Significance of Serum Potassium Level at Admission in Organophosphorus Poisoning and Impact on Outcome - A Hospital Based Study from North East India

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ABSTRACT

BACKGROUND

Organophosphorus (OP) pesticides are one of the most common cause of morbidity and mortality due to poisoning worldwide especially in agrarian countries like India. Hence it is prudent to undertake a detailed study of clinico-pathological evaluation of OP poisoning and assess the role of serum potassium as an alternative, easy and convenient prognostic indicator in estimating the severity of OP poisoning. This study was undertaken to assess serum potassium levels in patients of acute organophosphorus poisoning and determine association between serum potassium level and outcome in cases of acute organophosphorus poisoning.

METHODS

This was a prospective observational study conducted in Department of General Medicine, Silchar Medical College & Hospital for one year from 1st June 2019 to 31st May 2020 with a sample size of 100 after satisfying the inclusion and exclusion criteria. Peradeniya organophosphorus poisoning (POP) scale was used for categorizing study population according to severity.

RESULTS

Among patients who were admitted with organophosphorus poisoning, 72 % of the patients discharged were having normal serum potassium levels on admission, whereas 22 % (n = 22) patients who died had hypokalaemia at the time of admission. The chi-square value for the association between serum potassium and outcome is statistically significant [P value is 0.001 (P < 0.05)].

CONCLUSIONS

The serum potassium level on the day of admission was significantly correlated with the severity of the acute organophosphate poisoning as determined by Peradeniya OP poisoning scale. The cases that had lower serum potassium levels on admission had poor outcome. Reduced serum potassium levels also had significant association with the need for ventilator support. Therefore, serum potassium can be used as a predictive marker of severity in organophosphorus poisoning. This can help in early triage of patients and will be helpful in reducing mortality and morbidity.

KEYWORDS

Organophosphorus Compound Poisoning, Serum Potassium, POP Scale

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BACKGROUND

Organophosphorus pesticides are one of the most common cause of poisoning related to morbidity and mortality worldwide especially in developing countries like India, where agriculture is the backbone of the economy.[1,2] With increased use of compounds for agricultural and industrial purposes and due to its easy availability and low cost, they are becoming a major cause of health hazard. Increasing incidence of organophosphorus poisoning is an alarming health care challenge in developing countries, in the twenty first century.[3,4]

Organophosphorus insecticides are irreversible inhibitors of carboxylic ester hydrolases, including acetylcholinesterase (AChE), erythrocyte cholinesterase (EChE), plasma or butyl cholinesterase (BChE) and other non-specific proteases. The primary toxicity from these compounds is derived from excessive stimulation of muscarinic and nicotinic cholinergic receptors by added acetylcholine in central and autonomic nervous systems as well as in skeletal neuromuscular junction.[5]

Potassium plays a vital role at the cellular level. Its functions relate mainly to the heart and skeletal muscle contraction, nerve conduction, and glomerulo-tubular renal function.[6] It is seen that hypokalaemia is one of the most common electrolyte abnormality associated with organophosphorus poisoning which has already been demonstrated by Tripathy et al.[7,8] He also demonstrated cardiac comorbidities associated with hypokalaemia in organophosphorus poisoning.[7] It is also seen that hypokalaemia is associated with a ten-fold mortality risk among hospitalized patients due to adverse effects on cardiac rhythm, blood pressure and cardiovascular mortality.[8] Estimation of serum potassium is economical and levels are usually deranged. Serum potassium can be used as a low budget, easily available prognostic marker for acute organophosphorus poisoning.[7]

Organophosphorus poisoning constitutes a major health hazard in northeast India and constitutes a sizeable number of hospital admissions in emergency situations.[8] There is a paucity of literature regarding the clinico-pathological profile of organophosphorus poisoning and its association with serum potassium levels, in India. The data are scarce especially in northeast India regarding the OP poisoning and the consequent role of serum potassium in assessing the severity.

Objectives

The index study was undertaken with the aim to 1) Assess the serum potassium levels in the patients of acute organophosphorus poisoning, 2) Determine association between serum potassium level and outcome in cases of acute organophosphorus poisoning.

