INTRODUCTION

Myasthenia gravis (MG) is an autoimmune neuromuscular disorder characterized by autoantibodies targeting proteins at the neuromuscular junction (NMJ). Antibodies against nicotinic acetylcholine receptors (AchR), muscle-specific kinase (MuSK), and lipoprotein-related protein 4 (LRP4) at the postsynaptic membrane are central to the disease mechanism. Additionally, autoantibodies against agrin, Kv1.4 potassium channels, collagen Q, titin, and ryanodine have been identified in some MG patients.[1-3] The production of anti-AchR antibodies is mediated by CD4+ T cells, which stimulate B cells to produce these autoantibodies. This leads to an IgG-mediated attack that reduces the number of functional AchRs, impairing neuromuscular transmission.[4]

Recent evidence suggests that heightened inflammatory responses may contribute to the pathogenesis of various autoimmune diseases, including rheumatoid arthritis, systemic lupus erythematosus, and multiple sclerosis.[5,6]

Inflammation has long been recognized as a key factor in the pathogenesis of MG. While the exact trigger of the immune response in MG remains unclear, the thymus plays a critical role in disease development. Experimental studies have shown that inflammatory mediators, particularly cytokines and chemokines, are released by monocytes and macrophages at the affected postsynaptic NMJ and thymic tissue, entering peripheral circulation.[7] One study found that the neutrophil-lymphocyte ratio (NLR) in peripheral blood was elevated in MG patients compared to that in controls, further emphasizing the inflammatory nature of the disease.[8] Research has highlighted the involvement of various proinflammatory mediators in MG pathogenesis. While biomarkers such as NLR, C-reactive protein (CRP), and albumin have been studied for MG disease activity and prognosis, no previous studies have evaluated CRP, albumin, and CAR together.

Recent research focuses on identifying novel targets involved in MG-associated inflammation. An easy-to-use, well-designed biomarker could aid clinicians in diagnosis, prognosis, and treatment monitoring. Moreover, adjuvant therapies targeting key inflammatory pathways may offer promising strategies for disease control.

CRP is a well-known systemic inflammatory marker produced by the liver in response to cytokines such as interleukin (IL) -6, IL-1, and tumor necrosis factor-α (TNF-α).[9] CRP

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is widely used in various diseases to assess inflammatory status because of its accessibility and ease of application. It is also a significant marker in autoimmune diseases such as systemic lupus erythematosus and rheumatoid arthritis.[10] In recent years, interest in CRP has increased for diagnosing and monitoring neurological diseases. A systematic review of 11 studies highlighted CRP as a reliable prognostic biomarker in amyotrophic lateral sclerosis (ALS) patients.[11]

Albumin, produced by the liver, is the primary protein responsible for serum osmotic pressure. In inflammation, vascular permeability increases, leading to a redistribution of albumin between intravascular and extravascular spaces, causing hypoalbuminemia. Hypoalbuminemia is associated with poor prognosis and higher mortality in many critical conditions.[12,13]

During inflammation, CRP and other acute-phase proteins rise while albumin levels typically decrease. Studies have demonstrated that the CAR is more sensitive than either parameter alone in predicting systemic inflammatory status.[14]

A study on Guillain-Barré syndrome (GBS) patients reported that those with high CRP and low albumin levels at initial hospital admission had a poor prognosis.[15] Similarly, high CAR levels were associated with poor prognosis and high mortality in Parkinson's patients.[16] However, no studies have examined the prognostic or clinical relevance of CAR levels in MG patients.

Clinicians continue to seek reliable biomarkers to aid in diagnosis and predict prognosis and mortality in MG patients. Therefore, we aimed to investigate CAR in MG patients, given its success in reflecting inflammatory states in clinical practice.

METHODS

Patients

This study was approved by the Sakarya University Faculty of Medicine Ethics Committee (Date: 22.06.2019, Decision No: 71522473/050.01.04). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. Data from 66 patients, aged 18-80, diagnosed with generalized MG and followed in the neuromuscular outpatient clinic were included. For the control group, leftover blood samples from hypertension patients without comorbidities, who attended the family medicine outpatient clinic for medication report renewals, were used. These patients had routine blood tests as part of their visit.

Patients were excluded if they were receiving steroid or immunosuppressant therapy or if they had malignancies or chronic diseases (hematological, renal, or hepatic). Acute inflammation, infection, dehydration, and cachexia conditions that could alter CRP and albumin levels were exclusion criteria for both the patient and control groups. Written informed consent was obtained from all participants included in the study.

