ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research

Vol. 16, Issue, 11, pp.30528-30533, November, 2024
DOI: https://doi.org/10.24941/ijcr.48062.11.2024

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

A STUDY OF SERUM ALBUMIN AND SERUM FERRITIN LEVEL IN ORGANOPHOSPHORUS POISONING AS A PROGNOSTIC MARKER AND ITS CORRELATION WITH SEVERITY AND OUTCOME

Dr. Mahesh Dave‡, Dr. Ramgopal Saini†, Dr. Avinash Sharma##,*, Dr. Geetika Roat#, Dr. Deepanshu##, Dr. Anshul Doshi##, Dr. Sushma N.## and Dr. Kartavya Nandwana##

‡Senior Professor and Unit Head, Dept. of General Medicine, RNT Medical College, Udaipur, Rajasthan
†Assistant professor, Dept. of General Medicine, RNT Medical College, Udaipur, Rajasthan
#Senior Resident, Dept. of General Medicine, RNT Medical College, Udaipur, Rajasthan
##Junior Resident, Dept. of General Medicine, RNT Medical College, Udaipur, Rajasthan

ARTICLE INFO

Article History:
Received 24th August, 2024
Received in revised form
17th September, 2024
Accepted 29th October, 2024
Published online 30th November, 2024

Key Words:
Organophosphorus,
Poisoning,
Albumin, Ferritin.

Corresponding author:
Dr. Avinash Sharma

ABSTRACT

Introduction: In developing countries poisoning is a common method of suicide. OPC poisoning either suicidal (intentional self-poisoning) or accidental is a significant health hazard in developing countries like India. Various biochemical markers correlates with severity and outcome in OPC poisoning, helps in determine prognosis and effective treatment strategy. **Material and Methods:** This was a hospital-based cross-sectional study. We studied 100 patients of OPC poisoning admitted in medicine wards confirmed by history, examination and circumstantial evidence of ingestion. Patients were classified into 3 categories based on severity according to POPS scale: Mild (score 0-3), Moderate (score 4-7), Severe (score 8-11). Patients were also classified into 2 categories based on clinical outcome: Improved (complete recovery) and death. Severity and clinical outcome of OPC poisoning correlated with Serum Albumin and Serum Ferritin level on day 1 and day 3. Clinical outcome of OPC poisoning also correlated with POPS scale. **Results:** Out of 100 patients we studied, 74 (74%) patients had mild, 18 (18%) had moderate and 8 (8%) had severe poisoning according to POPS scale. Out of 100 patients, Outcome of patients was: 12 (12%) patients died and 88 (88%) survived. Correlation between POPS scale severity and clinical outcome was found to be statistically significant. Hypoalbuminemia and Increased Serum ferritin level on the day of admission and also the rate of change (on day 3) correlated with severity and outcome, which was found to be statistically significant. **Conclusion:** Hypoalbuminemia and increased serum ferritin level was linked with increasing severity and mortality risk in OPC poisoning. Specifically, serum albumin appears to have a protective effect that may influence the outcome in OP poisoning cases. Given this finding, there is a suggestion that the therapeutic potential of direct albumin replacement therapy should be explored for patients with low serum albumin levels in OP poisoning. They tell us about patient's prognosis and guide the development of more effective treatment strategies.

Citation: Dr. Mahesh Dave, Dr. Ramgopal Saini, Dr. Avinash Sharma, Dr. Geetika Roat, Dr. Deepanshu, Dr. Anshul Doshi, Dr. Sushma N. and Dr. Kartavya Nandwana. 2024. "A study of serum albumin and serum ferritin level in organophosphorus poisoning as a prognostic marker and its correlation with severity and outcome*". International Journal of Current Research*, 16, (11), 30528-30533.

