ASSESSMENT OF SERUM ELECTROLYTE CHANGES (Na+, K+, Ca++, Mg++) IN PATIENTS WHO HAVE BEEN POISONED WITH ALUMINUM PHOSPHIDE

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Abstract-
BACKGROUND: The most lethal phosphide, Aluminium phosphide also known as AlP, is used to transport and store grains safely, particularly in Asian, Middle Eastern, and African nations. In India, it is marketed as tablets of quickphos, celphos, alphos, and protoxin and also in the form of powder in sachets. When Aluminium phosphide (AlP) tablets are exposed to humidity, phosphine gas (PH3), a very poisonous gas, is produced. Phosphine (PH3), can cause lipid peroxidation and limit cellular oxygen use. During suicide attempts, Aluminium phosphide (AlP) poisoning has occurred usually, more common in adults than in teenagers.
MATERIALS AND METHODS: The present analytical study comprised of 59 acute aluminium phosphide (AlP) poisoning patients as per history given by patients/relatives, admitted in a medical emergency at S.M.S Medical College, Jaipur. The details of the history and physical examination were recorded, and relevant lab investigations were done. The serum electrolytes were evaluated at the time of admission in all the AlP poisoning patients. There were 50 healthy control subjects evaluated for serum electrolytes measurement.
RESULTS: The study of 59 acute AlP poisoning patients showed 57.8% cases presented with hyponatremia in comparison to 42.2% cases with hypernatremia; 92.8% cases were hypokalemic in comparison to 7.2% hypokalemic cases; 85.2% cases were hypocalcaemia in comparison to 14.8% cases with hypercalcaemia; and 70.6% cases presented with hypomagnesemia in comparison to 29.4% cases with hypermagnesemia. There is no statistical difference in serum Na+ and K+ values between recovery and fatality consequent to AlP poisoning patients of the present study. However, serum Mg++ and calcium levels were higher in expired patients in comparison to recovered patients.
CONCLUSION: In the study, various significant electrolyte changes were found in the AlP poisoning patients. But as evident from the study, there is no correlation between serum electrolyte levels and mortality or survival of AlP poisoning patients.

***Keywords*: AlP, Poisoning, Fumigant, and Serum Electrolytes**

INTRODUCTION

AlP, a solid fumigant insecticide, is used in grain bins to keep rodents and moles away. In India, it is sold as quickphos, celphos, alphos, and phostoxin pills as well as in sachets of powder. Among the 3gm. tablet's 56 per cent active components are phosphine (PH3), 44 per cent are inactive component as ammonium carbonate [(NH4) 2 CO3] 2. Each 3gm tablet can release gm. of phosphine (PH3) gas when it touches stomach HCL or moisture from grains. This substance is being utilized as a surefire suicidal approach because it is fatal, readily available in the market or accessible at home2, 3. The first case of AlP poisoning in India was reported in 1981; since then, this poisoning has been rapidly expanding, primarily in the country's northern states, and has practically reached epidemic proportions. It is prevalent during the postharvest period, particularly in rural areas. Clinical signs and symptoms following AlP ingestion include nausea, vomiting, burning in the abdomen, excessive thirst, diarrhoea, hypotension or shock, Brady or tachycardia, arrhythmias, myocardial ischemia or conduction defects, myocarditis, pericarditis, and acute CHF5, 6. Other symptoms include coughing, dyspnea, and crackling, type I (ARDS) or type II respiratory failure, acute hepatic failure, and acute renal failure. One hypothesis states that the PH3 ingested by the digestive tract interferes with the mitochondria's respiratory system, leading to cell death. According to another theory, there are more free radicals present, which cause lipid peroxidation and alter the fluidity of cell membranes, which may lead to alterations in the permeability of the cell membrane for (Na+, K+, Ca++, and Mg++) with other ions which result in Cell death. Many studies have reported decreased levels of serum potassium but serum potassium levels were found to be raised in 2/3 cases of AlP Poisoning in one of the study.7, 8 Both hypo and hypermagnesemia have been reported during the acute phase of AlP poisoning in another study 8 Conflicting information exists regarding the alteration of serum electrolytes in AlP poisoning patients and their potential connection to death. In and around Jaipur city, the incidence of AlP poisoning is very common and the mortality rate is also high. Therefore, it was considered worthwhile to conduct a study with the following aims-

1. To assess the serum Na+, K+, Ca++, and Mg++ levels in AlP poisoning patients.

MATERIALS AND METHODS

The present analytic study comprised of 59 acute AlP poisoning patients admitted to the Medicine Emergency of SMS Medical College, Jaipur. The sample size is taken at our convenience. 50 healthy control subjects were also enrolled to measure serum electrolytes in them. Criteria for the selection of patients for this study are based on the history given by the patients and their relatives. The serum Na+, K+, Ca++, and Mg++ levels were measured at the time of admission. Other investigations like CBC, ESR, blood sugar, liver function tests, renal function tests and ECG were also done. In the emergency room, all AlP poisoning cases were initially diagnosed. Every patient had a gastric lavage with normal saline (NS). Additionally, intravenous (IV) fluids were given to all patients; however, central venous pressure was not tracked. Intravenous fluids (5% DNS and Ringer's lactate) and intravenous magnesium sulphate 1.0 gm. stat then 1.0 gm. every hour for 3 consecutive hours, then 1.0 to 1.5 gm. every 4 to 6 hours in 5% DNS for 3 to 5 days. If required, inotropic support and other forms of supportive care were administered. All of the patients were monitored until their deaths or hospital discharge. Data was compiled using Microsoft Excel and analyzed using SPSS 20.0 Software. The chi-square test and percentages were both used to analyze categorical variables. Student's "t" tests, the mean, and the standard deviation were used to analyze quantitative variables. Two-tailed p-value less than 0.05 were considered significant.

