Original Article

Outcome prediction using sequential organ failure assessment (SOFA) score and serum lactate levels in organophosphate poisoning

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ABSTRACT

Background: Organophosphorus compounds are widely used as pesticides in agriculture practicing countries like India. Since it is readily available and accessible, it is one of the most commonly used agents for suicidal poisoning. The current study was undertaken to evaluate the performance of the SOFA score (scoring system) and the serum lactate level (laboratory parameter) as a mortality predictor in organophosphorus poisoning. **Material and Methods:** This prospective observational study was conducted at AIIMS, Bhubaneswar, for 17 months. The study population included all patients with an alleged history of ingestion of organophosphorus (OP) compounds reporting to the casualty. The receiver operating characteristic (ROC) curve and the logistic regression analysis were used for the analysis. **Results:** In our study, 75 patients with OP poisoning were studied after satisfying the inclusion criteria. OP poisoning was commonly seen in married males aged 21–40 years. Twelve (16%) patients died during the process of treatment. There was a statistically significant difference in the mean SOFA score, serum lactate level, pH value, and mean duration of hospital stay between the discharged and the deceased patients. In the current study, the ROC curve analysis used to assess the predictor of the outcome of OP poisoning showed that the area under the curve for SOFA score and serum lactate level were 0.794 (95% CI 0.641–0.948) and 0.659 (95% CI 0.472–0.847), respectively. **Conclusion:** Sequential Organ Failure Assessment (SOFA) score is significantly associated with the outcome of organophosphate poisoning and can be utilized to predict mortality.

Keywords: Lactate, mortality, organophosphate poisoning, organophosphorus compound, SOFA score

Introduction

Poisoning contributes a significant proportion to morbidity and mortality throughout the world. As per the data of National Crime Records Bureau (NCRB), suicidal deaths due to poisoning in India contributed 26.7% (35,862) and 25.8% (35,882) among 29 states and 7 union territories in the years 2018 and 2019, respectively.[1] In Odisha, sixty percent (60%) of the population is involved in the agricultural sector directly or indirectly.[2] Pesticides are used by farmers to increase crop productivity. Crop failures due to natural calamities like cyclones, droughts, flash floods, financial issues, and family or personal issues may trigger the person to consume poison. Because of their extensive use and easy availability in the household, pesticides have become one of the common modalities of ending one's life.

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The poisoning cases attribute 10% of the load in the emergency (casualty) setting; out of that, about 50% of the cases are due to organophosphorus poisoning.[3] The poisoning due to organophosphorus compounds can be intentional or unintentional. Most cases are due to intentional poisoning when OP (organophosphorus) compounds are self-ingested, while unintentional poisoning occurs due to spraying these compounds without adequate personal protective equipment. The clinical symptoms and severity of the poisoning will depend on the amount, type of OP compound, and route of exposure. The time after which treatment is initiated will also affect the morbidity and mortality of the patient. The case fatality rate due to the organophosphorus compound is 15–30% in India,[4] despite the easy availability of antidotes across all levels of health care.

The SOFA score is widely used in critical care units to monitor acute morbidity. It was developed by the European Society of Intensive Care and Emergency Medicine in October 1994.[5] It measures the degree of organ dysfunction in patients both quantitatively and qualitatively. This scoring system has the advantage over other scoring systems since it is objective, simple, and easy to calculate. A higher score suggests worse organ dysfunction.

Studies have shown that hyperlactatemia is associated with mortality among critically ill patients.[6,7] The serum lactate level is raised due to increased production and decreased clearance by the liver, kidneys, and skeletal muscle due to generalized or localized tissue hypoxia.[8,9] Organophosphate poisoning leads to a series of muscarinic and nicotinic symptoms, which affects tissue microcirculation. Microcirculatory dysfunction can cause regional tissue hypoxia and hyperlactatemia.[10]

The toxicity of organophosphorus compounds is more seen in developing countries because of its easy availability and minimal awareness resulting in high morbidity and mortality.[11] The severity of OP poisoning can be assessed on the basis of signs and symptoms, scoring system, and laboratory markers. Early detection of the severity of OP poisoning will result in more effective patient management and minimize the mortality rate. The severity of OP poisoning could be assessed more objectively even by the primary care providers based on the various parameters available to them corresponding to the SOFA score. Many studies have been carried out to know the severity and the prognosis of organophosphorus poisoning. To date, the SOFA score and serum lactate level have not been studied in relation to organophosphorus poisoning in India. This study aims to evaluate the performance of SOFA score and lactate levels in predicting the mortality of patients with organophosphate poisoning.

