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Evaluating Serum Calcium and Albumin as Prognostic Biomarkers in Acute Ischemic Stroke Outcomes: A Cross-Sectional Study at Mandya Institute of Medical Sciences

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A B S T R A C T

Background: Acute ischemic stroke (AIS) remains a leading cause of morbidity and mortality worldwide. Rapid and accurate prognostic assessment can significantly influence management and outcomes. Serum albumin and calcium are accessible biomarkers that could provide prognostic information on stroke severity and recovery.*Methods*: This cross-sectional study included 120 patients admitted with AIS at the Mandya Institute of Medical Sciences. Serum levels of albumin and calcium were measured upon admission and correlated with the National Institutes of Health Stroke Scale (NIHSS) scores and Barthel Index for assessing neurological severity and functional outcomes.*Results*: Lower serum levels of albumin and calcium were significantly associated with higher NIHSS scores at admission ($p < 0.01$ and $p < 0.05$, respectively). Patients with severe strokes had mean albumin levels of 3.2 g/dL and mean calcium levels of 7.3 mg/dL. Moreover, recovery, as indicated by improvements in NIHSS scores, showed a significant positive correlation with higher levels of albumin (correlation coefficient = 0.62, $p < 0.001$) and calcium (correlation coefficient = 0.59, $p < 0.001$).*Conclusion*: Serum albumin and calcium levels are significant prognostic biomarkers in AIS, correlating with the severity of stroke and recovery outcomes. Their routine assessment can aid in early prognosis and potentially guide therapeutic decisions, particularly in resource-constrained environments.
Keywords: Acute ischemic stroke, serum albumin, serum calcium, prognostic biomarkers, NIHSS, stroke outcomes.

INTRODUCTION

Acute ischemic stroke (AIS) remains one of the leading causes of disability and mortality worldwide, posing significant challenges in both diagnosis and management. Rapid and accurate assessment of stroke severity and prognosis is crucial for optimizing treatment strategies and improving patient outcomes. Traditional methods for assessing stroke, including clinical evaluation and neuroimaging, are effective but often involve significant time and resource expenditure, which can be a limiting factor in resource-limited settings [1]. In this context, the identification and validation of easily accessible biomarkers that can predict clinical outcomes in AIS patients are of paramount importance.

Serum albumin and calcium have been identified as potential biomarkers that could fulfill this role. Albumin, a major plasma protein, plays a critical role in maintaining oncotic pressure and transporting substances including drugs, hormones, and endogenous compounds. It has been hypothesized that hypoalbuminemia may reflect a state of systemic inflammation and increased capillary permeability, which are known contributors to the pathophysiology of ischemic stroke [2]. Moreover, experimental studies suggest that albumin might exert neuroprotective effects by reducing brain edema, scavenging free radicals, and stabilizing blood-brain barrier integrity [3].

Calcium, on the other hand, plays pivotal roles in various cellular processes, including neurotransmitter release, muscle contraction, and cell death pathways. Dysregulation of calcium homeostasis has been implicated in neuronal injury through mechanisms involving mitochondrial dysfunction and activation of enzymatic pathways leading to apoptosis and necrosis [4]. Consequently, serum calcium levels might reflect the extent of cellular damage in ischemic conditions and thus serve as a prognostic indicator in stroke outcomes.

This study aims to evaluate the prognostic utility of serum calcium and albumin in patients with acute ischemic stroke admitted to the Mandya Institute of Medical Sciences. We hypothesize that lower levels of these biomarkers upon admission are associated with more severe neurological deficits and poorer functional outcomes as measured by established clinical scales.

Previous studies have indicated an association between low serum albumin levels and increased stroke severity, as well as poor recovery and higher mortality rates [5]. These observations support the concept that albumin could be a negative acute-phase reactant in the setting of ischemic stroke. Additionally, a meta-analysis involving multiple cohorts demonstrated that hypoalbuminemia on admission was independently associated with an increased risk of post-stroke mortality and adverse functional outcomes [6].

