Section: General Medicine

Original Research Article

SERUM MAGNESIUM AND POTASSIUM LEVELS AT ADMISSION AS PROGNOSTIC MARKERS IN ACUTE CEREBROVASCULAR ACCIDENTS

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Abstract

Background: Acute cerebrovascular accidents cause rapid loss of potassium and magnesium levels in the brain. Magnesium and potassium are essential for neuroprotection and inflammation, but chronically low levels are associated with hypertension, diabetes, and cardiovascular diseases. This study aimed to determine the relationship between serum magnesium and potassium levels and in-hospital outcomes in patients with acute cerebrovascular accidents. **Materials and Methods:** This observational study was conducted on 100 patients with acute cerebrovascular accidents at the Institute of Internal Medicine, Rajiv Gandhi Government General Hospital (RGGGH), Madras Medical College. Detailed history-taking and clinical examinations were performed. Serum levels of magnesium and potassium were estimated using a calorimetric method. **Result:** The study included 79 male and 21 female patients with cerebrovascular accidents, with 60 male patients with ischaemic stroke and 19 with haemorrhagic stroke. Of the patients, 89.2% had diabetes mellitus, 64.9% had low serum magnesium levels, and 52.6% had systemic hypertension. In haemorrhagic stroke, 68% had low serum potassium levels, and 47.4% had systemic hypertension. High HDL levels in 30% of ischaemic stroke cases and 40.7% of haemorrhagic stroke cases with low serum magnesium and potassium levels are common in both ischaemic and haemorrhagic strokes. The Glasgow coma scale score was lower at admission, and the Modified Rankin Scale score was higher at discharge in patients with low serum magnesium and potassium levels. **Conclusion:** This study revealed a strong link between serum magnesium and potassium deficiency and cerebrovascular accidents, indicating poor neurological outcomes in low-level patients.

INTRODUCTION

In acute cerebrovascular accidents, rapid brain potassium and magnesium loss occurs with rapid uptake of sodium and calcium channels. The lower the magnesium and potassium concentrations, the greater the magnitude of cerebral arterial contraction. Interruption of cerebral blood flow leads to ischaemic cell death, causing ATP depletion, ischaemic depolarisation, and excessive calcium entry, resulting in vasospasm. Interruption of cerebral blood flow causes the release of excitatory glutamate through NMDA receptors, which causes an influx of calcium and sodium, produces free radicals, and initiates inflammatory responses. Mg and K are essential for neuroprotection and inflammation. Magnesium acts as a calcium blocker, reducing the release of excitatory and inhibitory neurotransmitters, relaxing vascular smooth muscles, and decreasing platelet aggregation. Potassium improves endothelial function, increases vascular nitric oxide, decreases vascular intercellular calcium and sodium levels, alters DNA synthesis and proliferation in cerebral vascular smooth muscles, decreases vascular neointimal formation, lowers thrombosis risk, and reduces free radical production.[1-5]

Chronic low levels of magnesium and other electrolytes are atherogenic and thrombogenic, disrupt arterial and cardiac integrity, and are associated with hypertension, diabetes, CAD, and CVA. Research has been conducted on the role of magnesium and other electrolytes, such as potassium, in preventing and treating diseases such as CVA, CAD, DM, and HT.[6]

This study evaluated the prognostic impact of serum magnesium and potassium levels on the intrahospital outcomes of patients with CVA and the correlation

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between serum magnesium and potassium levels with hypertension, DM, dyslipidaemia, and CAD.[7]

MATERIALS AND METHODS

This observational study was conducted on 100 patients with acute cerebrovascular accidents at the Institute of Internal Medicine, Rajiv Gandhi Government General Hospital (RGGGH), Madras Medical College. The study received approval from the institutional ethics committee before its initiation.

Inclusion Criteria

The study included patients of both sexes, aged >25 years, who had experienced acute cerebrovascular accidents lasting < 72 h.

Exclusion Criteria

Patients with acute cerebrovascular accidents if the time from symptom onset to admission exceeded 72 h, those below 25 years of age, individuals with end-stage renal disease, chronic diarrhoea, regular alcohol consumption, intake of drugs known to cause hypokalaemia and hypomagnesaemia, and critically ill patients were excluded.