METHODS

This was a prospective observational study conducted in Department of General Medicine, Silchar Medical College & Hospital for one year from 1st June 2019 to 31st May 2020 with a sample size of 100 after satisfying the inclusion and exclusion criteria Peradeniya organophosphorus poisoning scale was used for categorizing study population according to severity. The POP scale was based on five clinical sign of acute OP poisoning with each parameter being graded from 0 to 2 in a scale of 3 as per severity. Patient of OP poisoning were categorized as mild (0 - 3), moderate (4 - 7) and severe (8 - 11) on the basis of POP scale at the time of admission. The POP scale is depicted in the Table 1. Data were presented as mean ± standard deviation (SD). Pearson's chi-squared test was done whenever it was necessary and the results were considered statistically significant when the P value was < 0.05.

Inclusion and Exclusion Criteria

Patients who were more than 13 years of age and history of exposure to organophosphorus compound within 24 hours and who gave consent for the study were included in the study whereas patients with other pesticide poisoning, mixed poisoning, consumption of poison with alcohol, patients with renal, hepatic and cardiac disorders were excluded.

All patients were treated as per standard treatment of organophosphorus poisoning followed in our institute. Patients were treated with intravenous fluid, oxygen inhalation as per requirement, a muscarinic antagonist like atropine and an oxime like pralidoxime that helps in rejuvenation of acetylcholinesterase enzyme by removing the phosphate group from it. Ryle's tube insertion was used to remove gastric contents containing the pesticides in order to decontaminate the stomach. Patient's vitals were monitored from time to time with meticulous maintenance of input output values and blood oxygen level. After stabilization, patients were also monitored for need to reduce the dose of atropine, improvement in oxygenation or need for intensive care unit (ICU) admission or ventilation due to worsening hypoxemia or tachypnoea, development of recurrent cholinergic features that occurs from fat soluble organophosphorus pesticides.

Parameter		Score
Pupil size	More than 2 mm	0
	Less than or equal 2 mm	1
	Pin-point pupil	2
Fasciculation	No fasciculation	0
	Present but not generalized or continuous	1
	Generalized or continuous fasciculation	2
Respiratory rate	Less than or equal 20/min	0
	More than 20/min	1
	More than 20/min and cyanosis	2
Pulse rate	More than 60/min	0
	Between 41-60/min	1
	Less than or equal 40/min	2
Conscious level	Conscious and oriented	0
	Impaired but responds to verbal commands	1
	Impaired and no response to verbal commands	2
	Impaired with convulsion	3
	Total Score	11

Table 1. Peradeniya Organophosphorus Poisoning Scale[16]

Once patient's conscious level improved, they were allowed for oral intake of food with head end elevation in

order to prevent aspiration of gastric contents and precipitation of respiratory distress. Many of the patients with OP poisoning developed delirium and were treated with benzodiazepines. As the organophosphorus is rapidly absorbed into blood, activated charcoal was not found to be beneficial in OP poisoning. Regular monitoring of respiratory rate and blood oxygen level was carried out in ICU set up and patient was intubated when tidal volume falls below 5 ml/kg or vital capacity decreases below 15 ml/kg or if patient develops apnoeic episodes. A PaO2 of less than 8 kPa on more than 60 % FiO2 is also an indicator of putting patient into ventilation. Patients were discharged after full stabilization and psychiatric consultation as well as counseling was done.

Statistical Analysis

Statistical analysis will be carried out by Microsoft Excel / Statistical Package for Social Sciences (SPSS) software. During data analysis, student t-test was used to compare continuous variables whereas chi square test was used for comparing categorical variables. Descriptive statistics was used as per requirement. The P value ≤ 0.05 is considered to be a statistically significant value.