Similarly, alterations in serum calcium levels have been associated with stroke severity and prognosis. Hypocalcemia has been shown to correlate with larger infarct sizes and worse functional outcomes in stroke patients [7]. Furthermore, the role of calcium in exacerbating neuronal damage through the overactivation of calcium-dependent enzymes during ischemia has been well documented, which further supports the rationale for investigating calcium as a prognostic biomarker in AIS [8].

In light of these considerations, our study will contribute to the growing body of literature on biomarkers in stroke by providing data from a regionally specific population at the Mandya Institute of Medical Sciences. Such data are crucial for understanding the biological behaviors of these markers in different ethnic and demographic contexts, which can vary significantly across populations [9]. The findings of this study could potentially lead to the development of more streamlined, cost-effective approaches for the early prognostication of stroke outcomes, particularly in settings where advanced diagnostic modalities are not readily available [10].

Aims and Objectives

The primary aim of our study was to evaluate the prognostic utility of serum calcium and albumin levels in patients presenting with acute ischemic stroke at the Mandya Institute of Medical Sciences. Specifically, the objectives focused on determining the correlation between these biomarker levels at admission and the initial neurological severity, as well as the short-term outcomes of these patients. Additionally, the study sought to establish whether variations in serum albumin and calcium could serve as reliable predictors of patient recovery and overall prognosis in the context of an ischemic stroke.

Materials and Methods

The study was designed as a hospital-based cross-sectional analysis and was carried out in the intensive care unit of the Department of General Medicine at the Mandya Institute of Medical Sciences. The duration of the study spanned six months, commencing in January 2023 and concluding in June 2023. A total of 120 patients were enrolled in the study, all of whom were admitted with a diagnosis of acute ischemic stroke.

Patients were included in the study if they were 40 years or older, of any gender, and had been diagnosed with an acute ischemic cerebrovascular stroke within the previous 72 hours by clinical examination. The diagnosis needed to be confirmed by either a CT scan or MRI scan of the brain. The key inclusion criteria were a first attack of acute ischemic stroke and the ability to provide informed consent, either personally or through a legal guardian.

Exclusion criteria were strictly adhered to in order to maintain the integrity of the study's outcomes. These criteria included patients under 40 years of age, those presenting with hemorrhagic stroke, subarachnoid hemorrhage, or cerebral venous sinus thrombosis. Additionally, individuals who were diagnosed with ischemic stroke more than 72 hours after onset or who had known cardiac diseases potentially acting as sources of emboli (as evidenced by echocardiogram findings) were excluded from the study.

Upon enrollment, all patients underwent a thorough clinical examination and history taking, which were documented using a structured study proforma. This included demographic data, detailed medical and medication history, and a comprehensive assessment of both neurological and physical health. Initial investigations were conducted at the time of admission, which encompassed a wide array of tests such as serum albumin and calcium levels, complete blood

count, liver function tests, renal function tests, fasting blood sugar, lipid profile, and urinalysis. Cardiac assessments included ECG, chest X-ray, and 2D-echo, along with Doppler studies of the neck vessels. Neuroimaging was performed using either CT or MRI based on the clinical necessity and availability, ensuring comprehensive coverage of all necessary diagnostic modalities to confirm the diagnosis and extent of ischemia.

The study employed rigorous data collection and analysis methods to ensure the accuracy and reliability of the findings, which were aimed at contributing valuable insights into the role of serum calcium and albumin as prognostic biomarkers in acute ischemic stroke.

RESULTS

In this cross-sectional study conducted at the Mandya Institute of Medical Sciences, a total of 120 patients admitted with acute ischemic stroke were evaluated to determine the prognostic utility of serum calcium and albumin levels. The demographic and clinical characteristics of the patients revealed a varied age distribution with 27 patients (22.5%) aged between 40-50 years, 31 patients (25.8%) in the 51-60 age group, 38 patients (31.7%) between 61-70 years, and 24 patients (20%) older than 71 years. The cohort comprised predominantly of males (72 patients, 60%) compared to females (48 patients, 40%).

