

Prognostic Value of the Mini Nutritional Assessment, Key Biomarkers, and Body Mass Index for Mortality in Acute Ischemic Stroke

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Objective: The predictive values of the Mini Nutritional Assessment (MNA), along with those of albumin, prealbumin, blood glucose, and body mass index (BMI), for prognosis and mortality in patients with acute ischemic stroke (AIS) are not known. The study aimed to evaluate the association of the MNA score, albumin, prealbumin, blood glucose, and BMI with prognosis and mortality in patients with AIS.

Methods: 250 patients diagnosed with AIS and admitted to the emergency department of a tertiary hospital from February 15, 2022, through February 15, 2023 were analysed. The study used hospital records and collected demographic data, as well as albumin, prealbumin, and blood glucose levels. The MNA was used.

Results: The mean age of the patients was 70.10 ± 11.28 years; 128 (51.2%) were male, and the mean BMI was 28.20 ± 4.47 . The MNA showed 105 (42%) patients at risk of malnutrition and 11 (4.4%) malnourished. There were 21 (8.4%) deaths among patients with AIS. Pearson correlation analysis showed MNA total score significantly positively correlated with BMI ($P < .001$), albumin ($P < .001$), and prealbumin ($P < .001$). Univariate binary logistic regression analysis showed that older age was associated with increased risk of death ($P = .003$), whereas higher BMI and higher albumin and prealbumin levels were associated with decreased risk of death. Multivariate binary logistic regression analysis showed that higher MNA scores were significantly associated with decreased risk of death ($P < .001$).

Conclusion: High MNA scores and albumin and prealbumin levels may predict reduced mortality in AIS patients.

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Key words: Acute ischemic stroke, Albumin, Body mass index, Malnutrition, Prealbumin

Stroke is a major cause of long term disability in developed countries and a leading cause of death worldwide (1). Evaluating nutritional status and implementing early plans nutritional plans are crucial components of stroke care, with several recent studies linking malnutrition at admission to adverse clinical outcomes, including prolonged hospital stay, poorer functional recovery, and increased mortality (2-4). A systematic review of clinical practice guidelines highlights the importance of early nutritional screening in acute stroke, ideally within the first 24 hours of hospital admission, to identify high risk patients and guide interventions (5).

Low serum protein and albumin levels have been proposed as markers of malnutrition and are associated with impaired functional status and adverse outcomes in ischemic stroke (6). Furthermore, high serum prealbumin levels at hospital admission have been shown in large prospective cohorts to be independently associated with lower risks of mortality and adverse functional outcomes in AIS patients (7). In the present study, serum albumin and prealbumin levels were obtained at hospital admission prior to therapeutic or nutritional interventions to better reflect baseline nutritional and inflammatory status and to minimize the confounding effects of acute metabolic changes.

Recent evidence from meta analyses and large observational cohorts confirms that malnutrition, assessed with objective indices such as the Controlling Nutritional Status score, Geriatric

Nutritional Risk Index, and Prognostic Nutritional Index, is strongly associated with higher mortality and poorer recovery after AIS (8-10).

MNA is a validated and widely used tool for assessing nutritional status in adult populations, demonstrating good diagnostic performance with acceptable sensitivity and specificity in diverse clinical and community settings (11). Although other screening tools are also used in stroke care, the MNA offers a comprehensive evaluation of dietary, anthropometric, and functional parameters.

Our study aimed to evaluate the relationship of the MNA score with albumin, prealbumin, and blood glucose levels and with BMI in predicting prognosis and mortality in AIS. Furthermore, to provide a more complete assessment of nutritional vulnerability in patients with AIS, it aimed to evaluate MNA, biochemical markers, and BMI, together.