RESULTS

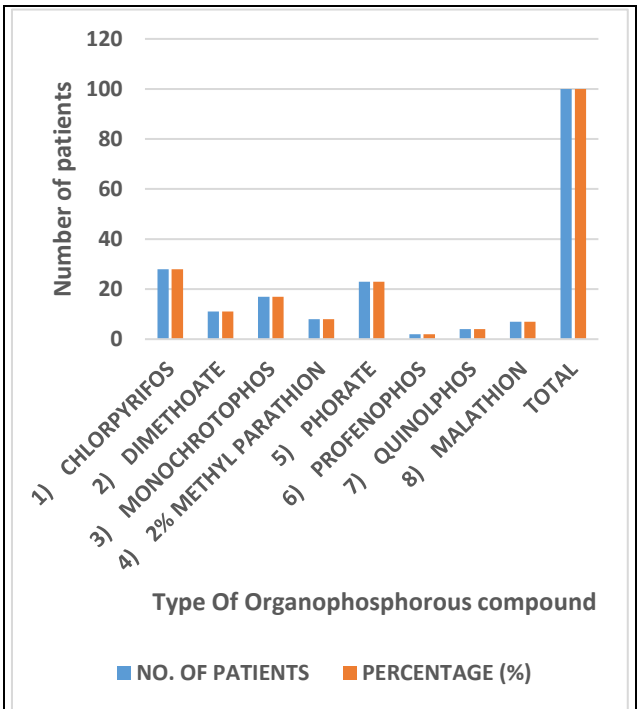

Figure 1. Different Types of OP Pesticide Detected in the Study

Majority of the study population were male (62 %) and 38 % of the patients (n = 38) were female. Most of the patients were between 20 to 40 years age group with the mean age of the study population was 29.06 ± 11.9 years (Range 16 to 60) years. During presentation at emergency, 85 % of our patients were having impaired consciousness while 15 % of the patients were conscious and oriented on admission. The conscious level of the patients at the time of admission was associated with adverse outcome as it was noted that 73 % of the patients with impaired conscious level at admission had poor outcome (P = 0.0001). Most of the patients were students (30 %) by occupation followed by farmers who constituted 22 % of the study population. 18 % of the patients were housewives while service holders were responsible for 11 % of total poisoning cases. Most common compound consumed in the present study as chlorpyrifos (28 %) followed by Phorate (23 %) and monocrotophos (17 %).

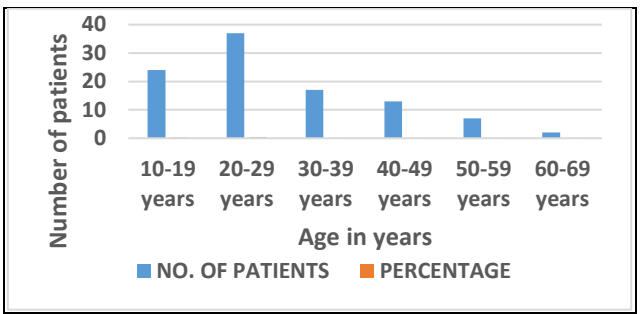

Figure 2. Age Distribution among the Patients of OP Poisoning

Out of all patients admitted with organophosphorus poisoning, 88 % cases were due to consumption of poison from suicidal ideation, 1 % had homicidal intention while accidental poisoning was observed among 11 % of the patients. Majority of suicidal ideation was contributed by depressive disorder exacerbated by anxiety followed by borderline personality disorder which was 2nd most attributable cause of suicidal intake of poison.

Total Number of Patients = 100		
Serum Potassium	**No. of Patients**	**Percentage**
Normal potassium level	72 (Mean serum K + 4.014 ± 0.75)	72 %
Hypokalaemia	28 (Mean serum K + 2.87 ± 0.33)	28 %

Table 2. Distribution of Serum Potassium in Study Population

Hypokalaemia was present among 28 percent (28 patients) out of the total 100 organophosphorus poisoning patients admitted whereas 72 % (72 patients) were having normal serum potassium levels and no one had hyperkalaemia among the study population as shown in Table 2. The mean potassium level among the patients with hypokalaemia was 2.87 ± 0.33 milliequivalent/dl. The association between serum potassium level and need for mechanical ventilation has been depicted in Table 3.

Overall, 18 out of 100 OP poisoning cases required ventilation and 82 patients recovered without ventilator use. Out of the 100 patients on presentation, 13 patients with hypokalaemia required ventilator whereas only 5 patients with normal serum potassium required ventilator assistance. Thus, serum potassium (hypokalaemia) is significantly associated with ventilator requirement as per the chi-square test (P value = 0.0001).

Total Number of Patients = 100				
Serum Potassium	**No Ventilator Requirement**	**Ventilator Required**	**Total**	**Percentage of Ventilator Requirement**
Normal	67	5	72	6.94 %
Hypokalaemia	15	13	28	46.42 %
Total	82	18	100	18 %

Table 3. Association of Serum Potassium with Ventilator Requirement

Among patients with hypokalaemia, 2 out of 15 patients did not required ventilator whereas 62 patients out of 67 patients who had normal potassium level did not required ventilator use at all. The association between serum potassium and outcome is shown in Table 4.

