Original Article

Serum Potassium Level in Acute Organophosphorus Poisoning and its Correlation with Severity in Patients Presenting to Emergency Room in a Tertiary Hospital

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ABSTRACT

Background: Organophosphorus compounds (OPCs) are common causes of accidental and suicidal poisoning in agricultural countries like Nepal. Serum cholinesterase, used to diagnose organophosphorus poisoning (OP), is not reliable for predicting its severity. This study aimed to assess serum potassium as an alternative prognostic indicator for OP poisoning severity.

Methodology: This single-centric cross-sectional study included patients presenting with OP poisoning at a tertiary care center over six months. Total 86 cases met the inclusion criteria. The Peradeniya organophosphorus poisoning (POP) scale categorized patients by severity. The association between OP poisoning severity and serum potassium level at presentation was studied.

Results: Of the 86 cases, 47 (55%) were females. The mean age was 26.96 years (SD: 8.73), ranging from 18 to 65 years. Most cases, 53% (n=46), were aged 20-29 years. Chlorpyriphos (50%) + cypermethrin (5%) was the most common OP compound, used in 29% cases. Malathion (50%) was the least used, in 7% (n=6) of cases. At presentation, 36% (n=31) had hypokalemia, among which 6 had mild poisoning (POP score: 0-3), while 25 had moderate to severe case of poisoning (POP score: 4-11). The association between OP poisoning severity and hypokalemia was statistically significant (p-value <0.001, OR: 23.958, 95% CI).

Conclusion: Serum potassium levels in patients presenting within 12 hours of OP poisoning significantly correlate with severity, as determined by the POP scale. Hypokalemia is prevalent in moderate to severe OP poisoning cases, with higher POP scores linked to lower serum potassium levels.

Keywords: Hypokalemia, Organophosphorus Poisoning, POP Scale, Serum Potassium, Severity

Article Information

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INTRODUCTION

Organophosphates are widely used pesticides in rural Asia, where they are easily accessible. Annually, there are about 3 million cases of organophosphate poisoning (OPP) worldwide, mostly from self-poisoning suicide attempts (78.4%), with a mortality rate of 6-30% in low and middle-income countries [1–3]. OPP represents approximately 5.95% of the patient admissions to hospital emergency departments within Nepal [4]. The clinical features of OPC poisoning comprise a triphasic response which includes an initial acute cholinergic phase, an intermediate syndrome (which is associated with high mortality), and nonlethal delayed polyneuropathy associated with morbidity. Hypokalemia is a common electrolyte abnormality seen in patients presenting with acute organophosphorus poisoning which is seen in 24% of patients with OPC poisoning[5]. Hypokalemia in organophosphate poisoning is due to direct gastric and gastrointestinal potassium losses from vomiting and diarrhea, as well as persistent kaliuresis caused by hypochloremic alkalosis and secondary hyperaldosteronism [6].

Various international studies have concluded that serum potassium can be used as a predictive marker of severity in organophosphorus poisoning. Studies have also shown that hypokalemia can be used as a reliable and a cost-effective marker of morbidity and mortality in organophosphorus compound poisoning [7]. However, few studies have been conducted in Nepal on this topic. Hence realizing the limitation of data from Nepal, this study will be conducted in Tribhuvan University Teaching Hospital, to give some insight about the prevalence and clinical profile of acute organophosphorus poisoning in population presenting to a tertiary care center emergency and association of hypokalemia with severity of acute organophosphorus poisoning [8].

Peradeniya Organophosphorus Poisoning (POP) Scale is used to assess the severity of organophosphorus poisoning developed by N Senanaayake et al.[9]. Various studies has demonstrated its usefulness in predicting morbidity and mortality in OPC poisoning [5,10,11]. POP scale at admission, correlated well with the need for ventilator support, the total dose of atropine required, length of stay in the ICU, complications, and mortality. It can thus be used for prognostication and risk stratification of patients with OPC poisoning [12].

METHODS

The study was a mixed method study utilizing both quantitative and qualitative methods in a hospital-based cross-sectional study. The study population included all patients who met the inclusion criteria and visited the emergency service at Tribhuwan University Teaching Hospital (TUTH). The institutional review committee (IRC) at the Institute of Medicine (IOM), approved this study on August 17, 2022 with reference number 101(6-11) E2. The study duration was two years, with data collected from 2079/10/20 to 2080/4/20.