Clinical Evaluation

Our study is retrospective. Patients' demographic and medical history data were recorded from the patients' files, including information on their treatments. CAR values were calculated by assessing albumin and CRP levels in blood samples collected within 24 hours of admission. CRP and albumin levels were measured using an automated analyzer system.

The clinical severity of MG patients was assessed immediately after admission using the MG activities of daily living (MG-ADL) scale, which measures MG symptoms and functional status. The MG-ADL stages of the patients were calculated from the neurological examinations performed in the first 24 hours of hospital admission and other information in the file. In MG-ADL staging, patients' findings such as speaking, chewing, swallowing, breathing, brushing hair and teeth, getting up from the chair, double vision, and droopy eyelids are scored and the total score is obtained. The total score ranges from 0 (normal) to 24 (the most severe). The MG-ADL is quick to administer and frequently used in both clinical practice and research.[17]

CAR levels were compared between the control group and MG patients to evaluate its utility in disease identification. The relationship between CAR levels and MG-ADL scores was examined to assess disease severity. CAR levels were also compared between patients with and without mortality to evaluate the relationship between CAR and mortality.

Statistical Analysis

The statistical analyses were performed using SPSS version 21 software. The suitability of the variables to normal distribution was examined according to the ±2 skewness coefficient. The independent effects of different variables on the MG-ADL variable were examined using a multivariate linear regression model. Model fit was examined using the required residual and fit statistics, cases where the p value was less than 0.05 were considered statistically significant. Descriptive statistics were presented as mean, standard deviation, minimum, and maximum values for normally distributed variables and as the median and interquartile range (with frequency tables for categorical variables) for non-normally distributed variables. The frequencies of categorical variables by group were shown in cross tables. Differences in frequencies between groups were determined using the Pearson chi-squared test. Group comparisons for normally distributed variables were performed using the student's T test, while the Mann-Whitney U test was used for non-normally distributed variables. Pearson correlation was used to examine relationships between normally distributed variables, and Spearman correlation was used when at least one variable was not normally distributed. A p-value <0.05 was considered statistically significant.

RESULTS

The study included 66 patients (35 males and 31 females) and 51 controls (27 males and 24 females). Age and sex distribution between the patient and control groups were similar (p=0.425 and 0.992, respectively) (**Table 1**). CRP and CAR levels in the patient group were significantly higher than in the control group. The difference in mean albumin values between the patient and control groups was not statistically significant (**Table 2**).

The distribution of CRP, albumin, and CAR levels by sex was analyzed in both groups, and no significant differences were observed between males and females (**Table 3**).

Table 1. Comparison of patient and control groups according to age and gender

		n	Mean	SD	Min	Max	Median	IR	z	p
Age	Patient	66	59.35	14.51	22	84	62.5	17.5	-0.797	0.425
	Control	51	58.86	10.15	39	78	59	15		
		n	**Male**	**Female**					**Chi-squared**	**p**
Gender	Patient	66	35	31					0.000	0.992
	Control	51	27	24						

z: Mann-Whitney U test, pearson Chi-square, SD: Standard deviation, Min: Minimum, Max: Maximum, IR: Interquartile range

Table 2. CRP, albumin, and CAR levels in the patient and control groups

		n	Mean	SD	Min	Max	Median	IR	z	p
CRP	Patient	66	17.08	28.54	1.70	134.00	5.23	8,87	-3.025	0.002
	Control	51	5.73	7.21	0.60	42.20	3.90	4.70		
Albumin	Patient	66	38.80	5.34	20.00	47.50	39.75	4.10	-1.426	0.154
	Control	51	40.44	1.89	37.00	44.00	40.00	3.00		
CAR	Patient	66	0.55	1.11	0.04	6.70	0.13	0.22	-3.001	0.003
	Control	51	0.14	0.18	0.02	1.06	0.10	0.11		

Mann-Whitney U test, CRP: C-reactive protein, CAR: C-reactive protein/albumin ratio, SD: Standard deviation, Min: Minimum, Max: Maximum, IR: Interquartile range

Table 3. CRP, albumin, and CAR levels by gender in the patient and control groups

			n	Mean	SD	Min	Max	Median	IR	z	p
Patient	CRP	Male	35	16.59	32.58	2.00	134.00	4.46	6.49	-0.694	0.487
		Female	31	17.63	23.70	1.70	79.70	6.88	14.78		
	Albumin	Male	35	38.66	5.66	20.00	47.50	39.40	4.40	-0.475	0.634
		Female	31	38.97	5.05	23.40	45.30	39.80	3.00		
	CAR	Male	35	0.57	1.34	0.05	6.70	0.10	0.19	-0.803	0.422
		Female	31	0.52	0.79	0.04	2.98	0.17	0.40		
Control	CRP	Male	27	6.31	9.43	0.60	42.20	3.90	4.30	-0.623	0.533
		Female	24	5.07	3.41	0.80	11.00	4.10	6.23		
	Albumin	Male	27	40.69	1.92	37.00	44.00	40.00	3.00	-0.869	0.385
		Female	24	40.17	1.86	37.00	44.00	40.00	3.80		
	CAR	Male	27	0.16	0.24	0.02	1.06	0.09	0.11	-0.538	0.591
		Female	24	0.13	0.09	0.02	0.26	0.10	0.17		

