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A study of prognostic significance of serum magnesium and serum potassium levels in acute stroke

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Abstract

Background: Stroke is one of the major causes of morbidity and mortality worldwide. Various studies have examined the neuroprotective effects of magnesium and potassium ions through their effects on the glutamate receptor and the endothelium, achieved by lowering blood pressure and through their anti-inflammatory and anti-apoptotic properties. The objective of our study was to determine the prognostic significance of serum magnesium and serum potassium levels in acute stroke.

Methods: An observational study was conducted at Rajendra Institute of Medical Sciences, Ranchi, for 18 months on 150 adults in patients with acute stroke, enrolled within 72 hours after applying appropriate inclusion and exclusion criteria. Correlations between the Modified Rankin Scale (mRS) score at discharge and the Glasgow Coma Scale (GCS) score at admission with serum levels of magnesium and potassium were calculated. Statistical analysis was performed using SPSS software version 27.0.

Results: Two groups were formed based on serum magnesium levels: <1.5 mg/dL and >1.5 mg/dL. Similarly, two groups were created based on serum potassium levels: <3.5 mEq/L and >3.5 mEq/L. A significant correlation was found, using Spearman's coefficient test, between serum potassium and magnesium levels and the GCS score at admission, as well as the mRS score at discharge ($p < 0.05$).

Conclusion: Lower concentrations of magnesium and potassium are associated with increased cerebral arterial contraction and greater neurological damage.

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Introduction

The World Health Organization defines stroke as a rapidly developing clinical manifestation of focal or global disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than a vascular origin (1). Stroke is the second most common cause of death and disability worldwide after ischemic heart disease (2). It is the fifth leading cause of disability-adjusted life years in India (3). There were 6.5 million stroke cases in India, with an incidence of approximately 105-152 cases per one lakh population (4-6). In acute stroke, there is a rapid loss of brain potassium and magnesium levels, accompanied by the rapid uptake of sodium and calcium ions along with water. Magnesium and potassium also have a neuroprotective role through various mechanisms. Magnesium primarily acts via the N-methyl-D-aspartate (NMDA) receptor and helps regulate neuron hyperexcitability by modulating inhibitory GABA receptors. In cases of low Mg^{2+} concentration, the membrane potential becomes higher, relieving the Mg^{2+}-mediated block of NMDA receptors and subsequently contributing to neuronal hyperexcitability. Mg^{2+} also plays a role in regulating the release of neuropeptides and oxidative stress, which significantly contribute to maintaining healthy neurological function. Potassium acts on cerebral arteries and increases the release of nitric oxide and prostacyclin, which in turn causes vasodilation and inhibits platelet aggregation. Potassium also reduces the formation of free radicals, thereby helping to minimize the extent of free radical-mediated injury in the setting of ischemic brain injury (7-9). Our aim was to study the prognostic significance of serum magnesium and potassium levels on clinical outcomes in patients admitted with acute stroke.

Methods

A hospital-based observational study was conducted at Rajendra Institute of Medical Sciences, Ranchi, over a period of 18 months after obtaining clearance from the institutional ethical committee. After obtaining consent, 150 patients with acute stroke of less than 72 hours' duration, aged 25 years and above, both male and female, were included in the study. Patients with end-stage renal disease, chronic diarrhea, regular alcohol intake, malabsorption syndrome, or a history of taking drugs causing hypokalemia and hypomagnesemia were excluded from the study.

After a detailed history, examination, and informed consent, 2 mL of venous blood was collected from the patient in a plain vial. Serum was separated by centrifugation, and magnesium and potassium levels were estimated using the colorimetric method. The cutoff for serum potassium levels was taken as 3.5 mEq/L (7,8) and for serum magnesium levels as 1.5 mg/dL, based on different studies (9,10). The neurological status of patients suffering from stroke was assessed using the Glasgow Coma Scale (GCS) at admission and the Modified Rankin Scale (mRS) at the time of discharge.