A non-probability convenience sampling method was employed. The sample size for this study was calculated using the standard formula for proportions: $N= [Z^2 p (1-p)] / d^2$, where Z represents the standard normal variate corresponding to a 95% confidence level (1.96), p is the expected proportion of acute OP poisoning cases based on previous studies (0.0595) [4], and d is the precision of the estimate or absolute error, set at 5% (0.05). Substituting these values into the formula, the calculated sample size was approximately 86. Inclusion criteria encompassed all OP poisoning cases confirmed by history, circumstantial evidence of ingestion, and characteristic clinical findings within 12 hours of ingestion at TUTH emergency. Exclusion criteria were: patients with mixed poisoning, chronic kidney disease, cardiac disease, or those on potassium-altering drugs. Study variables included demographic characteristics (age, sex, ethnic group), clinical features (pupil size, respiratory rate, heart rate, fasciculations, level of consciousness, seizure), Peradeniya

Table 1: Clinical Parameters for POP Score Components			
Clinical parameters	Score 0	Score 1	Score 2
Pupil Size	>= 2mm	< 2mm	Pinpoint
Respiratory Rate	<20/min	>= 20/min	>= 20/min with central cyanosis
Heart Rate	>60/min	41-60/min	<40/min
Fasciculations	None	Present, Generalized/ Continuous	Present, Both Generalized and Continuous
Level of consciousness	Conscious and rationale	Impaired response to verbal commands	No response to verbal commands
Seizure	Absent	Present	-

Organophosphorus Poisoning (POP) scale scores, and serum potassium levels. The POP Scale Score categorizes severity as follows: 0-3 is Mild, 4-7 is Moderate, and 8-11 is Severe. After explaining the study and obtaining consent from patients and their families, history was taken and physical examination were conducted. Data was entered into Microsoft Excel 2013 and analyzed using IBM SPSS Statistics Version 26. Parametric data were reported as mean (SD) and compared using independent t-tests, ANOVA tests, and Chi-square tests. Tables and bar graphs were created as needed, with a significance level set at 0.05. A p-value less than 0.05 was considered statistically significant.

Table 1. Outlining the criteria for scoring the severity of organophosphorus poisoning based on six clinical parameters: pupil size, respiratory rate, heart rate, fasciculations, level of consciousness, and seizures. Each parameter is assigned a score from 0 to 2, with higher scores indicating more severe symptoms.

RESULTS

The age distribution of patients shows that the majority (53%) were between 20-29 years old, with smaller proportions in other age groups, and a total of 86 cases included in the study (Table 2). Among the 86 cases in the study sample, the majority were females [47 (55%)], with a male-to-female ratio of 0.83:1. Their age ranged from 18 to 65 years, with a mean age of 26.96 years (SD: 8.73) (Table 3).

The most commonly used organophosphate compound was Chlorpyriphos (50%) + Cypermethrin (5%), used by 25 (29%) patients. Malathion (50%) was the least commonly used, with only 6 patients using it. The frequency of other organophosphorus compounds used by the patients (Table 4).

Most patients experienced mild poisoning, with 53(61%) patients having a POP score of 0–3. Moderate poisoning (POP score: 4–7) was observed in 27(32%) patients, while severe poisoning (POP score: 8–11) was seen in 6 patients (7%). Additionally, 31 (36%) cases presented with hypokalemia at the time of admission. Patients with moderate to severe presentations are significantly more likely to have hypokalemia compared to those with mild presentations. The strong association is highlighted by both the very low p-value and the high odds ratio. (Table 5).

Serum potassium levels varied significantly across different components of the POP score. Patients with a POP score of 0 consistently had the highest mean potassium levels, while those with higher POP scores (1 and 2) had progressively lower levels. This pattern was observed in all components: pupil size, respiratory rate, heart rate, fasciculation, loss of consciousness, and seizure. The differences in potassium levels across POP scores were statistically significant, with p-values < 0.001 for all comparisons, indicating a clear association

between higher POP scores and lower serum potassium levels. (Table 6)

Table 2: Age Distribution of Patients (n=86)

Age (In years)	Frequency	Percentage (%)
<20	14	16
20-29	46	53
30-39	20	24
40-49	3	4
50-59	2	2
60-69	1	1
Total	86	100

Table 3: Frequency of Organophosphorus Compounds Used

OP compounds	Frequency	Percentage:
Chlorpyriphos (50%) + cypermethrin (5%)	25	29%
Dichlorovos (76%)	16	19%
Chlorpyriphos (50%)	15	17.5%
Methylparathion (2%)	15	17.5%
Deltamethrin (1%) + Triazophos (35%)	9	10%
Malathion (50%)	6	7%
Total	86	100%

Table 4: Severity Distribution and Mean Serum Potassium Levels

Severity Distribution	Mild (POP score: 0-3)	Moderate (POP score: 4-7)	Severe (POP score: 8-11)
Frequency (n)	53 (61.6%)	27 (31.4%)	6 (4.7%)
Mean K+ Level (mEq/L)	4.1	3.35	2.88

Table 5: Association Between Hypokalemia and Poisoning Severity

Presentation	Hypokalemia present: (K<3.5mEq/L)	Hypokalemia absent:(K>=3.5mEq/L)	Chi-square value	p-value	OR (95% CI)
Mild	6(11.4%)	47(88.6%)	35.9343	< 0.001*	23.958 (7.4718 to 76.8224)
Moderate to severe	25(75.8%)	8(24.2%)			

* Significant at 99% confidence.