CRP: C-reactive protein, CAR: C-reactive protein/albumin ratio, SD: Standard deviation, Min: Minimum, Max: Maximum, IR: Interquartile range

There was a positive, moderate, statistically significant relationship between the MG-ADL stage and CRP and CAR levels in the patient group. As the MG-ADL stage increased, CRP and CAR levels also increased. A negative, low-level, statistically significant relationship was observed between the MG-ADL stage and albumin levels. As the MG-ADL stage increased, albumin levels decreased (Table 4).

The model created by regression analysis is a statistically significant model. (ANOVA F value=12.080, p=0.004). Accordingly, the relationship between Mg ADL and the CAR variable is statistically significant. According to the analysis result, a 1 unit increase in CAR causes a 6.672-unit increase in the MG ADL variable. Age and gender have no effect on the MG ADL score (Table 5).

Table 4. Correlation between MG-ADL score and CRP, albumin and CAR levels in patients

	n	r	p
MG-ADL score & CRP	66	0.526	0.000
MG-ADL score & albumin	66	-0.361	0.003
MG-ADL score & CAR	66	0.525	0.000

Spearman correlation test, MG-ADL: Myasthenia gravis activities of daily living, CRP: C-reactive protein, CAR: C-reactive protein/albumin ratio

Table 5. Linear regression analysis of factors affecting MG-ADL score

	B	SE	95% CI	r	r^2	DW	t	p
Gender (male)	-0.205	0.756	-1.717-1.307				-0.271	0.787
Age	-0.041	0.028	-0.097-0.014	0.607	0.369	1.584	-1.490	0.141
CAR	6.672	1.381	3.5-12.73				1.894	0.000

MG-ADL: Myasthenia gravis activities of daily living, SE: Standard error, CI: Confidence interval, r: Correlation coefficient, r^2: Coefficient of determination, DW: Durbin Watson

In the patient group, the mean CRP and CAR levels of deceased patients were higher than those of surviving patients, with statistically significant differences between them. The mean albumin level of deceased patients was lower than that of surviving patients, and this difference was also statistically significant (Table 6).

Eleven of the 66 MG patients had additional autoimmune diseases. Of these, eight had autoimmune thyroid disease, one had sarcoidosis, one had autoimmune thyroid disease, vitiligo, and rheumatoid arthritis, and one had autoimmune thyroid disease with IgA nephropathy. MG patients with and without other autoimmune diseases were compared in terms of CRP, albumin, and CAR levels, and no significant differences were detected between the two groups (p=0.339, 0.636, 0.385, respectively) (Table 7).

DISCUSSION

In our study, CRP and CAR levels, considered indicators of acute inflammation, were elevated in the MG patient group. Few studies in the literature have evaluated the relationship between clinical worsening and routine laboratory tests in MG patients, possibly owing to the variable nature of the disease.[18] Most of the MG patients in our study presented to the outpatient clinic with symptoms that fluctuated throughout the day, significantly affecting their daily activities. It is known that infections and certain medications used for infection control can exacerbate MG symptoms.[19] Additionally, infectious agents are thought to trigger autoimmune diseases.[20] The elevation of CRP and CAR levels in these patients may reflect acute inflammation contributing to clinical worsening. These inflammatory markers could help identify patients who may require intensive care or more frequent follow-up. Another parameter we examined was albumin, given its relevance to the inflammatory pathogenesis of MG. No difference in albumin levels was observed between the patient and control groups at admission. However, studies suggest that albumin may be valuable for assessing clinical severity and prognosis in MG patients.[21,22] Given its correlation with disease severity, the tendency for albumin levels to decrease as MG-ADL scores increase highlights its potential as a prognostic biomarker rather than a diagnostic one.

Although CRP, albumin, and CAR levels were all found to be related to disease prognosis, CRP and CAR showed a stronger correlation with disease severity. CAR appears to be more valuable for assessing disease severity than albumin alone. Similarly, all three parameters were significantly associated with mortality. The relationship between CRP and CAR with mortality was stronger than that between albumin and mortality. As with disease severity, CAR is a more valuable biomarker for mortality than albumin alone.