INTRODUCTION

In developing countries, poisoning is a common method of suicide. Pesticide poisoning is a significant health hazard in these regions.[1] According to a World Health Organization report, approximately three million cases of pesticide poisoning occur globally each year, with most cases occurring in Asia. Among these, 50% involve organophosphate poisoning. Despite the availability of antidotes, the mortality rate from OP poisoning remains high at 10%-20%.[2]

OPC poisoning manifests through a triphasic response: an initial acute cholinergic phase, an intermediate syndrome (which carries a high mortality risk), and a nonlethal delayed polyneuropathy that causes morbidity. Diagnosing organophosphorus poisoning relies heavily on clinical suspicion due to the absence of specific features. A combination of exposure history and typical clinical signs often facilitates diagnosis. Early recognition and aggressive treatment are essential for improving survival rates in OPC poisoning cases. Identifying predictive prognostic features can help clinicians categorize patients by their risk of deterioration.

To assess the severity of OPC poisoning and predict clinical outcomes, various clinical and laboratory parameters are used. The Peradeniya Organophosphorus Poisoning Scale (POPS), developed by N. Senanayake, H.J. de Silva, and L. Keralliceede at the University of Peradeniya, Sri Lanka, is a tool designed to evaluate the severity of OPC intoxication.[3] Studies have demonstrated its efficacy in predicting morbidity and mortality in OPC poisoning cases.[4] Hypoalbuminemia is widely recognized as a marker of poor outcomes, including higher mortality rates, increased morbidity and extended stays in ICUs and hospitals across a variety of medical conditions and injuries. Serum albumin is a marker of poor nutritional status. Additionally, hypoalbuminemia correlates with impaired physiological functions of albumin, including maintaining oncotic pressure, transporting ions and drugs, scavenging free radicals, and acting as an antioxidant.[5] Albumin is also a negative acute-phase reactant, with its synthesis decreasing during inflammation. Serum albumin also has a role in OP detoxification and reducing the availability of OP compounds to inhibit acetylcholinesterases.

Ferritin, a key component of the immune system, plays a crucial role in signaling cellular defensive responses to inflammation, functioning as both an acute-phase reactant and a mediator of immune dysregulation during infections. In conditions such as sepsis, characterized by dysregulated organ function due to infection, inflammatory cytokines can further elevate serum ferritin levels, highlighting its role as a biomarker of systemic inflammation and disease severity.[6] Despite its widespread availability and routine collection in medical settings, the role of ferritin in predicting mortality in OPC poisoning patients has not been studied to date. Recent studies have explored the use of various parameters, such as liver enzymes, serum amylase, and serum CPK, as new markers to assess the severity and prognosis of OPC poisoning.[7] Our study aims to assess parameters such as serum albumin and serum ferritin levels to predict the severity and prognosis in patients with OPC poisoning.

MATERIAL AND METHODS

This was a hospital-based cross-sectional study. The study design was approved by institutional ethical committee at RNT Medical College & Controller & Attached Hospitals, Udaipur. We enrolled 100 patients in our study, conducted from October 2023 to completion of sample size.

The Inclusion criteria were as follows: Patients who have consumed Organophosphorus compound confirmed by history, circumstantial evidence of ingestion, admitted in our hospital with characteristic clinical finding. Patients/Relatives who had given written informed consent. Age≥18 years

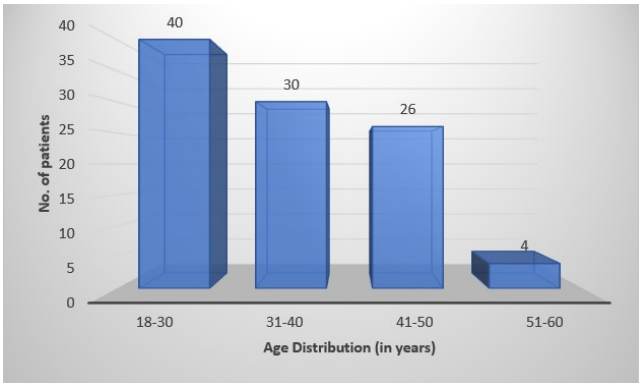
Exclusion criteria were as follows: Patients with feature of exposure to another compound not relating to OPC poison. Patients with consumption of more than one poisonous substance. Patients having history of chronic inflammatory conditions. Patients with history of any chronic illnesses like Chronic liver disease, Chronic kidney disease etc., Covid-19, Tuberculosis, Acute febrile illness, Severe anemia, hemochromatosis.

