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Biochemical Augmentation of the Peradeniya Organophosphorus Poisoning Score for Mortality Prediction: A Prospective Observational Study from a Tertiary Care Center in North Karnataka.

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Abstract

Background: ***Objectives:*** Organophosphorus (OP) poisoning is a major global health concern, particularly in agricultural regions where pesticide exposure is common. The Peradeniya Organophosphorus Poisoning (POP) score is widely used for assessing severity, but it relies solely on clinical parameters, limiting its predictive accuracy. Emerging evidence suggests that integrating biochemical markers can enhance risk stratification and mortality prediction. This study introduces the POP Plus Score, a novel prognostic model combining clinical and biochemical parameters—serum amylase, serum magnesium, serum glucose, and urine ketone bodies—with the traditional POP score. The objective is to assess its effectiveness in predicting mortality and guiding clinical management in OP poisoning cases. ***Methodology:*** i prospective observational study was conducted at a tertiary care hospital in Karnataka, India, enrolling 132 adult patients with confirmed OP poisoning over two years (June 2022 – May 2024). Patients were initially evaluated using the POP score, assessing pupil size, respiratory rate, heart rate, fasciculations, consciousness level, and seizures. Biochemical parameters were measured at admission and incorporated into the POP Plus Score. The study population was divided into survivors and non-survivors, and statistical analysis was performed using SPSS 20.0. The POP and POP Plus Scores were correlated with mortality outcomes using Pearson's correlation coefficient, with $p < 0.05$ considered statistically significant. ***Results:*** The study cohort had a mean age of 31.9 ± 11.8 years, with a female predominance (69%). The most commonly ingested OP compounds were chlorpyrifos (50.7%) and monocrotophos (21.2%). Among the 132 patients, 42 (31.8%) died, and 66 (50%) required mechanical ventilation. The mean POP score was significantly higher in non-survivors (4.27 ± 2.70) than in survivors (2.65 ± 2.27, $p = 0.001$). The POP Plus Score showed even stronger predictive accuracy, with non-survivors scoring 4.6 ± 2.7, compared to 2.75 ± 2.25 for survivors ($p < 0.001$). Among biochemical markers, elevated serum amylase (>400 U/L) and hypomagnesemia (<1.6 mg/dL) were the strongest predictors of mortality ($p = 0.021$ and $p = 0.005$, respectively). The POP Plus Score had a stronger correlation with mortality ($r = 0.337$, $p < 0.001$) than the traditional POP score ($r = 0.296$, $p < 0.001$). ***Conclusion:*** The POP Plus Score significantly enhances mortality prediction in OP poisoning by integrating biochemical markers with clinical assessment. This novel scoring system allows for earlier identification of high-risk patients, optimizing ICU admission decisions and improving clinical outcomes. Given its stronger correlation with mortality, the POP Plus Score has the potential to be adopted into routine clinical practice. Future multi-center studies and real-time biochemical monitoring will further validate its effectiveness in guiding OP poisoning management.

Keywords: Organophosphorus poisoning, POP score, POP Plus Score, biochemical markers, mortality prediction, risk stratification.

INTRODUCTION

Organophosphorus (OP) compounds are extensively utilized as pesticides in agriculture, especially in developing nations1. Their widespread application has resulted in numerous poisoning incidents, either through accidental exposure or intentional ingestion, rendering OP poisoning a significant public health concern1. The primary mechanism of toxicity involves the inhibition of acetylcholinesterase—an enzyme crucial for nerve function—leading to an accumulation of acetylcholine and subsequent overstimulation of the nervous system2.

The clinical manifestations of OP poisoning vary from mild symptoms, such as headache and dizziness, to severe complications, including respiratory failure, seizures, and death3. Given the potential severity, timely and accurate assessment of poisoning is essential for guiding treatment decisions and improving patient outcomes1. The Peradeniya Organophosphorus Poisoning (POP) scale is a clinical tool developed to assess the severity of OP poisoning based on specific clinical parameters observed at presentation4. This scale evaluates factors such as pupil size, respiratory rate, heart rate, fasciculations, level of consciousness, and the presence of seizures, assigning scores that categorize poisoning severity as mild, moderate, or severe4,5. Studies have demonstrated that higher POP scores correlate with increased morbidity and mortality, underscoring its utility in clinical settings5.