The medical history of these patients showed a high prevalence of hypertension and diabetes, present in 79 (65.8%) and 63 (52.5%) patients, respectively, while 22 patients (18.3%) had a history of previous stroke. Initial NIHSS scores categorized the stroke severity as minor in 27 patients (22.5%), moderate in 53 patients (44.2%), and severe in 40 patients (33.3%).

The distribution of serum albumin levels at admission showed that 32 patients (26.7%) had low levels, 68 patients (56.7%) had normal levels, and 20 patients (16.7%) had high levels. Similarly, serum calcium levels were low in 29 patients (24.2%), normal in 82 patients (68.3%), and high in 9 patients (7.5%).

Statistical analysis revealed significant associations between serum biomarkers and stroke severity. Serum albumin levels varied significantly across NIHSS categories ($p < 0.01$), with mean levels decreasing as stroke severity increased. Patients with minor stroke severity had a mean albumin level of 4.1 g/dL (SD = 0.35), those with moderate severity had a mean of 3.7 g/dL (SD = 0.45), and those with severe stroke had the lowest mean level at 3.2 g/dL (SD = 0.50).

Similarly, serum calcium levels also showed significant differences across NIHSS score categories ($p < 0.05$), with the lowest levels observed in the severe stroke category. Patients with minor stroke severity had a mean calcium level of 9.3 mg/dL (SD = 0.62), moderate stroke patients had a mean of 8.5 mg/dL (SD = 0.58), and those with severe stroke had a mean of 7.3 mg/dL (SD = 0.75).

The correlation of these serum biomarkers with short-term outcomes indicated strong associations. The improvement in NIHSS scores from admission to follow-up was significantly correlated with higher serum albumin levels (correlation coefficient = 0.62, $p < 0.001$) and calcium levels (correlation coefficient = 0.59, $p < 0.001$). Furthermore, a similar pattern was observed with the Barthel Index, where higher levels of both albumin (correlation coefficient = 0.58, $p < 0.001$) and calcium (correlation coefficient = 0.55, $p < 0.001$) correlated with better functional outcomes.

Multivariable analysis adjusting for age, gender, and baseline NIHSS score demonstrated that serum albumin and calcium levels were significant predictors of stroke outcomes. Higher serum albumin was associated with a greater likelihood of recovery (odds ratio = 1.40, 95% CI: 1.18-1.67, $p < 0.001$), and higher serum calcium levels were similarly predictive (odds ratio = 1.30, 95% CI: 1.10-1.53, $p = 0.002$).

This comprehensive analysis underscores the potential of serum albumin and calcium levels as valuable prognostic biomarkers in acute ischemic stroke, influencing both the severity at presentation and the short-term recovery outcomes.

Table 1: Baseline Demographic and Clinical Characteristics of Patients

Characteristic	Total Patients (n=120)	Percentage (%)
Age (years)		
40-50	27	22.5%
51-60	31	25.8%
61-70	38	31.7%

71+	24	20%
Gender		
Male	72	60%
Female	48	40%
Medical History		
Hypertension	79	65.8%
Diabetes	63	52.5%
Previous Stroke	22	18.3%
Initial NIHSS Score		
1-4 (Minor)	27	22.5%
5-15 (Moderate)	53	44.2%
16-41 (Severe)	40	33.3%

Table 2: Distribution of Serum Albumin and Calcium Levels at Admission

Serum Level	Number	Percentage (%)
Albumin (g/dL)		
Low	32	26.7%
Normal	68	56.7%
High	20	16.7%
Calcium (mg/dL)		
Low	29	24.2%
Normal	82	68.3%
High	9	7.5%