METHODOLOGY: All patients of Organophosphorus poisoning who were admitted in various medical wards and ICU's of Maharana Bhupal Government Hospital attached with RNT medical college, Udaipur after taking written consent were enrolled in study. In all patients after initial resuscitation and gastric lavage, variables like age, gender, occupation, Rural/ urban, education status, economic background were noted. Nature of poisoning (suicidal/accidental), the dose and characteristics of the poison consumed and the delay in presentation/lag period to hospital were noted. Clinical presentation like Nausea/vomiting, lacrimation, salivation, diarrhea, Urinary incontinence, hypotension/hypertension, bradycardia/tachycardia, fasciculations were recorded. General physical examination as well as complete systemic examination was done. All routine investigations including CBC, RFT, LFT, serum amylase, Cardiac markers like Troponin T and CKMB, X-ray chest, ECG was done. Serum Albumin and Serum Ferritin level was done on day 1 and day 3. Peradeniya Organophosphorus Poisoning (POP) scale was applied to all study subjects at the time of admission, and cases were graded as mild (score 0–3), moderate (score 4–7), and severe (score 8–11) poisoning. Statistical analysis of various parameters was made to determine the prognostic factors. Parameters like Age, Sex, Lag period, clinical presentation and lab. parameters were compared. Serum albumin and serum ferritin level was correlated with severity of OPC poisoning and also correlate with outcome of the OPC poisoning.

Statistical Analysis: All the information's were recorded in predesigned proforma and a master chart for all patients were prepared in Microsoft excel. Tabulated and graphical data was generated with the help of Microsoft word and excel. Then this data was analyzed in terms of descriptive statistics using SPSS software 26.0 version. Nominal or categorial data between the groups was compared using the Chi-square test or Fisher's exact test, thereafter p-value was calculated. Similarly, Mean and Standard deviation were calculated for continuous data of comparison groups and p-value was calculated. P-value less than 0.05 was considered statistically significant.

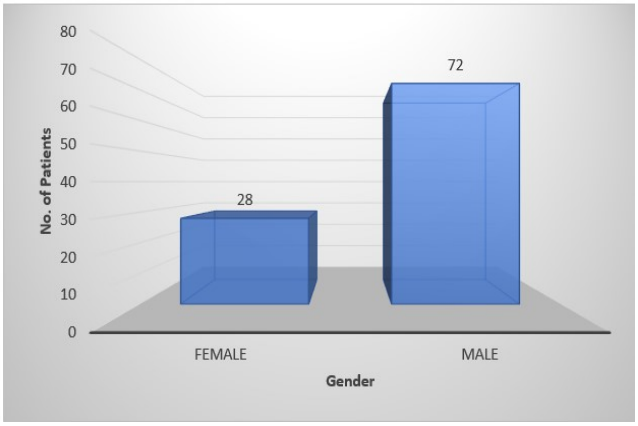
RESULTS

This study was done in Maharana Bhupal Govt Hospital Udaipur Rajasthan from October 2023 to July 2024. 100 patients were enrolled in the study.