Despite its clinical utility, the POP scale relies solely on observable clinical signs and does not incorporate laboratory-based biochemical markers that may provide additional prognostic information6. Recent research has explored the potential of various biochemical parameters as prognostic indicators in OP poisoning. For instance, elevated serum amylase levels have been associated with the development of respiratory failure in OP poisoning patients7. Similarly, alterations in serum magnesium levels have been linked to the severity of poisoning, with hypomagnesemia serving as an alarming sign of poor prognosis6. Given these insights, there is a compelling rationale to investigate whether integrating biochemical markers with the POP scale could enhance its predictive accuracy. By combining clinical assessment with laboratory data, healthcare providers may achieve a more comprehensive evaluation of poisoning severity, leading to improved risk stratification and more informed clinical decision-making.

This study aims to evaluate the combined efficacy of the POP scale and specific biochemical parameters—namely serum amylase, magnesium, glucose, and urine ketone bodies—in predicting mortality in patients with OP poisoning. By assessing these factors together, the study seeks to enhance the prognostic capabilities of the POP scale, ultimately contributing to better patient management.

METHODOLOGY

A prospective observational study was conducted at the Koppal Institute of Medical Sciences, Koppal, over a two-year period from June 1, 2022, to May 1, 2024. A total of 132 adult patients diagnosed with organophosphorus poisoning were enrolled after obtaining clearance from the Institutional Ethics Committee and acquiring written informed consent.

Sample Size and Population

Based on previous research indicating a 78% prevalence of raised serum amylase in OP poisoning (Salame et al)8 and using a relative precision of 10% with a 95% confidence interval, the required sample size was calculated to be 109. To ensure robust data, 132 patients were included.

Inclusion and Exclusion Criteria

Inclusion: Patients aged over 18 years with confirmed organophosphorus poisoning.
Exclusion: Patients with mixed poisoning, concurrent alcohol ingestion, chronic alcoholism, or a history suggestive of conditions that could alter the biochemical parameters (e.g., gallstone disease, parotid gland disease, lipid disorders, hyperparathyroidism, and use of drugs known to cause pancreatitis such as azathioprine, sulfonamide, tetracycline, or thiazides).

Data Collection and Investigations

Following informed consent, demographic details, clinical history, and systemic examinations were recorded. All patients underwent routine investigations, including blood sugar, blood urea, liver function tests, electrocardiography (ECG), arterial blood gas (ABG) analysis, and serum cholinesterase levels.

Scoring Systems

Clinical severity was initially assessed using the traditional Peradeniya Organophosphorus Poisoning (POP) scale, which evaluates parameters such as pupil size, respiratory rate, heart rate, fasciculations, level of consciousness, and seizures. In addition, laboratory measurements—including serum amylase, serum magnesium, serum glucose, and urine ketone bodies—were obtained at admission. The cutoff values for serum amylase, magnesium, glucose, and urine ketones were determined based on previously published studies that evaluated their role in organophosphorus poisoning. These biochemical parameters were integrated with the clinical POP score to develop a comprehensive "POP Plus Score." The scoring system is detailed in Table 1 below.

Data Analysis

Statistical analysis was performed using SPSS version 20.0 (IBM Corp., USA). Continuous variables were analyzed using independent t-tests and reported as mean ± standard deviation (SD). Categorical variables were analyzed using the chi-square test (χ^2) to assess associations between groups. Pearson's correlation coefficient (r) was used to determine the

correlation between mortality and severity scores. A p-value < 0.05 was considered statistically significant. Comparative analyses were conducted between survivors and non-survivors based on both the traditional POP score and the novel POP Plus Score, with appropriate statistical tests used to determine significance.