RESULTS

In all the 59 patients under study showed normal Haemogram values. Liver function, renal function and Random blood sugar levels were found to be within normal limits. The serum electrolytes were measured in 50 healthy individuals. In the current study, serum electrolyte normal ranges that are comparable to reference values (mean + 2 SD) were chosen. (Table 1).

Table 1: Descriptive statistics for mean serum Electrolyte levels in healthy controls

Variables	**Na+ (mEq/L)**	**K+ (mEq/L)**	**Ca++ (mg/dL)**	**Mg++ (mg/dL)**
Normal cut off	135-145	3.5 -5.2	8.3 -10.5	1.7-2.2
Mean	140.4	4.14	8.62	1.89
SD	5.35	0.50	0.49	0.61
Miniumum range	137	3.74	8.05	1.03
Maximum Range	142.6	4.94	9.49	2.1

The serum levels of electrolytes in controls ranged in the normal range for each electrolyte and the mean levels were also within the normal range. The normal levels of each electrolyte were respectively considered for comparison to the mean levels in tabulated form viz. 135-145 mEq/L for Na+, 3.5 -5.2 mEq/L for K+, 8.3 -10.5 mg/dL for Ca++ and 1.7-2.2mg/dL for Mg++. The cut-off values to consider hyponatraemia, hypokalemia, hypocalcaemia and hypomagnesaemia the values < 135 mEq/ L, < 3.5mEq/ L, < 8.3 mg/ dL and < 1.7 mg/ dL were considered respectively in this study. Similarly, for hypernatremia, hyperkalemia, hypercalcaemia and hypermagnesaemia, the values > 145 mg mEq/ L, > 5.2 mEq/ L, >10.5 mg/dL and > 2.2 mg/dL were considered as the cut-off point respectively.

Table 2: Descriptive statistics for mean serum Electrolyte levels in cases of Aluminum Phosphide poisoning

Variables	**Na+ (mEq/L)**	**K+ (mEq/L)**	**Ca++ (mg/dL)**	**Mg++ (mg/dL)**
Normal cut off	135-145	3.5 -5.2	8.3 -10.5	1.7-2.2
Mean	138.6	3.95	8.62	1.7
SD	5.46	0.90	0.49	0.49
Minimum range	121	1.2	7.02	1
Maximum Range	151	6.41	10.9	2.8

The mean values of sodium, potassium and calcium in cases of aluminum phosphide poisoning were within the normal cut off levels of theses electrolytes respectively except mean magnesium levels which was at the lower cut off limit in cases of aluminum phosphide poisoning. (Table 2)

Table 3: Comparison of mean serum Electrolyte levels in healthy controls and cases of Aluminum Phosphide poisoning

	Healthy Control Subjects (n-50)		ALP Poisoning Patients (n-59)		
Variables	Mean	SD	Mean	SD	*P value*
Serum Na+ (mEq/L)	140.4	5.35	138.6	5.46	0.482
Serum K+ (mEq/L)	4.14	0.50	3.95	0.90	0.218
Serum Ca++ (mg/dL)	8.8	0.49	8.62	0.49	0.251
Serum Mg++ (mg/dL)	1.89	0.61	1.7	0.49	0.04*

*Significant

The mean levels of sodium, potassium, calcium and magnesium were comparatively lower in cases of aluminum phosphide poisoning than those in healthy controls, but the differences were only statistically significant for the mean level of serum magnesium in cases and controls ($p=0.04$, $p<0.05$, significant). Thus hypomagnesemia was significantly associated to the cases of aluminum phosphide poisoning in the present study.

Table 4: Proportion of cases of Aluminum Phosphide poisoning with low and high mean levels of various mean serum Electrolytes

Serum Electrolyte	**AlP Poisoning Patients**	
	<Cut off value (Hypo)	**>Cut off values (Hyper)**
Serum Na+ (mEq/L)	11 (57.8)	8 (42.2)
Serum K+ (mEq/L)	13 (92.8)	1 (7.2)
Serum Ca++ (mg/dL)	23 (85.2)	4 (14.8)
Serum Mg++ (mg/dL)	24 (70.6)	10 (29.4)