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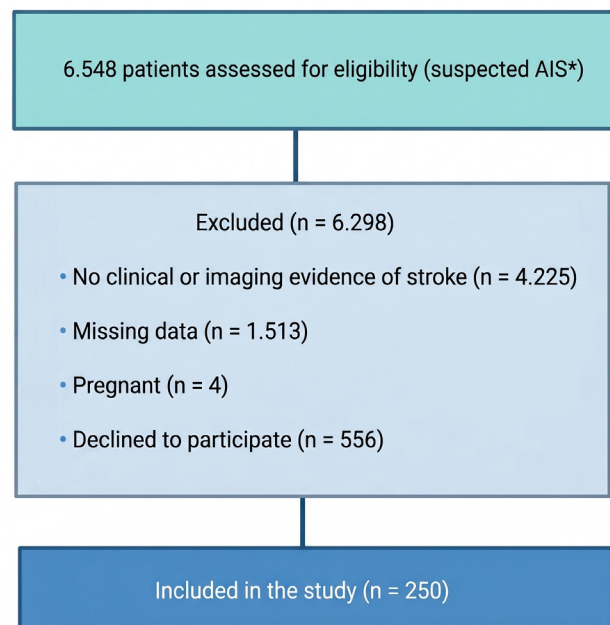
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Methods

The study involved 6,548 individuals aged 18 years or older, who were admitted to the Emergency Department of the Bursa High Specialization Training and Research Hospital from February 15, 2022, through February 15, 2023. These patients, comprising both males and females, were prospectively evaluated according to AIS inclusion criteria. Prior to the initiation of the study, all the potential participants or their legally authorized representatives provided informed consent, and 250 volunteers were ultimately included. Ethical approval was secured from the hospital ethics committee (2011-KAEK-25 2022/01-24). Individuals diagnosed with AIS who had clinical or imaging evidence of stroke, complete clinical and laboratory data, and who consented to participate were included in the study. Excluded from the study were 4,225 individuals who had no clinical or imaging evidence of stroke, 1,513 who were missing data, 4 who were pregnant, and 556 who declined to participate (Figure 1).

Serum albumin and prealbumin (the latter having a shorter half-life of approximately 2 days) were included to provide insight into short-term protein–energy status and acute nutritional changes at presentation. All biochemical measurements were obtained upon admission to the emergency department, in the early acute phase of stroke. These measurements were part of the routine biochemical evaluation performed at presentation and were used for analysis. Patients or their legally authorized representatives were contacted by phone, or their medical records were reviewed 3 later months discharge to assess mortality.

Figure 1. Flow diagram of patient screening, exclusions, and final inclusion.



*AIS: Acute isstroke

Because the prospective study was focused primarily on nutritional assessment, detailed data regarding smoking status and comorbid conditions (e.g., hypertension, diabetes mellitus, coronary artery disease, and atrial fibrillation) were not collected for inclusion in the regression analyses.

Assessment tools included the case-report form and the MNA. In this study, the full version of the MNA (maximum score: 30 points) was administered. The MNA consists of a 6-item screening section (maximum 14 points) that assesses appetite loss, weight loss, mobility, psychological stress or acute illness, neuropsychological problems, and BMI. This was followed by an extended assessment that evaluated dietary intake, protein consumption, fruit and vegetable intake, fluid intake, medication use, the presence of pressure sores, self-perceived health and nutritional status, arm and calf circumference, and functional independence.

Although the MNA was originally developed and validated primarily for adults aged 65 years and older, it has been widely used in clinical practice to assess nutritional risk in hospitalized adults, including those younger than 65. In the present study, adult patients (≥ 18 years) diagnosed with AIS were evaluated using the MNA at the time of admission to the emergency department, in the early post-stroke phase. The MNA was selected because it provides a comprehensive assessment of dietary, anthropometric, and functional parameters, enabling a multidimensional evaluation of nutritional status, even in younger adults.

While instruments such as the Malnutrition Universal Screening Tool (MUST) are considered particularly effective for very early post-stroke screening, the MNA provides a more detailed evaluation that is appropriate for patients beyond the immediate hyperacute phase. Thus, in the context of our cohort, the MNA score was considered a suitable measure for capturing nutritional risk during the early acute stage of hospitalization, prior to significant nutritional interventions.

Statistical analysis

The demographic and clinical characteristics of the cases were analyzed using descriptive statistics, including frequencies, percentages, means, standard deviations, and other statistical measures. Proportional data between groups were compared using the chi-square test. Mean demographic and clinical characteristics were compared across sex and age groups using 1-way analysis of variance (ANOVA) and independent-sample tests. Receiver operating characteristic (ROC) analysis determined the optimal cut-off scores for measurements related to mortality risk. Variables significantly associated with increased mortality risk were further evaluated through univariate and multivariate binary logistic regression analyses. Significance was deemed to be evaluated at the level of $P < .05$. Data normality was assessed as kurtosis and skewness within a range of ± 1.5 . All analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp, Armonk, NY, USA).