Table 6: Mean Serum Potassium Levels by POP Scale Components

POP Score component:	Mean potassium (mEq/L)	S.D.	Frequency (n)	Percentage (%)	Chi-square value	p-value	Statistical Test
Pupil size:							
POP Score 0:	4.14	0.636	35	41	14.7	< 0.001	ANOVA
POP Score 1:	3.58	0.652	43	50			
POP Score 2:	3.23	0.628	8	9			
Respiratory rate:							
POP Score 0:	4.08	0.629	34	40	12.04	<0.001	ANOVA
POP Score 1:	3.67	0.653	43	50			
POP Score 2:	3.16	0.628	9	10			
Heart Rate:							
POP Score 0:	4.21	0.653	39	45.5	37.22	<0.001	ANOVA
POP Score 1:	3.51	0.628	39	45.5			
POP Score 2:	2.98	0.645	8	9			
Fasciculation:							
POP Score 0:	3.9	0.653	71	83	29.09	<0.001	t-test
POP Score 1:	3.2	0.614	15	17			
POP Score 2:	-	-	-	-			
Loss of consciousness:							
POP Score 0:	4.074	0.653	51	59	36.33	<0.001	t-test
POP Score 1:	3.354	0.628	35	41			
POP Score 2:	-	-	-	-			
Seizure:							
POP Score 0:	3.91	0.653	72	84	41.20	<0.001	t-test
POP Score 1:	3.1	0.617	14	16			

DISCUSSION

Organophosphate (OP) poisoning represents approximately 0.9-1.0% of the patient admissions to hospital emergency departments within Nepal. In contrast, the incidence in the US is about one out of every two million patients presenting to emergency departments, making the incidence 18,000 times higher in Nepal. OP poisoning is significantly more common in developing countries compared to developed countries[13]. In Nepal where agriculture is the main source of the economy, cases of OP poisoning are relatively high, requiring significant attention to address the problem. While rural health facilities have improved, a significant number of cases are still transferred to tertiary care hospitals. This is because rural healthcare remains less equipped, both in terms of advanced medical equipment and skilled manpower, to manage critically ill patients. The inability to immediately triage and refer patients to higher referral centers on time leads to increased mortality and morbidity. Therefore, there is an unmet need for an easily available, inexpensive investigation that can help in the triage of sick patients upon admission to minimize morbidity and initiate treatment with antidotes and other lifesaving medicines immediately, or refer them to a well-equipped center urgently for better management.

Demographically, our study population consists of a total number of 86 patients among them 55% patient were females and 45% were males (M: F ratio = 0.83: 1). This finding is similar to that by Tripathy et al. conducted in Odissa, which showed 52% were females (M:F ratio=

0.92:1)[5] but less compared to the study done by Desai et al in Gujarat, India, which showed only 22% were female (M:F Ratio = 3.54:1).

This difference might be due to geographical distribution of population in different areas. It includes a population ranging from under 20 years to 69 years, with a mean age of 26.96 years. It is lower than the mean age of 33.78 years (S.D: 12.95) reported in the study by Tripathy et al. and 34.47 years. Most of the population were in the 20–29-year age range which is similar compared with the study conducted by Difoesa et al [14]. Based on this profile, most of the population are within the young aged group (20-29 age group). Chlorpyriphos (50%) + cypermethrin (5%) was the most used OP compound,25(29%) of cases used Chlorpyriphos (50%) + cypermethrin (5%) in our study. (Table 3) This finding is comparable with the finding of the study done by Tripathy et. al. and Difoesa et al [5,14]. Malathion (50%) was the least used OP compound, 6 (7%) of cases used malathion (50%), this finding is in contrast with the study done by Tripathy et. al. which showed that Triazophos was the least used OP compound [5].

Through this study, a very significant correlation between the level of serum potassium and the severity of OP poisoning was demonstrated. Sixty-two percent of cases (n=53) in the study had mild poisoning (POP scale: 0–3), 27(31%) of cases had moderate poisoning (POP scale: 4–7), and 6 (7%) of cases had severe poisoning (POP scale: 8-11). This finding is consistent with the study conducted by Umamaheswari et al. [15]. More than a third cases had hypokalemia at the time of presentation, which is higher than the finding of the study done by Tripathy et al., in which 24% of patients were hypokalemic [5]. In addition, the association between the severity of OP poisoning based on the POP scale and hypokalemia was statistically significant. This finding is comparable to the findings of studies conducted by Prasad D.R.M. et al. [7], Dandekar V. et al [8], Narasimhamurthy et al. [16], Kamath et al. [12], and Chandani G. et al. [17].