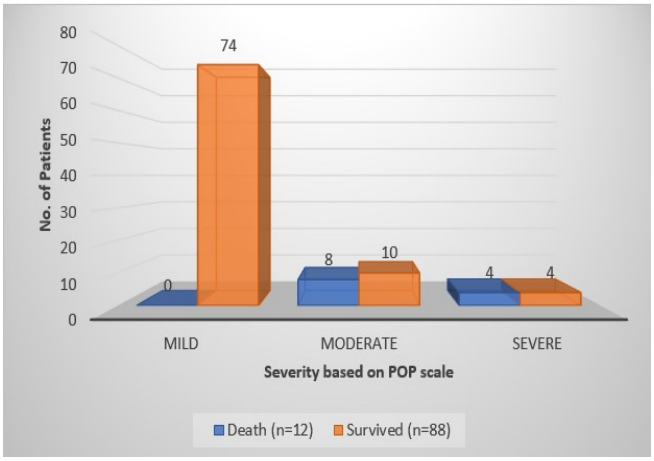
Graph 1. Distribution of patients according to age

Among 100 patients, 40 patients (40%) were aged between 18-30 years, 30 patients (30%) were aged between 31-40 years, 26 patients (26%) were aged between 41-50 years, and 4 patients (4%) were aged between 51-60 years. Graph 1 depicts that maximum patients of OPC poisoning in our study was in younger age group. Among 100 patients, there were 28 female patients (28%) and 72 male patients (72%). Graph 2 depicts that maximum patients of OPC poisoning in our study were males.



Graph 2. Distribution of patients according to gender

In our study patients are divided into three groups based on severity classification according to POP scale as mild, moderate and severe. 74 patients (74%) in the mild group, 18 patients (18%) in the moderate group and 8 patients (8%) in severe group. Based on Outcome (survival) patients were divided into two groups; 12 patients (12%) had died and 88 (88%) survived. Severity according to POP scale were correlated with Outcome of patients. Graph 3 shows that among those who died (n=12), none (0.00%) were classified as mild, 8 patients (66.67%) had moderate severity, and 4 patients (33.33%) had severe severity. In contrast, among the survivors (n=88), 74 patients (84.09%) were classified as mild, 10 patients (11.36%) had moderate severity, and 4 patients (4.55%) had severe severity. (Graph 3) .The p-value for this comparison was <0.0001, which was statistically significant.



Graph 3. Correlation between POP scale and clinical outcome (survival and death)

Table no.1 depicts that the mean serum albumin level on day 1 in mild, moderate and severe group was 4.03±0.5, 3.72±0.85 & 3.35±0.41 respectively. The difference was statistically significant between all three groups (p value 0.002). The mean serum albumin level on day 3 in mild, moderate and severe group was 3.92±0.6, 3.04±0.61 & 2.77±0.26. The difference was statistically significant in all three groups (p value <0.001).

With increasing severity, albumin level was decreasing. On day 3 albumin level was decreasing, more in moderate & severe group in comparison to mild group , which showing the significant result in predicting severity. The mean serum ferritin level on day 1 in mild, moderate and severe group was 96.13±95.07, 343.44±228.39 & 523±253.12 respectively. The difference was statistically significant between all three groups (p value <0.001) . The mean serum ferritin level on day 3 in mild, moderate and severe group was 111.56±132.14, 496.33±205.63 & 563±177.17. The difference was statistically significant in all three groups (p value <0.001). With increasing severity, ferritin level was increasing. On day 3 ferritin level was increasing, more in moderate and severe group in comparison to mild group, which showing the significant result in predicting severity.

Based on clinical outcome patients were divided into two groups, death and survival group and albumin & ferritin level was compared in both the groups on day1 and day 3. Table no. 2 depicts that majority of patients showing hypoalbuminemia on day 1 and all the patients showing hypoalbuminemia on day 3 in death group in comparison to survival group that showing normal albumin level in majority of patients . The difference was statistically significant between both the groups (p value <0.001). The mean serum albumin level on day 1 in death & survival group was 3.25±0.53 & 4.01±0.70 respectively. The difference was statistically significant in both the groups (p value <0.001). The mean serum albumin level on day 3 in death & survival group was 2.61±0.30 & 3.81±0.75 respectively. The difference was statistically significant in both the groups (p value <0.001).