Results

The mean age of the participants in this study was 70.10 ± 11.28 years (range, 41.00–97.00 years), and the mean BMI was 28.20 ± 4.47 (range, 18.67–53.42). Of the participants, 128 (51.2%)

were male. Fifty participants (19.5%) had a BMI of 18.5–24.9, 123 (47.9%) had a BMI of 25–29.9, 59 (23.6%) had a BMI of 30–34.9, 16 (6.4%) had a BMI of 35–39.9, and 2 (0.8%) had a BMI ≥ 40 (Table 1).

Table 1. Characteristics of the study population

Variable	Category	Value
Age, mean $\pm$ SD (range), y		70.10 $\pm$ 11.28 (41.00–97.00)
Sex	Male	128 (51.2)
	Female	122 (48.8)
BMI*, mean $\pm$ SD (range) kg/m ²		28.20 $\pm$ 4.47 (18.67–53.42)
	<18.5	0 (0)
	18.5–24.9	50 (19.5)
	25.0–29.9	123 (47.9)
BMI range		
	30.0–34.9	59 (23.6)
	35.0–39.9	16 (6.4)
	≥ 40.0	2 (0.8)

Data are presented as mean $\pm$ SD (range) or number (%).

*BMI: body mass index

One-way ANOVA revealed significant differences across age groups in the mean MNA screening score ($P < .001$), MNA evaluation score ($P < .001$), total MNA score ($P < .001$), albumin levels ($P = .027$), and prealbumin levels ($P < .001$). Participants aged 65–79 years had a significantly higher MNA screening score than those aged ≥ 80 years did ($P < .005$). Additionally, the MNA evaluation score was significantly higher in participants aged <65 years than in those aged 65–79 years ($P < .005$), and the score was higher in those aged 65–79 years than in those aged ≥ 80 years ($P < .005$). Similarly, the MNA total score was significantly higher in participants aged 65–79 years than in those aged ≥ 80 years ($P < .005$).

Mean albumin levels were significantly higher in participants aged <65 years than in those aged ≥ 80 years ($P < .005$). Similarly, mean prealbumin levels were significantly higher in participants aged <65 years than in those aged 65–79 years and those aged ≥ 80 years ($P < .005$, Table 2).

Although albumin and prealbumin were measured only at admission, it should be noted that these values primarily reflect acute nutritional and inflammatory status. Chronic malnutrition, which may be more accurately captured after 2 weeks of sustained low protein intake, could not be assessed longitudinally in this cohort. Thus, albumin dynamics over time were not evaluated, and admission levels were used as early prognostic indicators.

ROC analysis demonstrated area under the curve (AUC) values below 0.5 for MNA, albumin, and prealbumin. Higher values for these predictors may be associated with lower mortality rates, but this situation is reversible. When the direction was adjusted, the effective AUC values were 0.872 for MNA, 0.717 for albumin, and 0.769 for prealbumin, indicating good discriminatory performance (Figure 2).

A higher BMI (OR = 0.830, $P = .003$, 95% CI: 0.734–0.939) and higher MNA scores (OR = 0.697, $P < .001$, 95% CI: 0.608–0.799) were each associated with a significant reduction in mortality risk. Similarly, higher albumin (OR = 0.853, $P < .001$, 95% CI: 0.790–0.921) and prealbumin levels (OR = 0.853, $P < .001$, 95% CI: 0.790–0.921) were also associated with a significant reduction in mortality risk.

In the multivariate binary logistic regression analysis, only higher MNA scores remained an independent predictor of reduced mortality risk (OR = 0.697, $P < .001$, 95% CI: 0.608–0.799) (Table 3).