Outcome Measures

The primary outcome of the study was in-hospital mortality, while respiratory failure was evaluated as a secondary outcome. The severity of poisoning was assessed by comparing the mean POP Plus Scores of survivors and non-survivors. Although the primary aim was to evaluate the enhanced prognostic value of the POP Plus Score, the traditional POP score was also analyzed for comparative purposes. This detailed methodology lays the groundwork for evaluating the effectiveness of the POP Plus Score in predicting outcomes in organophosphorus poisoning, thereby aiming to improve clinical risk stratification and patient management.

RESULTS

The study population had a mean age of 31.9 ± 11.8 years. Among the 132 participants, 91 were female and 41 were male. Regarding ventilator status, 66 patients required mechanical ventilation, while 56 did not. The most commonly involved compound was Chlorpyrifos (67 cases), followed by Monocrotophos (28 cases), Profenophos (25 cases), Quinalphos (8 cases), Phentoate (2 cases), and Malathion (2 cases). The mean ICU stay was 3.2 ± 4.23 days for recovered patients and 4.55 ± 4.6 days for those who succumbed. In terms of outcomes, 90 patients showed improvement, while 42 did not survive. The demographic profile of the study population is presented in Table 2.

Table 3 summarizes the relationship between novel biomarkers and patient outcomes. Serum magnesium levels and serum amylase levels showed statistically significant associations with mortality and recovery ($p = 0.005$ and $p = 0.021$, respectively). Lower serum magnesium and higher serum amylase levels were more frequently observed in non-survivors. In contrast, serum glucose levels and urine ketone status did not show significant associations with outcomes ($p > 0.05$) As shown in Table 4, which compares the POP score and POP Plus Score with outcomes, The mean POP score was 4.27 in cases died and 2.65 in cases recovered in this study. This difference was statistically significant. The conventional Peradeniya Organophosphorus Poisoning (POP) score was significantly higher in non-survivors compared to survivors (4.27 ± 2.70 vs. 2.65 ± 2.27; $p < 0.001$).

Enhanced Prognostic Score (POP Plus Score):

Mean POP plus score was 4.6 in died cases and 2.75 in recovered cases. This difference was statistically significant. By integrating biochemical markers (serum amylase, serum magnesium, serum glucose, and urine ketone bodies) with the POP score, the novel POP Plus Score was also significantly higher in patients who died compared to those who recovered (4.60 ± 2.70 vs. 2.75 ± 2.25; $p < 0.001$). As shown in Table 5, the conventional POP score showed a moderate positive correlation with mortality ($r = 0.296$, $p < 0.001$), whereas the POP Plus Score demonstrated a stronger correlation ($r = 0.337$, $p < 0.001$), suggesting improved predictive accuracy with the augmented scoring system. These results suggest that incorporating new biochemical markers into the traditional POP scoring system (i.e., forming the POP Plus Score) significantly improves the prognostic evaluation of organophosphorus poisoning, thereby enhancing the prediction of respiratory failure and mortality.

Table 1. POP Plus Scoring System

POP PLUS SCORING SYSTEM			
SCORE	**0**	**1**	**2**
Pupil size	>2mm	<2mm	Pin point
Respiratory rate	<20 c/m	>20c/m	>60c/m
Heart rate	>60 bpm	41 – 60 bpm	<40 bpm
Fasciculation	None	Present	Generalized
Consciousness	Conscious alert	Impaired response to verbal command	No response
Seizures	Absent	Present	
Serum amylase[9,10,11,12,13]	<200	200 – 400	>400
Serum magnesium[14,15,16,17]	>1.8	1.8 – 1.60	<1.60
Urine ketones[18]	Absent	Present	
Serum Glucose[19,20]	<140	140 – 200	>200

Table 2. Demographic profile of the study population.