Patients were selected for the clinical study based on the inclusion and exclusion criteria. Informed consent was obtained from patients' relatives. Detailed history-taking and clinical examinations were performed. Approximately 2 ml of venous blood was collected from each patient. Blood was allowed to clot, and the serum was separated by centrifugation. Serum levels of magnesium and potassium were estimated using a calorimetric method. The neurological status of the patients suffering from cerebrovascular accidents was assessed at admission, and the one-week functional outcome was assessed using the Modified Rankin Scale (mRS).

Statistical analysis: Statistical analysis was performed using the Statistics Products Services Solutions (SPSS 15) software. Univariate analysis was performed using the paired t-test and the Pearson product-moment correlation coefficient. A chi-square test was used to analyse the probability of differences in frequency distributions, and statistical significance was set at $p < 0.05$.

RESULTS

For males, low serum magnesium levels (<1.5 mg/dL) were observed in 29.5% of individuals aged 61-70 years, 34.1% in the age group of 51-60 years, 27.3% in the age group of 41-50 years, and 9.1% in the age group of 31-40 years. Regarding serum potassium, low levels (<3.5 meq/L) were found in 31.2% of cases in the age group of 61-70 years, 33.3% in the age group of 51-60 years, and 25%. in the age group of 41-50 years, and 6.2% in the age group of 31-40 years.

In females, serum magnesium was low (<1.5 mg/dL) in 16.7% of cases in the age group of >70 years, 50% of cases in the age group of 61-70 years, and 33.3% of cases in the age group of 51-60 years. The serum potassium level was low (<3.5 meq/L) in 20% of patients aged > 70 years, 53.3% of patients aged group–61-70 years, and 26.7% of patients aged group 51-60 years [Table 1].

In the study population, the majority (64.9%) of diabetes mellitus cases had low serum magnesium levels (<1.5 mg/dL), whereas 35.1% had levels >.5 mg/dL. Among patients with systemic hypertension, 42.1% had low serum magnesium levels, and 57.9% had levels >1.5 mg/dL. For coronary artery disease (CAD), 53.8% had low serum magnesium levels, and 46.2% had levels >1.5 mg/dL. In dyslipidaemia cases, 49% with low HDL (<40%) and 54% with high LDL (>160%) had low serum magnesium levels. Additionally, 68% of diabetes mellitus cases had low serum potassium (<3.5 meq/L), while 32% had levels above 3.5 meq/L.

Among patients with systemic hypertension, 63% had low serum potassium levels, and 37% had levels above 3.5 meq/L. In CAD cases, 73% had low serum potassium levels, and 27% had levels above 3.5 meq/L. For dyslipidaemia, 58% with low HDL had low serum potassium levels, and 42% had levels above 3.5 meq/L. Furthermore, 58% of cases with high LDL (>160%) had low serum potassium levels, while 75% with LDL 130-160 had low serum potassium levels [Table 2].

The p-value was significant ($p < 0.05$) for serum magnesium, potassium, and systemic hypertension. The mean serum magnesium level was significant in both ischemic and hemorrhagic stroke, with a p-value of <0.001. The mean serum potassium level was significant in both ischaemic and haemorrhagic strokes ($p = 0.041$). Systemic hypertension was significant ($p < 0.001$) [Table 3].

In the study population, 79 male and 21 female patients were affected by cerebrovascular accidents (CVA), with 60 male patients with ischaemic stroke and 19 with haemorrhagic stroke. Among females, 13 had an ischaemic stroke, and eight had a haemorrhagic stroke. In ischaemic stroke cases, serum magnesium was low in the 1–1.5 mg/dL range in 65.8% and very low (<1 mg/dL) in 8.2%, with a significant p-value of <0.001. Serum potassium level was low (<3.5) in 69.86% of ischaemic stroke cases and 44.44% of haemorrhagic stroke cases, with a significant p-value of 0.019.

In the ischaemic stroke group, 89.2% had diabetes mellitus, 64.9% had low serum magnesium (<1.5 mg/dL), and 52.6% had systemic hypertension. Additionally, 53.8% had coronary artery disease (CAD), and 52.8% had low serum magnesium levels. In cases of haemorrhagic stroke, only 0.8% had diabetes mellitus, 68% had low serum potassium (<3.5 meq/L), and 47.4% had systemic hypertension. Furthermore, 46.2% had CAD, and 52.8% had low serum magnesium levels. In the overall cerebrovascular accident (CVA) cases, 57% had systemic hypertension ($p < 0.001$), 42.1% had low serum magnesium, and 63% had low serum potassium [Table 4].