Discussion

The aim of this study was to explore the relationship between the MNA score and various nutritional indicators, including albumin, prealbumin, and glucose levels, as well as BMI, and to examine how these factors influence clinical outcomes in patients with AIS. We assessed the impact of age, sex, and nutritional status on these outcomes and examined whether malnutrition and MNA score can predict prognosis and mortality in AIS, interpreting these findings in the context of existing literature. Our findings indicate that the

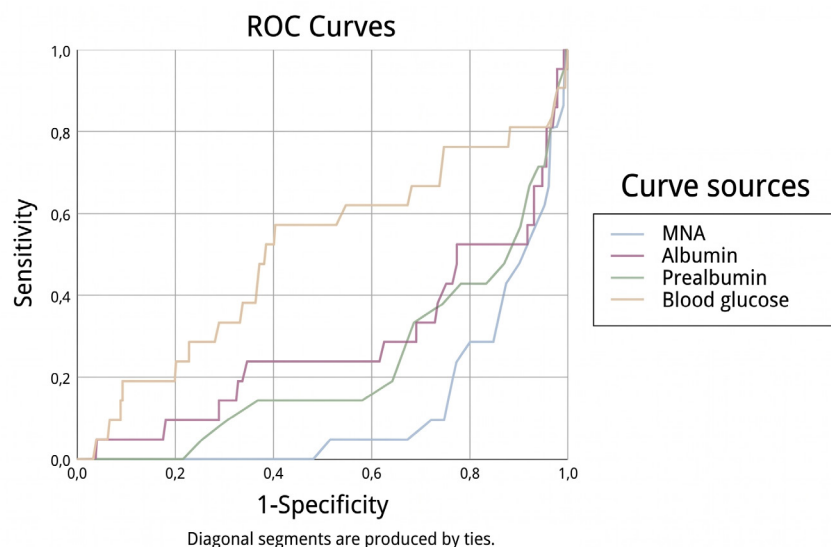
Table 2. Comparison of clinical and nutritional parameters according to age group

Variable	<65 years (I)	65–79 years (II)	≥ 80 years (III)	P value
BMI (kg/m ²) ^a	28.44 $\pm$ 4.92	27.86 $\pm$ 4.19	28.66 $\pm$ 4.42	.487
MNA Screening Score ^b	13.25 $\pm$ 1.61	12.94 $\pm$ 1.62	11.98 $\pm$ 2.00	<.001
MNA Assessment Score ^b	11.46 $\pm$ 1.90	10.38 $\pm$ 1.86	9.42 $\pm$ 1.82	<.001
MNA Total Score ^b	24.71 $\pm$ 3.22	23.31 $\pm$ 3.18	21.40 $\pm$ 3.48	<.001
Albumin (g/L)	38.44 $\pm$ 5.43	37.47 $\pm$ 5.56	35.73 $\pm$ 5.58	.027
Prealbumin (mg/dL)	20.10 $\pm$ 6.73	17.60 $\pm$ 6.17	15.20 $\pm$ 6.13	<.001
Blood glucose (mg/dL)	154.56 $\pm$ 74.20	145.70 $\pm$ 74.39	146.60 $\pm$ 59.44	.676
MNA category				<.001
Normal	58 (73.4%)	62 (51.2%)	14 (28.0%)	
At risk of malnutrition	18 (22.8%)	55 (45.5%)	32 (64.0%)	
Malnourished	3 (3.8%)	4 (3.3%)	4 (8.0%)	
BMI category				.690
18.5–24.9	17 (21.5%)	25 (20.7%)	8 (16.0%)	
25.0–29.9	36 (45.6%)	60 (49.6%)	27 (54.0%)	
30.0–34.9	21 (26.6%)	29 (24.0%)	9 (18.0%)	
35.0–39.9	4 (5.1%)	6 (5.0%)	6 (12.0%)	
≥ 40.0	1 (1.3%)	1 (0.8%)	0 (0.0%)	

^aBody mass index; ^bMNA: Mini Nutritional Assessment; score ranges – screening 0–14, assessment 0–16, total 0–30; higher scores indicate better nutritional status

Continuous variables are presented as mean $\pm$ SD and compared using ANOVA or Kruskal–Wallis test. Categorical variables are expressed as n (%) and compared using the chi-square test.

Figure 2. Receiver operating characteristic curves for albumin, prealbumin, blood glucose, and MNA score for the prediction of mortality



ROC curves illustrating the predictive performance of these markers for mortality in patients with acute ischemic stroke. MNA: Mini Nutritional Assessment

MNA score is a significant predictor of mortality when assessed at the time of emergency department admission, during the early acute phase of stroke. Poor nutrition in AIS patients can lead to prolonged hospitalization and an unfavorable prognosis. Appropriate nutritional assessment in clinical management can both improve clinical outcomes and potentially expedite hospital discharge.