Material and Methods

This study was a prospective observational study conducted in the Department of Forensic Medicine &Toxicology in collaboration with the Department of Trauma & Emergency at AIIMS, Bhubaneswar, from August 2019 to December 2020. The study

was approved by the Institutional Ethics Committee vide IEC/AIIMS BBSR/PG THESIS/2019-20/46 dated 20-08-2019. The study population included all patients with an alleged history of ingestion of organophosphorus (OP) compounds reporting to the casualty of the Trauma & Emergency Department at AIIMS, Bhubaneswar. Participants were excluded from the study if (1) had an unclear history regarding the ingestion of OP compound, (2) were associated with another poisoning, (3) OP poisoning in a manner other than oral ingestion, (4) patients who were discharged against medical advice, (5) those who refused to give consent, and (6) brought dead to the casualty. The universal sample size method was adopted for the sample population for the study.

After confirming the poisoning case to be due to ingestion of organophosphorus compound, the data was collected in the case record form after taking the informed consent. The diagnosis of OP poisoning was based on the history or material evidence. The data collected included initial parameters at presentations such as blood pressure, pulse rate, respiratory rate, pH, lactate level, cholinesterase level, and the SOFA score. The patients were followed up in the casualty, ward, and ICU to observe the length of hospital stay and correlate with the outcome. The collected data were statistically analyzed using SPSS version 20. Quantitative data were expressed as mean and standard deviation. Qualitative data were summarized as frequency and percentage. A test of significance for quantitative data was done using Student's t-test for comparison between two groups. Logistic regression analysis was used to find out the association between various parameters and outcomes and the area under the ROC curve to evaluate the predictive value. A P value <0.05 was considered statistically significant for all the statistical tests.

Results

The study was carried out on 75 patients with organophosphorus poisoning cases reported to the casualty of AIIMS, Bhubaneswar, during the study period. Patients aged 21–40 years accounted for 48% of the total study population. The average age of the participants in the study was 33.69 (14.49) years. Socio-demographic details of the study population have been mentioned in Table 1. In our study, married males commonly consumed the OP pesticide. Twelve (16%) patients died during the process of treatment [Table 2].

The presentation parameters were compared between the discharged and the deceased patients as shown in Table 3. The mean hospital stay for the study population was 7.30 (2.94) days. The mean hospital stay was higher in the discharged patients, and the serum lactate levels and the SOFA score were higher in the deceased patients. There was a statistically significant difference in the mean duration of hospital stay, the serum lactate levels, and the SOFA score.

In the study population, the SOFA score ranged from zero to six. We observed the mortality of 57.1% if the SOFA score

was ≥ four, and 14.3% of deaths occurred if the score was between two and three, and 4.3% if the score was ≤ one. The outcome distribution of the study population on the basis of the SOFA score has been depicted in Table 4.

The mean duration of hospital stay was lesser in deceased patients, and the difference was statistically significant for the SOFA score zero to one and two to three. But there was no significant difference in the mean hospital duration for the SOFA score four to six. These findings have been highlighted in Table 5.

The serum lactate levels varied from 0.7 to 12.7. We observed the mortality of 41.6% if the serum lactate levels were >4 and 13.6% of deaths occurred if the value were ≤2. The outcome distribution of the study population on the basis of serum lactate level has been depicted in Table 6.