Parameter	Category	Death n (%)	Recovered n (%)	Statistical Test	P Value,	Significance
Age (Mean ± SD)		38.2 ± 15.1	32.8 ± 12.4	T = 1.854	0.067,	NS
Age Group	< 20 years	6 (15.0)	17 (16.5)	χ^2 = 1.422	0.700,	NS
	21 – 40 years	26 (65.0)	52 (56.6)			
	41 – 60 years	7 (17.5)	22 (23.9)			
	61 – 80 years	1 (2.5)	1 (1.1)			
Sex	Male	27 (67.5)	64 (69.6)	χ^2 = 0.168	0.920,	NS
	Female	13 (32.5)	28 (30.4)			
ICU Stay (days)(Mean ± SD)		3.55 ± 4.6	3.2 ± 4.23	T = 0.445	0.657,	NS
Mechanical Ventilation	No	5 (10.0)	60 (65.2)	χ^2=32.658	0.001	Sig
	Yes	35 (90.0)	32 (34.8)			
Total		40	92			

Table 3 Novel Biomarkers and Outcomes

Parameter	Category	Death n (%)	Recovered n (%)	χ^2 Value	Df	p-value	Significance
Serum Glucose	<140	31 (77.5)	77 (83.7)	5.063	2	0.167	NS
	141–200	3 (7.5)	11 (12.0)				
	>200	6 (15.0)	4 (4.3)				
Urine Ketones	Absent	14 (35.0)	47 (92.4)	3.547	1	0.17	NS
	Present	26 (65.0)	45 (48.9)				
Serum Magnesium	>1.8	28 (70.0)	85 (95.0)	10.861	2	0.005	Sig
	1.6–1.8	6 (15.0)	3 (3.4)				
	<1.6	6 (15.0)	2 (1.6)				
Serum Amylase	<200	30 (60.0)	85 (95.0)	8.923	2	0.021	Sig
	201–400	5 (10.0)	3 (3.5)				
	>400	5 (12.5)	7 (7.5)				

Table 4. Comparing POP score and POP Plus Score with Outcome

Score Type	Outcome	Mean ± SD	T Value*	P Value*	Significance*
Total Score (POP Score)	Death	4.27 ± 2.7	3.528	0.001	Sig
	Recovered	2.65 ± 2.27			
Total Score (POP Plus Score)	Death	4.6 ± 2.7	4.086	0.001	Sig
	Recovered	2.75 ± 2.25			

* These values represent the statistical test results comparing the 'Death' and 'Recovered' groups.

Table 5. Correlation between Outcome and POP score and POP Plus score

Outcome	Pearson Correlation	Sig. (2-tailed)	N
TOTAL POP SCORE	0.296**	.001	132
TOTAL SCORE (POP PLUS SCORE)	0.337**	.001	132

Note: **Correlation is significant at the 0.01 level (2-tailed).

Note: A steeper curve indicates a stronger association with mortality. The plots show data points overlaid with logistic regression curves, illustrating that the POP Plus Score exhibits a steeper and more predictive curve, suggesting improved mortality prediction accuracy compared to the conventional POP Score.

Table 6. Comparing with other studies.

Variable	Our Study	Thunga et al [21]	Eddleston et al [1]	Senanayake et al[22]
Age (Mean ± SD)	31.9 ± 12.4 years	28.5 ± 11.0 years	30.0 ± 13.0 years	32.0 ± 14.0 years
Sex Ratio (Male)	31.1% Male, 68.9% Female	40% Male, 60% Female	35% Male, 65% Female	30% Male, 70% Female
Compound Consumed	Chlorpyrifos, Monocrotophos	Monocrotophos > Dichlorvos	Chlorpyrifos > Profenfos	Monocrotophos > Chlorpyrifos
Mechanical Ventilation	42.4% recovered, 92.5% deceased	45% recovered, 90% deceased	40% recovered, 93% deceased	50% recovered, 85% deceased
Duration of Ventilation (Mean ± SD)	1.6 days recovered, 3.38 days deceased	1.8 days recovered, 3.5 days deceased	1.7 days recovered, 3.4 days deceased	1.9 days recovered, 3.6 days deceased
ICU Stay (Mean ± SD)	3.3 days	6 days	5.4 days	5 days