Age had a notable impact on nutritional status and clinical outcomes. Patients aged <65 years exhibited significantly higher MNA scores and albumin and prealbumin levels compared to those aged 65–79 years and ≥80 years. This finding aligns with prior research indicating that malnutrition risk increases with age and adversely affects mortality (12, 13). One previous study demonstrated a strong correlation between malnutrition and increased mortality in older adults (4). Another emphasized the benefits of regular monitoring of nutritional status (14) which has been shown to improve stroke outcomes.

Although some recent studies, including a 2024 review by Mancin et al., indicate that screening tools such as the MUST may demonstrate higher sensitivity than other screening for the early assessment of nutritional status at hospital admission in patients with acute stroke (5).

Regarding the impact of sex on nutritional status, our analysis revealed a significant difference in BMI between male and female patients, with males having a lower mean BMI than females. This finding suggests that a higher BMI in women may mask underlying

malnutrition. The observed decrease in prealbumin levels among female patients suggests a protein-deficient diet. This finding highlights that women with AIS may be malnourished despite having a high BMI and underscores the importance of a nuanced approach to nutritional assessment in these patients.

Body mass index has limitations as an indicator of nutritional status, particularly in patients with AIS. It does not account for changes in body composition related to age, sarcopenia, or acute inflammation following stroke. Muscle mass loss and fluid shifts may alter BMI without reflecting actual nutritional risk. In contrast, the MNA incorporates dietary, functional, and anthropometric parameters, providing a more reliable early marker of malnutrition and prognosis than BMI alone. Therefore, the MNA may be more informative than BMI when assessing nutritional vulnerability in AIS patients.

In a previous study, 73.7% of overweight and 74% of obese patients were classified as malnourished (15). Furthermore,

other studies have demonstrated that is significantly associated with an unfavorable prognosis following a stroke, regardless of the screening or assessment tools used to define it (3, 9). Higher BMI in women was associated with an increased risk of AIS, but a decreased risk of hemorrhagic stroke (16). Additionally, some studies have indicated that male patients tend to experience more unfavorable outcomes following a stroke (17, 18). Being male may also be associated with increased mortality after a stroke (19).

Our study did not identify a significant correlation between sex and MNA scores, albumin levels, or prealbumin levels. However, the MNA score was identified as a significant predictor of mortality. Increases in BMI, MNA score, albumin levels, or prealbumin levels were found to significantly reduce mortality risk. Low albumin and prealbumin levels have been linked to elevated mortality risk

Table 3. Variables affecting mortality risk

Variable	Univariate OR ^a (95% CI) ^b	P value	Multivariate OR ^a (95% CI)	P value
Age	1.074 (1.024–1.126)	.003	1.057 (0.998–1.120)	.059
Male sex	0.855 (0.350–2.092)	.732	2.094 (0.661–6.631)	.209
BMI ^c	0.830 (0.734–0.939)	.003	0.940 (0.822–1.076)	.371
MNA ^d	0.697 (0.608–0.799)	<.001	0.733 (0.610–0.881)	.001
Albumin	0.875 (0.813–0.941)	<.001	1.050 (0.913–1.207)	.496
Prealbumin	0.853 (0.790–0.921)	<.001	0.915 (0.781–1.072)	.271
Blood glucose	1.000 (0.994–1.006)	.991	0.999 (0.991–1.007)	.843

^aOR: odds ratio; ^bCI: confidence interval; ^cBMI: body mass index; ^dMNA: Mini Nutritional Assessment
Variables with P < .05 in univariate analysis were included in the multivariate model.

in numerous studies. These findings highlight nutritional status as a robust predictor of survival in stroke patients (6, 7, 20). For example, low serum prealbumin levels were reported to increase infection risk after stroke and were associated with higher mortality rates (21). Additionally, low serum albumin levels have been shown to predict early mortality and adverse cardiovascular events in AIS patients (22).

Although the MNA score and albumin and prealbumin levels were associated with mortality, in our study, these markers alone may be insufficient as standalone predictors. However, more comprehensive insights can be gained when these measures are assessed alongside other clinical indicators. A similar conclusion was reported in a previous study, which found that assessing nutritional status based solely on biochemical indicators is insufficient (23).