Among the patients who were admitted with organophosphorus poisoning, 72 % of the discharged patients were having normal serum potassium levels on admission, whereas 22 % (n = 22) patients that could not recover and expired were having less than normal potassium level on admission. 6 % of discharged patients (n = 6) were having normal serum potassium levels on admission. The chi-square value for the association between serum potassium and outcome is statistically significant as P value is 0.001 (P < 0.05). This implies that in organophosphorus poisoning, outcome is significantly associated with the level of serum potassium on admission. When severity of poisoning was determined on the basis of POP scale out of 100 patients, 70 % of the patients had mild severity while moderate severity was noted among 8 % of the cases.

Total Number of Patients = 100			
Serum Potassium	**Discharged**	**Death**	**Total**
Normal	72	0	72
Hypokalaemia	6	22	28
Total	**78**	**22**	**100**

Table 4. Association of Serum Potassium with Outcome

However, 22 % of the patients had severe illness as per POP scale which was associated with poor outcome. Hypokalaemia at admission was associated with more severe disease and higher POP score with bad outcome as compared to normal potassium level at admission which was associated with mild illness with lower POP score and good outcome. The poor outcome in severe organophosphorus poisoning cases could be attributed to the abnormal cardiac rhythm observed among patients due to hypokalaemia. Out of 28 patients who presented with hypokalaemia on admission, 15 patients (53.5 %) had QT prolongation on electrocardiogram (ECG) while in 7 patients (25 %) ventricular ectopic was observed. However, 6 patients (21.5 %) with hypokalaemia had normal ECG and little cardiac dysfunction was observed amongst them. Thus, hypokalaemia at admission in patients with organophosphorus poisoning had profound effect on morbidity and associated with increased need for ventilation, cardiac dysfunction and poor outcome leading to prolonged hospitalisation and increased expenditure of healthcare system.

DISCUSSION

Organophosphorus poisoning is an important clinical entity more so in agrarian and rural countries of Asia where cultivation is the predominant source of economy as well as employment. The hospitals in these far flanged and rural areas bear most of the brunt of cases due to lack of hospital beds, ICU set up and ventilators. Also, paucity of skilled health care workers and availability of medicines, compound the problem leading to serious strain between the already fragile doctor patient relationships in these underdeveloped nations. Moreover, rural health care is less equipped both in terms of equipment and skilled manpower to deal with very sick patients and inability to immediately triage and refer patients to higher referral centre on time leads to increased mortality and morbidity. Therefore, there is an unmet need of an easily available, inexpensive investigation which can help in triage of sick patients on admission so as to minimise morbidity and start treatment with antidotes and other life-saving medicines in very sick patients immediately or refer them to a well-equipped centre urgently for better management.

The present study showed that there was a high degree of correlation between the serum potassium level on admission and the severity of organophosphorus poisoning as illustrated by negative correlation of serum potassium with Peradeniya organophosphorus score. The correlation was found to be statistically significant (P = < 0.00001). As the severity increases, serum potassium levels were decreasing and minimum serum potassium levels was noted in the severe forms of OP poisoning. Also, the study revealed that lower potassium level at admission was associated with increased risk of arrhythmia or other forms of disorder of cardiac rhythm in patients with OP poisoning.

D. R. Mahadeshwara Prasad et al.[9] SK Tripathy et al.[8] and Laudari S. and Patowary[10] in their study showed similar results as hypokalaemia was correlated with severity of organophosphorus poisoning. Our study has also observed that patients with organophosphorus poisoning with potassium level had developed more complications with increased need for ICU admission, higher need for ventilatory support.