The odds of increased mortality with a higher SOFA score are statistically significant. So, the SOFA score could be used as a predictor of outcome in acute organophosphorus poisoning. But serum lactate level and pH could not be used as independent prognostic factors. This finding has been represented in Table 7.

Since SOFA score and serum lactate levels were significantly associated with the outcome, the area under the ROC curve was calculated to evaluate the predictive value of the scoring system and the serum lactate levels. Figure 1 shows the ROC curve comparing the SOFA score with the lactate levels.

Table 1: Socio-demographic details of the study population

	n	Percentage
Age group		
≤20 years	17	23
21-40 years	36	48
41-60 years	20	26
>60 years	02	03
Sex		
Male	49	65
Female	26	35
Marital status		
Married	52	69
Unmarried	23	31
Education		
Illiterate	05	07
Primary	15	20
Secondary	30	40
Higher secondary	13	17
Graduate or above	12	16
Occupation		
Farmer	07	09
Housewife	11	15
Student	19	25
Job (government/private)	17	23
Self-employed	16	22
Unemployed	04	05
Retired	01	01

Table 2: Outcome of the studied patients

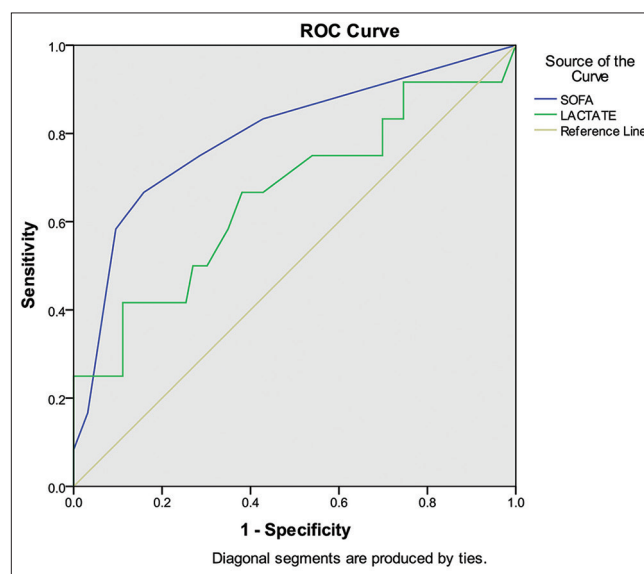| Outcome	Number	Percentage
Discharge	63	84
Death	12	16
Total	75	100

Figure 1: Comparison of ROC curves of SOFA score and serum lactate levels to predict mortality. *ROC = Receiver operating characteristic

Table 3: Basic clinical characteristics of both groups

Parameters	Overall (*n*=75)	Discharged (*n*=63)	Death (*n*=12)	*P**
Mean (SD) SBP (mmHg)	125.09 (22.93)	126.53 (22.27)	117.5 (25.83)	0.21
Mean (SD) DBP (mmHg)	79.38 (17.44)	80.46 (17.93)	73.75 (13.86)	0.22
Mean (SD) PR (beats/min)	107.57 (23.68)	107.69 (23.50)	106.91 (25.60)	0.91
Mean (SD) RR (rate/min)	20.5 (3.09)	20.49 (2.75)	20.58 (4.64)	0.92
Mean pH	7.34 (0.07)	7.35 (0.06)	7.29 (0.09)	0.03
Mean (SD) lactate (mmol/L)	2.58 (2.06)	2.21 (1.39)	4.54 (3.70)	0.02
Mean (SD) cholinesterase (U/L)	2966.05 (1223)	3288.11 (2618.41)	1275.25 (1158.91)	0.22
Mean (SD) SOFA score	1.41 (0.69)	1 (0.43)	3.58 (1.92)	<0.0001
Mean (SD) hospital stay (in days)	7.3 (2.94)	7.88 (2.43)	4.25 (3.57)	<0.0001

*P is considered statistically significant if <0.05. Abbreviations used: SD- standard deviation, SBP - Systolic blood pressure, DBP - Diastolic blood pressure, PR - Pulse rate, RR - Respiratory rate, SOFA-Sequential Organ Failure Assessment

The area under curves for the SOFA score and the serum lactate levels were 0.794 (95% CI 0.641–0.948) and 0.659 (95% CI 0.472–0.847), respectively. Although the area under the receiver operating characteristic curve value is more than 0.5 for serum lactate level, it is not statistically significant. Based on the ROC curves, the cut-off values and the predictive power of the mortality according to SOFA score and lactate levels were listed in Table 8. The sensitivity and specificity of the SOFA score in organophosphorus poisoning were found out with the best cut-off point at score 3.