Statistical analysis was done using SPSS software version 27.0. Correlations between mRS and GCS with serum levels of magnesium and potassium were calculated using Spearman's coefficient test. A p-value was calculated using an unpaired t-test, and $p < 0.05$ was considered statistically significant.

Results

To study the correlation between mRS and GCS scores with serum magnesium levels, two groups were made: one with a serum magnesium level <1.5 mg/dL and one with >1.5 mg/dL. The mean mRS and GCS in stroke cases with a serum magnesium level <1.5 mg/dL were 3.95 and 9.02, respectively. The mean mRS and GCS in stroke cases with a serum magnesium level >1.5 mg/dL were 3.56 and 9.69, respectively (Table 1). A positive correlation between mRS and GCS scores with serum magnesium levels was observed, which was statistically significant ($p < 0.05$) (Figure 1 and 2).

Table 1. Correlation between mRS Score and GCS Score with serum magnesium and serum potassium levels (n = Number of participants)

Cut off value	Magnesium		Potassium	
	< 1.5 mg/dl	≥ 1.5 mg/dl	< 3.5mEq/l	≥ 3.5mEq/l
n	74	76	72	78
mRS (Mean± SD)	3.95±0.99	3.56±1.27	4.06±1.22	3.47±1.02
GCS (Mean± SD)	9.02±1.47	9.69±2.25	8.84±2.03	9.84±1.69
P-value	0.03		0.001	

Similarly, to study the correlation between mRS and GCS scores with serum potassium levels, two groups were made: one with a serum potassium level < 3.5 mEq/L and one with > 3.5 mEq/L. The mean mRS and GCS in stroke patients

with a serum potassium level < 3.5 mEq/L were 4.06 and 8.84, respectively. The mean mRS and GCS in stroke patients with a serum potassium level > 3.5 mEq/L were 3.47 and 9.84, respectively (Table 1). A positive correlation between mRS and GCS scores with serum potassium levels was observed, which was statistically significant ($p < 0.05$) (Figure 3 and 4). A statistically significant correlation was also observed between mRS and GCS in stroke patients with serum potassium and magnesium levels.