Albumin level was decreasing more in the death group in comparison to survival group , which showing the significant result in predicting outcome. The mean serum ferritin level on day 1 in death & survival group was 517.66±248.57 & 128.04±137.81 respectively. The difference was statistically significant in both the groups (p value <0.001). The mean serum ferritin level on day 3 in death & survival group was 529.33±197.80 & 174.34±204.65 respectively. The difference was statistically significant in both the groups (p value <0.001). Ferritin level was increasing more in the death group in comparison to survival group, which showing the significant result in predicting outcome.

DISCUSSION

Suicidal and accidental poisoning with organophosphorus (OPC) pesticides is a significant public health issue in rural Asia.[8] Each year, approximately 500,000 deaths in the region result from self-harm, with about 60% attributed to pesticide poisoning, of which OPC pesticides account for two-thirds of these deaths.[9]

Table 1. Characteristic of patients based on severity according to POP scale

Parameters	Mild	Moderate	Severe	P-value
Total no. of patients	74	18	8	
Mean Serum albumin level Day 1 Day 3	4.03±0.5 3.92±0.6	3.72±0.85 3.04±0.61	3.35±0.41 2.77±0.26	0.002 <0.001
Mean Serum ferritin level Day 1 Day 3	96.13±95.07 111.56±132.14	343.44±228.39 496.33±205.63	523±253.12 563±177.17	<0.001 <0.001

Table 2. Characteristic of patients based on clinical outcome (survival and death)

Parameters	Death	Survived	P-value
Total no. of patients	12	88	
Hypoalbuminemia (<3.5 g/dl) Day 1 Day 3	 8 12	 10 24	 <0.001 <0.001
Normal albumin level (3.5-5 g/dl) Day 1 Day 3	 4 0	 74 64	 <0.001 <0.001
Hyperalbuminemia (>5 g/dl) Day 1 Day 3	 0 0	 4 0	 <0.001 <0.001
Mean serum albumin level Day 1 Day 3	 3.25±0.53 2.61±0.30	 4.01±0.70 3.81±0.75	 <0.001 <0.001
Mean serum ferritin level Day 1 Day 3	 517.66±248.57 529.33±197.80	 128.04±137.81 174.34±204.65	 <0.001 <0.001

Regions with readily available highly toxic OPC pesticides see higher rates of deaths from intentional poisoning. Ferritin plays a crucial role in iron metabolism, being involved in both iron homeostasis and the inflammatory process.[10] The potential prognostic and diagnostic value of serum ferritin levels has been demonstrated in various disorders.[11] Human albumin is critical protein in the body. It is widely recognized as a marker of poor outcomes, including higher mortality rates, increased morbidity and extended stays in ICUs and hospitals across a variety of medical conditions and injuries. In our study we studied 100 patients of OPC poisoning who fulfilled inclusion and exclusion criteria. Age distribution shows that majority of patients (40%) were in younger age group between 18-30 years. Similar results were found in Kamath *et al*[12] study in which majority of patients (28%) were between 20-29 years. Similar results also found in Gannur DG *et al*[13], Nigam M *et al*[14], and Kar SM *et al*[15] study in which majority of patients were in younger age group. Gender distribution shows that majority of patients (72%) were males. Similar results were found in Kamath S D *et al*[12] study in which 54% were males and He L *et al*[16] in which 55.47% were males. In the present study, the severity classification revealed significant differences between patients who died and those who survived. All patients who died had moderate (66.67%) and severe poisoning (33.33%). Those who survived majority (84.09%) was in mild group. This comparison yielded a statistically significant p-value of <0.0001. This is well supported by Vernekar PV *et al*[4] study in which all patients in the mild group survived, while 66.6% of those in the severe group and 18.18% in the moderate group died.

Dubey T *et al*[17] study reported that 100% of patients with severe poisoning (POP score 11) died. In our study, significant correlation was found between mean serum albumin level and severity of poisoning. Mean serum albumin level on day 1 were lower in patients in moderate (3.72 g/dL) and severe group (3.35 g/dL) compare to mild group (4.03 g/dL). The rate of decline in mean serum albumin level on day 3 were more in moderate (3.04 g/dL) and severe group (2.77 g/dL) than in mild group (3.92 g/dL).