Our study reveals a progressive decline in physiological parameters as POP Scores increase, which shows worsening of patient conditions. The data shows a significant decrease in potassium levels across all three categories: pupil size, respiratory rate, and heart rate. The trend suggests a steady drop in mean potassium levels from higher to lower score. Additionally, fasciculations were only observed at POP Scores 0 and 1, with significant difference between these two groups. Similarly, loss of consciousness and seizures showed significant differences between POP Score 0 and 1. These findings collectively highlight the correlation between increasing POP Scores and worsening physiological states.

Our study shows a strong correlation between hypokalemia and organophosphorus poisoning severity according to the POP scale. The results indicate that as the severity of poisoning increases, so does the likelihood of hypokalemia. This finding is consistent with previous studies [7][16]. Moreover, our data suggests that decreasing serum potassium levels are associated with increasing OP poisoning severity, which aligns with study by Difoesa et al [12]. Additionally, we observed a corresponding increase in respiratory rate and decrease in heart rate as serum potassium levels decreased, indicating an escalation of the patient's condition.

Hypokalemia is one of the most common electrolyte abnormalities associated with organophosphorus poisoning, a finding previously demonstrated by Tripathy et al [5]. Serum potassium is crucial at the cellular level, affecting heart and skeletal muscle contraction, nerve conduction, and glomerulo-tubular function [18,19].The resting membrane potential and functional activity of electrically excitable cells undergo significant alteration even due to minute changes in extracellular potassium concentration [20], and Balali-Mood et al. revealed that hypokalemia may aggravate muscular weakness due to inhibition of AChE by OP compounds [7].

In acute cases of OP poisoning, due to strong nicotinic actions, respiratory distress, muscle weakness and paralysis sets in. In such stressful conditions, hypokalemia can be established as an add-on to the clinical burden and/or these signs and symptoms can be aggravated in the presence of associated hypokalemia. Death in organophosphorus (OP) poisoning is caused by heart conduction disturbances and respiratory failure during the acute cholinergic crisis period, whereas it is due to respiratory failure in patients with an intermediate syndrome. Additionally, when patients have hypokalemia, cardiac comorbidities and respiratory failure are more frequently associated with organophosphorus poisoning.

In addition to measuring serum cholinesterase levels, it is important to measure potassium levels early to mitigate the severity of organophosphorus (OP) poisoning. Assessing serum potassium is cost-effective, and potassium levels are often abnormal in these cases. Thus, serum potassium can serve as an affordable and readily available prognostic marker for acute OP poisoning. The presence of hypokalemia at the time of admission in patients with OP poisoning indicates severity, necessitating close monitoring during hospitalization for potential dysfunction. Continuous monitoring of electrolytes, along with electrocardiograms and blood oxygen saturation can help prevent major complications in hospitalized patients with OP poisoning.

The study was conducted at a single center, limiting the generalizability of the results. Additionally, the impact of different types of organophosphorus (OP) compounds on serum potassium levels has not been studied individually. The exact amount and form of OP compounds consumed by the patients were not considered in the study. Furthermore, the presentation of patients at different time intervals (less than 12 hours) after consuming OP compounds can lead to varied outcomes in serum potassium levels, which this study did not explore in detail.

CONCLUSION

Our study shows that OP poisoning is more prevalent among females than males. The combination of chlorpyriphos (50%) and cypermethrin (5%) is identified as the most frequently used OP compound. A significant correlation was found between serum potassium levels at the time of emergency presentation and the severity of poisoning as determined by the POP scale. Hypokalemia is notably present in a substantial proportion of patients with moderate to severe OP poisoning. Furthermore, an increase in POP scores for individual components of the POP scale is associated with a statistically significant decline in serum potassium levels. These findings underscore the importance of early serum potassium measurement as a prognostic marker and the need for close monitoring of patients with OP poisoning to prevent severe outcomes.

Author Contributions:

DB, YLS, SG reviewed the literature, conceptualized and designed the research; MY, DB, NAS did data collection, analysis and prepare result, BG, DB, MY, YLS, and NAS drafted the manuscript; and all authors reviewed the manuscript and approved the final version of the manuscript. All authors agreed to be accountable for all aspects of the research work.

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Ethical Approval:

This research was approved by IRC of ABC Institute of Medicine, Tribhuvan University with the reference number of 101(6-11) E2 on 16th August, 2022.

Consent/Assent:

Informed written consent was obtained from the all the participants before data collection.

Data Availability Statement:
The data that support the findings of this study are available within the article and/or its supplementary materials.
Conflicts of Interest:
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