Discussion

Organophosphorus compounds are one of the most common causes of poisoning in developing countries. In the present

Table 4: SOFA score and the outcome

SOFA score	Discharge (*n*=63)	Death (*n*=12)
0-1 (*n*=48)	45	02
2-3 (*n*=14)	12	02
4-6 (*n*=13)	06	08

Table 5: SOFA score and mean duration of hospital stay (in days)

SOFA score	Hospital stay (in days)		P*
	Discharge	Death	
0-1	7.66	1.33	<0.001
2-3	8.33	2.5	<0.01
4-6	8.66	7	0.24

*P is considered statistically significant if <0.05

Table 6: Serum lactate levels and the outcome

Serum Lactate (mmol/L)	Discharge (*n*=63)	Death (*n*=12)
<1.1 (*n*=10)	09	01
1.1-2 (*n*=12)	10	02
2.1-4 (*n*=41)	37	04
>4 (*n*=12)	07	05

Table 7: Logistic regression analysis for GCS score, serum lactate levels, and pH values to detect independent predictors of outcome

Variables	Odds ratio	95% CI	P*
SOFA score	1.8	1.186-2.804	0.006
Serum lactate levels	1.3	0.945-1.913	0.10
pH	0.2	0.000-2.757	0.76

*P is considered statistically significant if <0.05. CI - Confidence interval

Table 8: Sensitivity and specificity of SOFA score and serum lactate levels in predicting the outcome

Variable	Cut off point	Sensitivity (%)	Specificity (%)	AUC*	P#
SOFA score	≥3	67	84	0.794	0.001
Serum lactate levels	≥3.1	41.7	74.6	0.659	0.08

*AUC=Area under the curve, #P is considered statistically significant if<0.05

study, the mortality rate was 16% (12 deaths in 75 patients), corresponding to the previous studies, i.e., 10–20%.[4,12-16]

There was no age restriction in our study. The minimum age of the study population was 14 years, and the maximum was 73 years, with a mean age of 33.69 (14.49) years. The majority (48%) of the study population aged between 21 and 40. This finding was similar to Moussa *et al*,[16] where 44.5% of the patients were in the age group 18–40 years. Similarly, the mean age was around 30 years in various studies.[4,17,18] The mean age of those who were discharged was 34.39 (13.88) years, while the mean age of those who died was 30.83 (17.78) years. The findings were consistent with Muley *et al*.[12] and Gündüz *et al*.,[13] in which the mean age of the deceased patients in both the studies was 34 years.

In the present study of 75 subjects, 49 (65.33%) were males while 26 (34.67%) were females with a male-to-female ratio of 1.8:1. Studies by Muley *et al*.,[12] Sun *et al*.,[19] Dash *et al*.,[20] and Mohite *et al*.[4] also showed male preponderance with 60%, 62%, 67.1%, and 69.8%, respectively. This was contrary to other studies where females were affected more than males.[13,16,18] Married males were more frequently affected, which is consistent with a study by Dash *et al*.[20]

The average length of hospital stay for the study population was 7.30 (2.94) days, similar to the findings observed by Muley *et al*.[12] (mean hospital duration of 8.5 days). This was contrary to Lee DH *et al*.,[21] where the mean duration of hospital stay was 14 days. The mean hospital stay for the patients discharged after the treatment was 7.88 (2.43) days and 4.25 (3.57) days for those who died. Our study was consistent with Lee DH *et al*.,[21] where hospital stay in discharged patients was more than in deceased patients, and the difference in hospital stay was statistically significant.