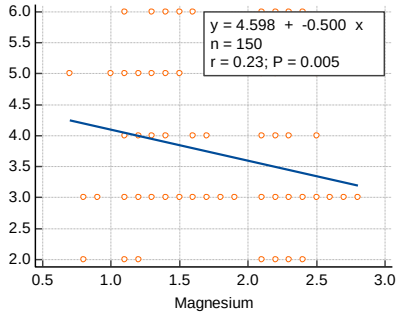

Figure 1. Spearman's coefficient for serum magnesium and mRS

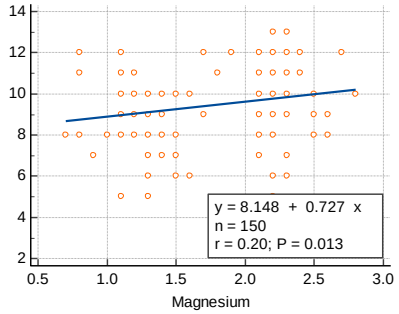

Figure 2. Spearman's coefficient for serum magnesium and GCS

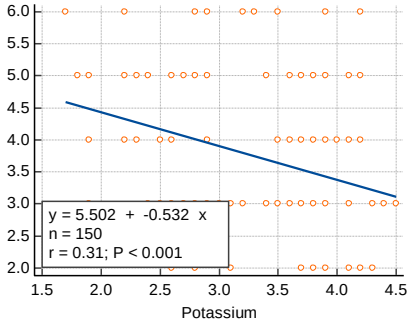

Figure 3. Spearman's coefficient for serum potassium and mRS

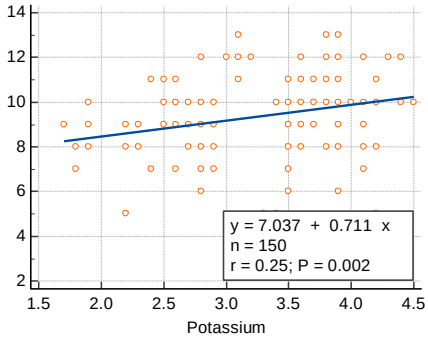

Figure 4. Spearman's coefficient for serum potassium and GCS

Discussion

Stroke is an acute medical condition in which neuronal cell death is caused by poor blood flow to the brain, which may be due to an interruption of blood flow or the rupture of blood vessels inside the brain. When the blood supply to the brain is disrupted for a prolonged period, it leads to ischemia, initiating an ischemic cascade that further causes neuronal damage (11,12). It has been found that glutamate is one of the main culprits in excitotoxicity through its action on NMDA and AMPA receptors. Various studies have suggested the neuroprotective effects of magnesium and potassium ions through their influence on the glutamate receptor, endothelium, blood pressure reduction, anti-inflammatory and anti-apoptotic abilities, and inhibition of free radical injury (13-16).

In our study, we compared serum potassium and serum magnesium levels at admission with the GCS of patients at admission, as well as with the final neurological outcome during their hospital stay. The GCS is used to objectively describe the extent of impaired consciousness in all types of acute medical and trauma patients. The scale assesses patients based on eye-opening, motor, and verbal responses, indicating the patient's state.

The mRS is a single-item, global outcome rating scale for patient's post-stroke. It is used to categorize the level of functional independence with reference to pre-stroke activities rather than observed performance on a specific task (17). Its concurrent validity is demonstrated by a strong correlation with measures of stroke pathology and agreement with other stroke scales.

In the year 2017, Johnson et al. studied the correlation between serum potassium levels and the incidence of stroke, as well as mortality due to stroke, and found a significant correlation between them (18). In the same year, Kim et al. conducted a retrospective case-control study aimed at examining the effect of hypokalemia on the functional outcomes of patients with subacute stroke. For this study, a total of 96 post-stroke hemiplegic patients admitted to an inpatient clinic of the Department of Rehabilitation Medicine were recruited. They found that hypokalemia could be considered one of the deteriorating factors for post-stroke functional prognosis (19). A similar study was conducted by Patel et al. to assess serum magnesium levels in acute stroke and their correlation with neurological disability. They found a statistically significant correlation between the mRS score and serum magnesium levels, indicating that the severity of a stroke is inversely related to serum magnesium levels (20). In this study, we assessed the serum magnesium and potassium levels of stroke patients on their arrival and studied their correlation with the general condition of the patient on arrival as well as with the final neurological outcome. We found that GCS was lower at admission and mRS was higher at the time of discharge in patients with low serum magnesium and potassium levels at admission. This was consistent with the results of various previously available studies (18-20). We inferred that there was a significant correlation between serum magnesium and potassium levels with the initial condition of patients at presentation and also with morbidity and mortality in cases of acute stroke.

This study had some limitations. First, the sample size was only 150, so to confirm the association between serum potassium and magnesium with clinical outcomes, further studies need to be conducted with a larger sample size. Second, this study was conducted in a single center; therefore, multicenter-based studies are needed to confirm the association between serum potassium and magnesium with clinical outcomes in acute stroke in the general population. Third, there was a lack of proper extended follow-up.

Conclusion

Stroke is globally the second most common cause of death and disability after ischemic heart disease. The serum potassium and magnesium levels at admission in stroke patients had a significant correlation with the GCS of the patient at admission and with the mRS score at the time of discharge. Our study suggests a prognostic role of serum potassium and magnesium levels in patients with acute stroke. The lower the concentration of magnesium and potassium, the greater the magnitude of cerebral arterial contraction.

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None.

Ethical statement

Approval has been taken from the institutional ethical committee (Ethics code: 106IEC.RIMS).

Conflicts of interest

The authors declare that they have no conflicts of interest.

Author contributions

Sudhanshu Subrat contributed to study conception, material preparation, and data collection. Manohar Lal Prasad checked the manuscript. Kavya Varshney contributed to manuscript preparation and correspondence. Kanika Bansal contributed to study design and manuscript preparation. Mayank Mahajan contributed to data collection and analysis. Anindya Chowdhury contributed to data collection and interpretation. All authors read and approved the final manuscript.

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