Among the 12 patients who died, majority of patients (66.67%) had hypoalbuminemia on day 1, 33.33% had normal levels, and none had hyperalbuminemia. On day 3, all deceased patients had hypoalbuminemia. Among those who survived majority of patient (84.09%) have normal albumin level on day 1 and 72.73% patients had normal albumin level on day 3. Consistent with our findings Noh E *et al*[18] found significantly higher serum albumin concentrations at presentation in the surviving group than in the non-surviving group. Lee SB *et al*[19] demonstrated an inverse association between albumin concentration at presentation and 30-day hospital mortality in 154 patients poisoned with OP. Lee JH *et al*[20] showed significantly lower albumin concentrations in non-surviving patients compared to survivors after OP poisoning. Vincent J L *et al*[21] similarly found an association between serum albumin and mortality in OP poisoning showing hypoalbuminemia is a risk factor for poor outcome. Significant correlation was found between mean serum ferritin level and severity of poisoning. Mean serum ferritin level on day 1 higher in patients in moderate (343.44 ng/ml) and severe group

(523 ng/ml) compare to mild group (96.13 ng/ml). The rate of rise in mean serum ferritin level on day 3 were more in moderate (496.33 ng/ml) and severe group (563 ng/ml) than in mild group (111.56 ng/ml). Ferritin levels were significantly higher in patients who died compared to survivors on both day1 and day 3: on day 1, the mean ferritin was 517.66 ng/mL in the deceased versus 128.04 ng/mL in the survivors ($p < 0.001$), and on day 3, it was 529.33 ng/mL in the deceased versus 174.34 ng/mL in the survivors ($p < 0.001$). Various previous studies was done to correlate serum ferritin level in different risk groups patients in relation to outcome and mortality in which higher ferritin level was associated with increased mortality and poor outcome. (Yokus O *et al*[22], He L *et al*[16], Grange S *et al*[23], Israel A *et al*[24]). But none of study was done in OPC poisoning patients in relation to serum ferritin. Our findings shows that ferritin levels have notable predictive capabilities for assessing severity and predicting outcome. It can also be used as risk stratification of patients presenting to us with OPC poisoning. In the context of organophosphorus poisoning, serum ferritin levels serve as a significant biomarker, reflecting both the inflammatory response and oxidative stress associated with the condition. Organophosphorus compounds trigger a robust inflammatory cascade, prompting macrophages to release cytokines and induce ferritin production as part of the acute-phase response. This elevation in serum ferritin mirrors the severity of systemic inflammation and oxidative damage seen in severe poisoning cases. This biomarker provides valuable insights into the extent of tissue damage and the systemic inflammatory response, aiding clinicians in assessing disease severity and tailoring treatment strategies accordingly.

CONCLUSION

Research indicates that the concentrations of serum albumin and serum ferritin at the time of presentation are linked to the mortality risk among patients who have been poisoned with organophosphates (OP). Specifically, serum albumin appears to have a protective effect that may influence the outcome in OP poisoning cases. Given this finding, there is a suggestion that the therapeutic potential of direct albumin replacement therapy should be explored for patients with low serum albumin levels in OP poisoning. This approach could potentially improve patient outcomes by addressing hypoalbuminemia, which is associated with increased mortality risk. Serum ferritin provides valuable insights into the extent of tissue damage and the systemic inflammatory response, aiding clinicians in assessing disease severity and tailoring treatment strategies accordingly. However, the results of this study are preliminary and require further validation to confirm the observed associations. Additionally, ongoing research into the roles of both albumin and ferritin in the context of OP poisoning is necessary. Such studies could provide deeper insights into how these biomarkers affect patient prognosis and guide the development of more effective treatment strategies.