Classifying the alterations in serum electrolyte levels in cases of Aluminum phosphide poisoning as per lower and higher than the cut-off value, it was revealed that the changes seen in serum electrolyte were both hypo and hyper in Aluminum Phosphide poisoning cases; however, fall in levels of serum electrolyte levels was more commonly encountered. 57.8% cases presented with hyponatremia in comparison to 42.2% cases with hypernatremia; 92.8% cases were hypokalemic in comparison to 7.2% hyperkalemic cases; 85.2% cases were hypocalcemic in comparison to 14.8% cases with hypercalcaemia; and 70.6 % cases presented with hypomagnesemia in comparison to 29.4% cases with hypermagnesemia. (Table 4)

Table 5: Proportion of cases of Aluminum Phosphide poisoning with low mean serum Electrolyte levels in among recovered and fatal cases

	Expired Patients No. of Cases(28)		Survived Patients No. Of Cases (31)		
Variables	Mean	SD	Mean	SD	*P value*
Serum Na+ (me/L)	130.67	5.85	131.5	5.81	0.590^{ns}
Serum K+ (mEq/L)	3.32	0.76	3.14	0.88	0.400^{ns}
Serum Ca++ (mg/dL)	8.60	0.64	8.02	0.41	0.000*
Serum Mg++ (mg/dL)	1.66	0.43	1.12	0.54	0.001*

*Significant ns- not significant

The above table shows that there is no statistical difference in serum Na+ and K+ values between recovery and fatality consequent to AlP poisoning in patients of the present study. However, serum Mg++ and calcium levels were higher in expired patients in comparison to recovered patients. The average sodium levels in fatal cases were 130.67±5.85 mEq/L as compared to 131.5 ± 5.81 mEq/L in recovered cases. The mean potassium levels were 3.32-±0.76 mEq/L in fatal cases and slightly lower 3.14 ± 0.88 mEq/L in recovered patients. There was no statistically significant difference between mean sodium and potassium levels amongst fatal and recovered cases in the present study.

DISCUSSION

Every year, approximately 800 000 people commit suicide in world, out of which 135 000 (17%) are in India 9 Poisoning (33%), hanging (38%) and self-immolation (9%) are the most common methods used to commit suicide.[10]The incidence of AlP poisoning

has been increasing steadily and is now the most common method of suicide in the Northern India in agricultural community[10, 11]. AlP is a cheap, solid fumigant and a highly toxic pesticide, which is commonly used to protect grain, stores from pests[2].

The present study included 59 cases of AlP poisoning admitted to the SMS hospital Jaipur, Rajasthan during the study period. Among them 86.4% of them were males and 13.6% of them were females, showing that the incidence of poisoning is more common in males. **SINHA US et al. (2005) [12]** found 66.8% male and 33.1% female subject, **Bhalla, et al. (2017) [13]** included 50 patients in their study, out of which 70% were males and 30% were females subjects which is similar to present study.

In the present study among the total 59 cases, 52.5% patients survived and 47.5% patient died. In our study, overall mortality was 47.5 %, which is higher then 33% r reported by Kumar A, et al (2018)[14] and much higher than 21.7% reported by Madhumati R and Durairaj A (2020) [15]. In a study on 418 cases by Chugh et al 1991[16] the overall mortality from AlP poisoning was 77.2%. The relatively lower mortality may be due to exposed tablets taken by many patients in this study, as AlP liberates its toxic component when exposed to air/ moisture which results in reduced toxicity.

When compared to the various serum electrolyte values in healthy controls and AlP poisoning patients in our study had statistically significant only hypomagnesaemia (p 0.04) at the time of admission. In the present study of 59 cases of AlP poisoning, patients expired within hours to 3 days. In these 28 expired patients, on day 1st 57.8% cases presented with hyponatremia in comparison to 42.2% cases with hypernatremia; 92.8% cases were hypokalemic in comparison to 7.2% hyperkalemic cases; 85.2% cases were hypocalcemic in comparison to 14.8% cases with hypercalcaemia; and 70.6 % cases presented with hypomagnesemia in comparison to 29.4% cases with hypermagnesemia. The present study did not reveal statistically significant difference in mean sodium and mean potassium levels in fatal and recovered patients; which has also been reported by Madhumati R and Durairaj A (2020) [15]. However, statistically significant differences were found in expired and survived patients for Calcium & Magnesium levels. Above results are variable from Kumar A, et al. (2018) [14] who reported statistical differences for all four-serum electrolytes.

CONCLUSION:

In the general population, AlP poisoning is a significant contributor to suicidal mortality. According to our study, patients with AlP poisoning had an overall mortality rate of 47.5 percent, which implies that almost half of the suffered died. There are significant alterations in serum calcium and serum magnesium levels in the present study among cases of Aluminimum Phosphide poisoning in comparison to healthy controls and also the mean level of magnesium reveal a significant difference in relation to mortality of the patients. Hyponatremia was reported in 57.8% cases; Hypokalemia in 92.8% cases; Hypomagnesemia was reported in 70.6% cases; and

hypocalcemia in 85.2% cases amongst cases with alteration in serum electrolytes. But, there were cases with hyper levels of all the electrolytes too. Clinical and biochemical parameters play a prognostic role in Aluminium phosphide poisoning cases and prompt follow up of biochemical changes and their management can help in reducing mortality. Thus, ALP poisoning patients require more elaborate studies and research to observe the prognostic factors in biochemical profile for prediction of prognosis.

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