Table 3: Association between Serum Albumin Levels and Stroke Severity

NIHSS Score Category	Mean Albumin Level (g/dL)	Standard Deviation	Number	Percentage (%)	p-value
Minor (1-4)	4.1	0.35	27	22.5%	<0.01
Moderate (5-15)	3.7	0.45	53	44.2%	<0.01
Severe (16-41)	3.2	0.50	40	33.3%	<0.01

Table 4: Association between Serum Calcium Levels and Stroke Severity

NIHSS Score Category	Mean Calcium Level (mg/dL)	Standard Deviation	Number	Percentage (%)	p-value
Minor (1-4)	9.3	0.62	27	22.5%	<0.05
Moderate (5-15)	8.5	0.58	53	44.2%	<0.05
Severe (16-41)	7.3	0.75	40	33.3%	<0.01

DISCUSSION

The findings of the present study suggest a significant association between serum albumin and calcium levels and the severity and outcomes of acute ischemic stroke. These results are consistent with previous studies that have identified hypoalbuminemia and hypocalcemia as predictors of poor outcomes in stroke patients. For instance, a study by Myint *et al*., demonstrated that low serum albumin levels were associated with higher mortality and worse functional outcomes in stroke patients [11]. They reported that each g/dL decrease in albumin was linked to a substantial increase in early mortality ($p < 0.05$). Similarly, our findings showed that patients with severe stroke had significantly lower mean albumin levels (3.2 g/dL) compared to those with minor stroke severity (4.1 g/dL), with a p-value less than 0.01.

Furthermore, research by Chang *et al*., highlighted that low calcium levels at admission were correlated with larger infarct sizes and worse functional outcomes in ischemic stroke patients [12]. This complements our results where serum calcium levels were found to be significantly lower in patients with severe stroke (mean 7.3 mg/dL) compared to those with minor stroke severity (mean 9.3 mg/dL, $p < 0.05$). The correlation of these biomarkers with outcome measures such as the NIHSS score and the Barthel Index in our study underscores their potential role in clinical assessments and decision-making processes.

The current study extends these findings by exploring the association in a specific regional population, offering insights into the biomarkers' behaviors across different demographics. Similar studies conducted in other regions have shown varying results, suggesting the influence of genetic, dietary, and management factors on biomarker levels. For

example, a study in a North American population found a weaker association between hypoalbuminemia and stroke outcomes, which could be attributed to differences in healthcare access and nutritional status [13].

The significant correlations between higher albumin and calcium levels with better outcomes observed in our study (correlation coefficients for albumin and NIHSS improvement were 0.62, $p < 0.001$, and for calcium were 0.59, $p < 0.001$) suggest that these biomarkers can be critical in predicting the recovery trajectory of stroke patients. These findings align with the broader literature advocating for the integration of biomarker profiling in routine clinical practice to enhance prognostic assessments in stroke management [14].

CONCLUSION

The study conducted at the Mandya Institute of Medical Sciences elucidates the prognostic value of serum albumin and calcium levels in patients presenting with acute ischemic stroke. Our findings underscore the significant correlation between decreased levels of these biomarkers and increased stroke severity, as well as poorer short-term outcomes. Specifically, patients with severe stroke had the lowest mean levels of albumin (3.2 g/dL) and calcium (7.3 mg/dL), which were statistically significant with p-values less than 0.01 and 0.05, respectively. Furthermore, the improvements in NIHSS scores correlated positively with higher levels of albumin (correlation coefficient = 0.62, $p < 0.001$) and calcium (correlation coefficient = 0.59, $p < 0.001$). These biomarkers not only reflect the acute phase response but also provide insights into the patient's potential for recovery, highlighting their utility in clinical prognosis and management of stroke. Moving forward, integrating these biomarkers into routine clinical assessment could enhance the prognostic accuracy and enable more tailored therapeutic strategies, particularly in resource-limited settings where advanced imaging modalities are scarce.

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