In D. R. Mahadeshwara Prasad et al.[9] 61.9 % of severe cases (according to Proudfoot classification) were having hypokalaemia. Our study has observed that patients who had hypokalaemia, had a higher mortality rate as compared to cases of OP poisoning who had normal potassium level. Increased mortality could be attributed to the higher incidence of cardiac disorder associated with low potassium level. Early decontamination of stomach by gastric lavage was found to be useful in reducing severity of poisoning when patient present early in emergency after consumption of OP pesticides. However, the utility of gastric lavage on late presentation after poison ingestion or repeated lavage is not very clear cut.[11] Renal involvement is rare but important sequelae of organophosphorus poisoning. Renal complication like renal tubular acidosis can lead to hypokalaemia associated ventricular arrhythmia which improves completely after treatment.[12] Other complications that can arise from organophosphorus poisoning or chronic exposure of OP pesticides includes involvement of central and peripheral nervous system, pancreatitis and hepatitis. Excess acetylcholine in neuromuscular junction is the predominant cause of nervous system dysfunction in organophosphorus poisoning. On the other hand, neuromuscular involvement due to excess acetylcholine can also precipitate muscular weakness predominantly involving head and neck muscle.[13] The muscular weakness that tends to appear 24 to 96 hours after resolution of acute cholinergic syndrome following treatment with atropine is defined as

intermediate syndrome. The muscular weakness most commonly affects the proximal neck and limb muscles of the body followed by muscles that are innervated by the cranial nerves. Progressive involvement can also affect muscles of respiration leading to respiratory failure. The disorderly neuromuscular transmission observed in OP poisoning is diagnosed on the basis of repetitive nerve stimulation and electromyography carried out on single nerve fibre. Although the muscular weakness due to neuromuscular junction abnormality in OP poisoning increases progressively over a period of time, the electrophysiological changes resolves in majority of the cases. However, in small minority of severe cases, the weakness can lead to fatal respiratory failure that contributes to mortality. The toxicokinetics of different OP pesticides as well as treatment with pralidoxime can influence the outcome and degree of neuromuscular transmission defect. Inadequate treatment by oximes as well as genetic predisposition of each patient is another potential factor that can influence the individual variability of muscular weakness and progression. Sequential repetitive nerve stimulation need to be carried out in OP poisoning patients in order to monitor decremental response to stimulation which indicates an ominous sign of progression and imminent respiratory failure.[14] Serum potassium level on admission could help in determination of the need for gastric lavage particularly in very sick patients and who should be shifted to ICU immediately for close monitoring.

Patients admitted with OP poisoning are treated with gastric lavage, intravenous fluid, oxygen inhalation as per requirement, atropine injection and pralidoxime. The role of pralidoxime is controversial and pralidoxime use has been found to be useful in reducing mortality as observed in few studies. However, atropine and pralidoxime combination is not beneficial as compared to atropine alone. The need for ventilatory support, duration of mechanical ventilation, frequency of intermediate syndrome, median days of ICU stay and mortality rate are not significantly different between pralidoxime plus atropine and atropine alone group.[15] The mortality rate in patients having severe OP poisoning is high as compared to moderate OP poisoning state. Around 20 % of admitted patients require ventilatory support and almost half of the ventilated patients die from complications although the overall mortality is around 27 %. The complications associated with severe OP poisoning include respiratory failure, convulsion, sepsis, cardiac arrhythmia, asystole and aspiration pneumonia. The cause of hospital mortality among not ventilated patients include cardiac asystole or arrhythmia and sudden respiratory arrest. Delayed presentation to hospital is an important factor in increasing mortality and complications associated with OP poisoning.[16] Hypokalaemia is an important cause of cardiac asystole and it is also associated with abnormal ventricular rhythm. Therefore, presence of hypokalaemia at admission in patients with OP poisoning is a sign of severity and such patients need to be closely monitored during hospitalisation for development of cardiorespiratory dysfunction. Close monitoring of electrolytes, electrocardiogram and blood oxygen saturation can help in preventing major catastrophe among hospitalised patients in OP poisoning.

CONCLUSIONS

In the present study, we found that the presentation of acute organophosphorus (OP) poisoning was more common among younger population, majority being students from the good educational background. The levels of serum potassium on the day of admission was significantly associated with the severity of the acute organophosphate poisoning as determined by Peradeniya OP poisoning scale. The cases that had lower serum potassium levels on admission had poor outcome. Reduced serum potassium levels also had significant association with the need for ventilator support. ECG changes such as QT prolongation and ventricular ectopics were also observed in a majority of patients with hypokalaemia.

Ethical Considerations

Consent was taken from all the participants in this study. The clearance for the study was obtained from institute ethical committee.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
Financial or other competing interests: None.
Disclosure forms provided by the authors are available with the full text of this article at jebmh.com.

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