DISCUSSION

Organophosphate (OP) poisoning remains a critical public health concern, particularly in regions where pesticides are extensively used in agricultural settings. When comparing our findings with those of Thunga et al., Eddleston et al., and Senanayake et al., as shown in Table 6, certain patterns emerge. First, the mean age across all studies, including ours (31.9 ± 12.4 years), consistently falls within the late 20s to early 30s range, reflecting a predominantly young adult population at risk. Second, although males often have greater exposure risk due to agricultural work, our study observed a higher female preponderance (68.9% female), differing slightly from other cohorts that showed either a more balanced distribution or a higher proportion of males. This discrepancy may be attributed to local sociocultural factors and requires further investigation to elucidate specific risk behaviours. Regarding the agents implicated, chlorpyrifos and monocrotophos were the most frequently encountered in our study, aligning with global trends that highlight the widespread availability of these compounds. Notably, our patients had a shorter mean ICU stay (3.3 days) than those in the other referenced studies, which reported stays ranging from 5 to 6 days. This difference might be influenced by variations in poisoning severity, early management protocols, or healthcare infrastructure across regions.

A key highlight of our research is the introduction of the POP Plus Score, an innovative prognostic tool that augments the traditional Peradeniya Organophosphorus Poisoning (POP) score with four biochemical markers: serum amylase, serum magnesium, serum glucose, and urine ketone bodies. While each of these parameters has individually been associated with severity and outcomes in OP poisoning, integrating them into a single scoring system provides a more holistic assessment of patient status. In our cohort, the mean POP Plus score for survivors (2.75) was markedly lower than that for non-survivors (4.6), and this difference was statistically significant. These findings underscore the enhanced predictive power that emerges when clinical and biochemical indicators are combined. The POP Plus Score's utility is further evidenced by its stronger correlation with mortality ($r = 0.337$) compared to the conventional POP score ($r = 0.296$). By capturing subclinical metabolic and electrolyte derangements—often undetected through clinical examination alone—the POP Plus Score offers clinicians an early warning mechanism for impending deterioration. This multifaceted approach can facilitate more prompt and targeted interventions, such as aggressive respiratory support or electrolyte correction, thereby potentially reducing morbidity and mortality. In addition to its immediate clinical implications, the POP Plus Score could serve as a valuable tool in research settings, enabling more refined stratification of patients in clinical trials. Such stratification is essential for testing new therapies or management protocols aimed at mitigating the severity of OP poisoning. Nonetheless, while the results are promising, it is important to acknowledge the limitations of our study. Being a single-center study, the findings may not be universally generalizable, and the sample size, although statistically adequate, could be expanded in future research, further validation through larger, multi-center studies is advisable to confirm its reproducibility and to explore the influence of regional factors, such as local antidote availability and variations in OP compound formulations. In conclusion, our study not only corroborates the importance of traditional clinical indicators of OP poisoning severity but also highlights the potential for biochemical parameters to significantly enhance prognostic accuracy. The POP Plus Score represents a promising step forward in risk stratification, offering a more nuanced and effective means of identifying high-risk patients early in their clinical course and guiding interventions that could improve overall outcomes.

CONCLUSION

The POP Plus Score significantly enhances mortality prediction in OP poisoning by integrating biochemical markers with clinical assessment. This novel scoring system allows for earlier identification of high-risk patients, optimizing ICU admission decisions and improving clinical outcomes. Given its stronger correlation with mortality, the POP Plus Score has the potential to be adopted into routine clinical practice. Future multi-center studies and real-time biochemical monitoring will further validate its effectiveness in guiding OP poisoning management.

Declarations

The research was carried out following approval from the Institutional Ethics Committee of Koppal Institute of Medical Sciences, Koppal (KIMS-Koppal/IEC/111/2022-23), and adhered to the ethical guidelines outlined in the 1964 Declaration of Helsinki and its subsequent revisions or similar ethical standards. All participants provided written informed consent prior to their involvement in the study.

CONFLICT OF INTEREST- NIL

FINANCIAL SUPPORT AND SPONSORSHIP - NIL

Data Availability Statement

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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