Our findings underscore the necessity of routine nutritional status monitoring in patients with AIS. In particular, the early detection of malnutrition and the implementation of appropriate nutritional interventions may play an important role in improving outcomes in elderly patients. Importantly, indicators such as the MNA score or albumin or prealbumin levels, which were used in this study, may be insufficient when used alone. Evaluations should also include inflammatory markers and other nutritional indicators (24, 25).

We therefore suggest a 3-domain model incorporating MNA, biochemical markers such as albumin, and stroke severity indicators. This integrative framework may enhance risk stratification and provide a more comprehensive evaluation of nutritional vulnerability in AIS patients. An increase in MNA score, albumin levels, or prealbumin levels was associated with a reduction in mortality risk, supporting the use of the MNA score in the early acute phase as a multidimensional nutritional indicator.

The MNA is valid and practical, but relying solely on anthropometric and functional parameters may not fully reflect the characteristic metabolic and inflammatory changes of AIS. In addition to assessing stroke severity and functional status, the MNA can be combined with biochemical markers commonly used to evaluate protein–energy status, such as serum albumin and prealbumin.

Limitations

This study has several limitations. The patient population was drawn from a single hospital, which may limit generalizability. Nutritional assessment relied on the MNA score and biochemical markers (albumin, prealbumin), without the inclusion of other potential indicators such as inflammatory markers. Smoking and comorbid conditions were not systematically accounted for, so residual confounding cannot be excluded. Finally, the MNA has been validated primarily in adults aged ≥ 65 years, limiting its psychometric validation in younger patients. Future studies should include larger, more diverse cohorts and incorporate a broader range of nutritional and clinical markers.

Conclusion

This study emphasizes the critical role of nutritional status in influencing prognosis and mortality in patients with AIS. The

observed associations among age, sex, and biochemical markers, including albumin and prealbumin levels, underscore their utility in predicting clinical outcomes. Our findings suggest that the MNA score, when combined with biochemical markers and functional indicators, can serve as a reliable tool for early risk stratification in AIS patients.

However, it is important to recognize that the combination of the MNA score, biochemical markers, and functional indicators may not capture the full spectrum of nutritional vulnerability. Additional markers and measures of functional status or stroke severity should be included to provide a more comprehensive assessment of nutritional risk and prognosis.

Regarding BMI, it is important to note that a high BMI tends to indicate suboptimal nutritional status. In the context of AIS, patients may have elevated BMI due to increased fat mass while simultaneously experiencing protein–energy malnutrition or functional impairment. Therefore, BMI should not be interpreted in isolation but rather in conjunction with other nutritional and clinical indicators.

Future studies should explore nutritional status in larger populations, incorporate a wider array of biochemical and functional markers, and validate multidimensional assessment models to deepen our understanding of the interplay between nutrition and stroke outcomes.

Resumen

Objetivo: En el ictus isquémico agudo (IIA), se desconocen los valores predictivos de la albúmina, la prealbúmina, la glucosa en sangre, el índice de masa corporal (IMC) y la Mini Evaluación Nutricional (MEN) para el pronóstico y la mortalidad. Evaluar la eficacia de la MEN al comparar la albúmina, la prealbúmina, la glucemia y el IMC en el pronóstico y la mortalidad del IIA. **Método:** Se analizaron 250 pacientes. Se recopilieron datos demográficos, así como los niveles de albúmina, prealbúmina y glucemia. Se utilizó la escala MEN. **Resultados:** La edad media fue de 70.10 ± 11.28 años; 128 (51.2%) eran varones y el IMC medio fue de 28.20 ± 4.47 . La MEN indicó que 105 (42%) pacientes presentaban riesgo de desnutrición y 11 (4.4%) pacientes presentaban desnutrición. Se produjeron 21 (8.4%) fallecimientos en casos de IIA. El análisis de correlación de Pearson mostró una correlación positiva entre la puntuación total de MEN y el IMC ($P < .001$), la albúmina ($P < .001$) y la prealbúmina ($P < .001$). La regresión logística binaria univariante mostró que la edad avanzada aumentaba el riesgo de muerte ($P = .003$), mientras que un IMC albúmina y prealbúmina elevados relación. La regresión logística binaria multivariante mostró que unos niveles elevados de MEN relación significativamente el riesgo de muerte. ($P < .001$). **Conclusión:** Valores altos MEN, albúmina y prealbúmina podrían estar asociados con una menor mortalidad en pacientes con IIA.

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