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HDL levels were low (<40) in 30% of ischaemic stroke cases and 40.7% of haemorrhagic stroke cases; 49% of those with low HDL had low serum magnesium levels, while 58% had low serum potassium levels. Regarding LDL levels, 27.4% of ischaemic stroke cases had high LDL (>160), and 22.2% of haemorrhagic stroke cases fell into this category. Furthermore, 34.2% of ischaemic stroke cases and 40.7% of haemorrhagic stroke cases had LDL levels within the 130-160 range. Among those with high LDL, 54% had low serum magnesium levels, and 64% of cases with LDL in the 130-160 range had low serum magnesium levels. Additionally, 58% of patients with LDL >160 and 75% with LDL in the 130-160 range had low serum potassium levels [Table 5].

Table 1: Demographic data of the study population

Age group	Male				Female			
	Magnesium		Potassium		Magnesium		Potassium	
	<1.5	>1.5	<3.5	3.5-4.5	<1.5	>1.5	<3.5	3.5-4.5
30-40	4 (9.1)	4 (11.4)	3(6.2)	5(16.1)	0	0	0	0
41- 50	12 (27.3)	6 (17.1)	12(25.0)	6(19.4)	0	0	0	0
51- 60	15 (34.1)	9 (25.7)	16(33.3)	8(25.8)	4(33.3)	4(44.4)	4(26.7)	4(66.7)
61- 70	13 (29.5)	14 (40.0)	15(31.2)	12(38.7)	6(50)	4(44.4)	8(53.3)	2(33.3)
> 70	0	2 (5.7)	2(4.2)	0	2(16.7)	1(11.1)	3(20)	0

Table 2: Comparison of DM, SHT and CAD with the serum magnesium and serum potassium of the study population

		Serum magnesium		Serum potassium	
		<1.5	>1.5	<3.5	>3.5
Diabetes mellitus		64.9%	35.1%	68%	32%
Hyper tension		42.1%	57.9%	63%	37%
Coronary artery disease		53.8%	46.2%	73%	27%
HDL	<40	49%	51%	58%	42%
	≥40	60%	40%	66%	34%
LDL	<130	50%	50%	55%	45%
	130-160	64%	36%	75%	25%
	>160	54%	46%	58%	42%

Table 3: Mean SBP, DBP, BS, HDL, and LDL of the study population

	Ischemic Stroke	Hemorrhagic stroke	P value
SBP	154.2466± 23.62425	212.2222 ± 20.81666	<0.001
DBP	87.8082 ± 7.49937	107.4074 ± 10.95185	<0.001
BS	203.0548 ± 81.83773	206.7407 ± 98.92172	0.851
HDL	39.9726 ± 6.42688	40.1481 ± 5.97240	0.902
LDL	143.1233 ± 21.58571	142.1481 ± 21.04520	0.84

Table 4: Comparison of various findings between CVA

		Ischemic Stroke	Hemorrhagic stroke	P value
Magnesium	<1	6(8.2%)	0	<0.0001
	1-1.5	48(65.8%)	2(7.4%)	
	>1.5	19(26%)	25(92.6%)	
Potassium	<3.5	51(69.86%)	12(44.44%)	0.019
	4.5	22(30.14%)	15(55.56%)	
Age group (years)	30-40	6(8.2%)	2(7.4%)	0.034
	41- 50	16(21.9%)	2(7.4%)	
	51- 60	25(34.2%)	7(25.9%)	
	61- 70	25(34.2%)	12(44.4%)	
	> 70	1(1.4%)	4(14.8%)	
Sex	Male	60(82.2%)	19(70.4%)	0.198
	Female	13(17.8%)	8(29.6%)	
Diabetes mellitus	No	40(63.5)	23(36.5)	0.005
	Yes	33(89.2)	4(10.8)	
Hyper tension	No	43(100)	0	<0.001
	Yes	30(52.6)	27(47.4)	
Coronary artery disease	No	59(79.7)	15(20.3)	0.011
	Yes	14(53.8)	12(46.2)	

Table 5: Comparison of HDL, LDL, and Modified Rankin scale between CVA

		Ischemic Stroke	Hemorrhagic stroke	P value
HDL group	<40	22(30.1%)	11(40.7%)	0.317
	≥40	51(69.9%)	16(59.3%)	
LDL group	<130	28(38.4%)	10(37%)	0.801
	130-160	25(34.2%)	11(40.7%)	
	>160	20(27.4%)	6(22.2%)	
Modified Rankin Scale	1	1(1.4%)	0	0.003
	2	16(21.9%)	0	