Low levels of albumin may increase susceptibility to infections.[23] Albumin levels can also be affected by factors such as steroid use and nutritional status.[24,25] Therefore, albumin alone may not be a sufficient biomarker in MG. In this context, we suggest that new markers are needed to better predict disease severity. When CRP and albumin levels are influenced independently, the CAR ratio, which combines these two parameters, may provide stronger data.

The relationship between MG, an autoimmune disease, and other autoimmune conditions, along with its clinical implications, has been previously studied. Accompanying autoimmune diseases are one of the factors that complicate the management of MG and may worsen its prognosis.[26,27] According to the literature, the prevalence of additional autoimmune diseases in MG patients ranges from 13-22%.[26] In our study, 11 patients had additional autoimmune diseases, accounting for 16%, which is consistent with the literature. No significant differences were found in CRP, albumin, or CAR levels, which are potential indicators of poor prognosis,

Table 6. Average CRP, albumin, and CAR levels of deceased and surviving patients

		n	Mean	SD	Min	Max	Median	IR	Test value	p
CRP	Alive	54	11.19	20.47	1.70	108	4.04	6.51	-3.819	0.000
	Dead	12	43.56	43.13	3.90	134	32.69	59.1		
Albumin	Alive	54	40.16	3.71	28.90	47.5	40.25	3.4	3.460	0.005*
	Dead	12	32.70	7.26	20.00	40.2	35.00	14.2		
CAR	Alive	54	0.30	0.62	0.04	3.737	0.10	0.168	-3.874	0.000
	Dead	12	1.66	1.95	0.10	6.7	0.96	2.649		

Test value: *Student's T test, Mann-Whitney U test, CRP: C-reactive protein, CAR: C-reactive protein/albumin ratio, SD: Standard deviation, Min: Minimum, Max: Maximum, IR: Interquartile range

Table 7. CRP, albumin, and CAR levels of MG patients with and without other autoimmune diseases

		n	mean	SD	Min	Max	Median	IR	z	p
CRP	MG	55	17.26	30.11	1.70	134.00	5.10	7.80	-0.956	0.339
	MG+AD	11	16.12	20.02	2.10	63.10	7.60	14.60		
Albumin	MG	55	38.80	5.31	20.00	47.50	39.70	4.10	-0.473	0.636
	MG+AD	11	38.84	5.80	24.40	45.10	40.90	4.20		
CAR	MG	55	0.56	1.17	0.04	6.70	0.12	0.21	-0.869	0.385
	MG+AD	11	0.49	0.76	0.05	2.59	0.20	0.38		

CRP: C-reactive protein, CAR: C-reactive protein/albumin ratio, MG: Myasthenia gravis, AD: Autoimmune disease, SD: Standard deviation, Min: Minimum, Max: Maximum, IR: Interquartile range

in patients with additional autoimmune diseases. Factors such as whether the other autoimmune diseases were in an acute exacerbation period at admission and the small number of patients with multiple autoimmune diseases may have influenced these results.

Limitations

The limitations of our study include the small sample size, its single-center study design, and the evaluation of only blood samples and MG-ADL scores at first admission. We believe that future studies incorporating long-term treatment follow-up, along with the evaluation of new biomarkers, will advance treatment strategies for MG.

CONCLUSION

We found that CAR may be a more powerful biomarker than albumin alone for disease diagnosis, monitoring severity, and predicting mortality.

Biomarkers that are easy to use, accessible, and cost-effective will aid clinicians in MG diagnosis, monitoring disease progression, assessing treatment response, and providing closer follow-up for patients at high risk of mortality. We believe that our study will also shed light on other neuromuscular diseases, particularly MG, which involve inflammatory mechanisms in their pathophysiology.

Although a clearer understanding of the disease's pathophysiology has shifted the research focus, MG remains a prognostically challenging condition and one of the leading neuromuscular emergencies. In cases where managing MG is difficult, close observation is essential. For this reason, we selected patients from the MG group who required hospitalization for symptom monitoring. Some MG patients are resistant to treatment, while others experience frequent exacerbations, including bulbar crises. Predicting critical periods and achieving clinical recovery in these patients remains a challenge for clinicians. Therefore, our study on inflammatory biomarkers is valuable in guiding future research and enhancing efforts toward the development of prognostic biomarkers.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was approved by the the Sakarya University Faculty of Medicine Ethics Committee (Date: 22.06.2019, Decision No: 71522473/050.01.04).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer- reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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