The mean lactate level for all the participants was 2.58 (2.06) mmol/l. The mean serum lactate levels for the discharged and the deceased patients were 2.21 (1.39) and 4.54 (3.70), respectively. The lactate levels were lower for the survivors as compared to non-survivors, and the difference was statistically significant, consistent with Yuan *et al*.,[22] Lee DH *et al*.,[21] and Tang *et al*.[14] However, Kim *et al*.[23] did not find any significant difference in the lactate levels between the discharged and deceased patients.

The mean SOFA score observed in the study was 1.41 (0.69). The mean SOFA score for the patients who died during the treatment was 3.58 (1.92), and for those discharged, it was 1 (0.43). The SOFA scores were higher for the non-survivors indicating the severity, and the difference was statistically significant and consistent with the studies by Moussa *et al*.,[16] Yuan *et al*.,[22] and Kim *et al*.[23] The current study showed that the SOFA score could be used as a predictor of outcome in organophosphorus poisoning using logistic regression analysis. The SOFA score is significantly associated with mortality. It also has discriminative power for predicting mortality, similar to the findings of Yuan *et al*.[22] and Kim *et al*.[23]

The patients with organophosphorus poisoning are at a risk of respiratory failure. The primary care physicians need to detect the severity of poisoning for appropriate intervention or referral to the higher centre for further management. The severity could be assessed by the limited clinical parameters available such as blood pressure, CNS dysfunction (GCS score), and respiratory rate. At present, SOFA score is done routinely at the ICU setting but not done at the time of admission in the casualty/emergency wards. So, the hospitals receiving high number of organophosphorus compounds poisoning should start the routine evaluation of the patients using SOFA score to help in achieving the goal toward better healthcare.

In our study, although there is a significant difference in the admission serum lactate levels and pH values between the discharged and the deceased patients, multivariate logistic regression analysis showed that lactate levels and pH values were not independent prognostic factors.

Conclusions

SOFA score is significantly associated with the outcome of organophosphate poisoning and can be utilized to predict mortality. Although there is a significant difference in the serum lactate levels and pH values between the discharged and the deceased patients, these cannot be used as prognostic factors.

Limitations

Certain limitations of this study should be taken into account. Firstly, the small sample size of the present study could limit the generalization of the results to the whole population. Secondly, the outcome was predicted based on the SOFA score calculated at admission (no serial measurement was done). Thirdly, the amount of OP ingested was not correlated, nor was the type of OP compound taken by the patients. Fourthly, the time interval between ingestion and the initiation of treatment was also not considered, as most of the patients were referred from nearby primary-level hospitals. Further studies should be conducted to evaluate the predictive capability of SOFA score in organophosphorus poisoning with larger sample size.

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Conflicts of interest

There are no conflicts of interest.

References

1. India. National Crime Records Bureau. Accidental Deaths & Suicides in India 2019. Delhi: Ministry of Home Affairs; 2020.

2. Government of Odisha, India. Directorate of Agriculture and Food Production. Odisha Agriculture Statistics 2017-18. Bhubaneswar: Department of Agriculture and Farmers' Employment; 2020.

3. Wadia SR. Organophosphate poisoning. In: Shah SN, Paul AM, Acharya VN, Bichile SK, Karnad DR, Kamath SA, *et al.* editors. API Textbook of Medicine. 7th ed. Mumbai: The Association of Physicians of India; 2003. p. 1271-2.

4. Mohite PM, Anjankar AJ, Patnod S. Organo phosphorus poisoning: Prognostic value of GCS score & other clinical indicators in assessing the final outcome. J Indian Acad Forensic Med 2018;40:197-205.

5. Vincent JL, Moreno R, Takala J, Willatts S, De Mendonça A, Bruining H, *et al.* The SOFA score to describe organ dysfunction/failure. On behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine. Intensive Care Med 1996;22:707-10.