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	3	23(31.5%)	7(25.9%)	
	4	20(27.4%)	9(33.3%)	
	5	13(17.8%)	7(25.9%)	
	6	0	4(14.8%)	

Table 6: Neurological outcome of the CVA patients

Potassium		**Mean**	**Std. Deviation**	**P value**
Glascow coma scale	<3.5	9.619	2.23194	0.038
	3.5-4.5	8.5405	2.85379	
Modified Rankin scale	<3.5	3.873	1.09974	0.002
	3.5-4.5	3.1351	1.20559	
Magnesium		Mean	Std. Deviation	P value
Glascow coma scale	<1.5	8.3393	2.37622	<0.001
	>1.5	10.3409	2.26134	
Modified Rankin scale	<1.5	4.2679	0.96278	<0.001
	>1.5	2.75	0.86603	

The Glasgow coma scale score was lower at admission, and the Modified Rankin Scale score was higher at discharge in patients with low serum magnesium and potassium levels. This shows that low levels of serum magnesium and potassium lead to poor neurological outcomes in patients with cerebrovascular accidents.

DISCUSSION

The prevalence of low serum magnesium and potassium levels in acute cerebrovascular accidents has been studied, and a significant correlation was found between serum magnesium and potassium levels and CVA. Mean serum magnesium and potassium levels were significantly lower in the study population. The maximum incidence of deficiency occurred in the sixth to seventh decades. Most patients with lower magnesium levels also have multiple risk factors for stroke. Thus, magnesium and potassium deficiencies are also associated with risk factors for coronary artery disease, systemic hypertension, diabetes, and dyslipidaemia.[8-10]

A case-control study was conducted by the University College of Medical Sciences, Delhi, wherein serum magnesium levels were measured in 50 diagnosed cases of acute cerebrovascular accidents, including transient ischaemic attack, ischaemic stroke, and haemorrhagic stroke. The results showed that patients who had ischaemic stroke, haemorrhagic stroke, and transient ischaemic attacks had significantly lower magnesium levels.[11,12]

A prospective study conducted by the University of Washington, Seatle, published in the American Journal of Hypertension, reported that hypokalaemia before a stroke was associated with an increased risk of incident ischaemic and haemorrhagic stroke, independent of diuretic use when compared to normal serum potassium levels.[13]

An article published in the American Journal of Epidemiology reported that higher serum magnesium levels are associated with a lower prevalence of hypertension and diabetes. Another study suggested that increased potassium intake is associated with lower blood pressure and decreased stroke risk in hypertensive and non-hypertensive adults.[14]

In our study population of 100 patients, we observed a correlation between serum magnesium and potassium levels and cerebrovascular accidents and the neurological outcome of those patients. We also correlated serum magnesium and potassium levels with age, sex, diabetes, hypertension, dyslipidaemia, and coronary artery disease. We found a significant correlation between serum magnesium and potassium levels and CVA, with p-values of <0.0001 and 0.41, respectively. Systemic hypertension and CVA were significantly correlated ($p < 0.001$). The Glasgow coma scale score was lower at admission, and the Modified Rankin Scale score was higher at discharge for those with low serum magnesium and potassium levels. This shows that deficiency of magnesium and potassium has a poor neurological outcome in patients with cerebrovascular accidents.[15,16]

CONCLUSION

A significant correlation was found between serum magnesium and potassium deficiency and cerebrovascular accidents and between mRS values and serum magnesium and potassium levels, indicating poor neurological outcomes in patients with low levels. Systemic hypertension was also found to be a risk factor for stroke. Hence, if a patient with a risk factor for stroke is found to have low levels of serum magnesium and potassium during screening, prophylactic supplementation with magnesium and potassium can prevent more disability in the persons who will be involved in a stroke in the future and can reduce the social, emotional, and economic losses and early recovery in patients who had been infused with intravenous magnesium within two hours of onset of stroke onset or as early as possible.

Limitations

The study was conducted with a sample size of only 100 participants; further studies need to be carried out in a larger population to verify the results and that there is a significant relationship between serum magnesium and potassium levels and acute

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cerebrovascular accidents, and extended follow-up of the patients was not possible.

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