6. Del Portal DA, Shofer F, Mikkelsen ME, Dorsey PJ, Gaieski DF, Goyal M, *et al.* Emergency department lactate is associated with mortality in older adults admitted with and without infections. Acad Emerg Med 2010;17:260-8.

7. Shapiro NI, Howell MD, Talmor D, Nathanson LA, Lisbon A, Wolfe RE, *et al.* Serum lactate as a predictor of mortality in emergency department patients with infection. Ann Emerg Med 2005;45:524-8.

8. Kraut JA, Madias NE. Lactic acidosis. N Engl J Med 2014;371:2309-19.

9. Levraut J, Ciebiera JP, Chave S, Rabary O, Jambou P, Carles M, *et al.* Mild hyperlactatemia in stable septic patients is due to impaired lactate clearance rather than overproduction. Am J Respir Crit Care Med 1998;157:1021-6.

10. Ince C. The microcirculation is the motor of sepsis. Crit Care 2005;9:1-7. doi: 10.1186/cc3753.

11. Kumar SV, Fareedullah MD, Sudhakar Y, Venkateswarlu B, Kumar EA. Current review on organophosphorus poisoning. Arch Appl Sci Res 2010;2:199-215.

12. Muley A, Shah C, Lakhani J, Bapna M, Mehta J. To identify morbidity and mortality predictors in acute organophosphate poisoning. Indian J Crit Care Med 2014;18:297-300.

13. Gündüz E, Dursun R, Icer M, Zengin Y, Güllü MN, Durgun HM, *et al.* Factors affecting mortality in patients with organophosphate poisoning. J Pak Med Assoc 2015;65:967-72.

14. Tang W, Ruan F, Chen Q, Chen S, Shao X, Gao J, *et al.* Independent prognostic factors for acute organophosphorus pesticide poisoning. Respir Care 2016;61:965-70.

15. Lee SB, Kang C, Kim DH, Kim T, Lee SH, Jeong JH, *et al.* Base deficit is a predictor of mortality in organophosphate insecticide poisoning. Hum Exp Toxicol 2018;37:118-24.

16. Moussa M, Mohamed S, Hilal M, Elnabi M, Zaki N. The Role of APACHE II, SOFA, serum amylase and lipase in assessment of severity and outcome of acute organophosphorus poisoning. Ain Shams J Forensic Med Clin Toxicol 2018;31:41-50.

17. Rabha M, Baruah C, Boro M. Clinical profile of acute organophosphorous poisoning with special reference to serum creatine phosphokinase and serum lactate dehydrogenase levels as prognostic markers: A tertiary care hospital based observational study in north-East India. Int J Med Res Prof 2017;3:83-8.

18. Acikalin A, Dişel NR, Matyar S, Sebe A, Kekec Z, Gokel Y, *et al.* Prognostic factors determining morbidity and mortality in organophosphate poisoning. Pak J Med Sci 2017;33:534-9.

19. Sun IO, Yoon HJ and Lee KY. Prognostic factors in

cholinesterase inhibitor poisoning. Med Sci Monit 2015;21:2900-8.

20. Dash SK, Mohanty MK, Mohanty S, Patnaik KK. Organophosphorus poisoning: Victim specific analysis of mortality and morbidity. Med Sci Law 2008;48:241-5.

21. Lee DH, Lee BK. Performance of the simplified acute physiology score III in acute organophosphate poisoning: A retrospective observational study. Hum Exp Toxicol 2018;37:221-8.

22. Yuan S, Gao Y, Ji W, Song J, Mei X. The evaluation of acute physiology and chronic health evaluation II score, poisoning severity score, sequential organ failure assessment score combine with lactate to assess the prognosis of the patients with acute organophosphate pesticide poisoning. Medicine (Baltimore) 2018;97:e10862. doi: 10.1097/MD.0000000000010862.

23. Kim YH, Yeo JH, Kang MJ, Lee JH, Cho KW, Hwang S, *et al*. Performance assessment of the SOFA, APACHE II scoring system, and SAPS II in intensive care unit organophosphate poisoned patients. J Korean Med Sci 2013;28:1822-6.