REFERENCES

1. Jeyaratnam J. Acute pesticide poisoning: a major global health problem. World Health Stat Q. 1990;43(3):139-44.
2. Eddleston M, Chowdhury FR. Pharmacological treatment of organophosphorus insecticide poisoning: the old and the possible new. Br J Clin Pharmacol. 2016;81:462-470.
3. Senanayake N, de Silva HJ, Karalliedde L. A scale to assess severity in organophosphorus intoxication: POP scale. Hum Exp Toxicol 1993;12:297-9.
4. Vernekar PV, Shivraj K. Peradeniya organophosphorus poisoning scale (POP) as a predictor of respiratory failure and mortality in organophosphorus poisoning. Sch J Appl Med Sci 2017;5:1841-4.
5. Kim SH, McClave SA, Martindale RG, Miller KR, Hurt RT. Hypoalbuminemia and clinical outcomes: what is the mechanism behind the relationship? Am Surg. 2017;83:1220-1227.
6. McCullough, K. & Bolisetty, S. Iron homeostasis and ferritin in sepsis-associated kidney injury. Nephron (2020);144(12):616–620.
7. Agarwal S, Bhatnagar V, Agarwal A, Agarwal U, Venkaiah K, Nigam S, *et al*. Impairment in clinical indices in acute organophosphate insecticide poisoning patients in India. The Internet Journal of Toxicology. 2007;4(1).
8. Batra AK, Keoliya AN, Jadhav GU. Poisoning: An unnatural cause of morbidity and mortality in rural India. J Assoc Physicians India 2003;51:955-9.
9. Lin TJ, Walter FG, Hung DZ, Tsai JL, Hu SC, Chang JS, *et al*. Epidemiology of organophosphate pesticide poisoning in Taiwan. Clin Toxicol (Phila) 2008;46:794-801.
10. Hua Z. *et al*. Serum ferritin is a good indicator for predicting the efficacy of adult HLH induction therapy. Ann. Med (2022);54(1): 283–292.
11. Suarez-Ortegon, M. F. *et al*. Serum ferritin and incident cardiometabolic diseases in Scottish adults. Cardiovasc. Diabetol. (2022);21(1): 26.
12. Kamath SD, Gautam VK. Study of organophosphorus compound poisoning in a tertiary care hospital and the role of Peradeniya Organophosphorus Poisoning scale as a prognostic marker of the outcome. J Family Med Prim Care 2021;10:4160-7.
13. Gannur DG, Maka P, Narayan Reddy KS. Organophosphorus compound poisoning in Gulbarga region-A five-year study. Indian J Forensic Med Toxicol 2008;2:1-6.
14. Nigam M, Jain AK, Dubey BP, Sharma VK. Trends of organophosphorus poisoning in Bhopal region an autopsy based study. J Indian Acad Forensic Med 2004;26:61-5.
15. Kar SM, Timsinha S, Agrawal P. An epidemiological study of organophosphorus poisoning at Manipal Teaching Hospital, Pokhara, Nepal. J Indian Acad Forensic Med 2010;32:108-9.
16. He L, Guo C, Su Y, Ning D. The relationship between serum ferritin level and clinical outcomes in sepsis based on a large public database. Scientific Reports (2023);13:8677.
17. Dubey TN, Yadav S, Kawre KK. Correlation of severity of organophosphorus poisoning as assessed by Peradeniya organophosphorus poisoning scale with serum amylase and CPK level. Int J Contemp Med Res 2016;3:2534-7.
18. Noh E, Moon JM, Chun BJ, Cho YS, Ryu S, Kim D. The clinical role of serum albumin in organophosphate poisoning. *Basic Clin Pharmacol Toxicol*. 2021;128:605–614.

19. Lee SB, Kang C, Kim DH, *et al*. Base deficit is a predictor of mortality in organophosphate insecticide poisoning. Hum Exp Toxicol. 2018;37(2):118-124.
20. Lee JH, Lee YH, Park YH, *et al*. The differences in C-reactive protein value between initial and 24 hours follow up data as a predictor of mortality in OP poisoned patients. Clin Toxicol (Phila). 2013;51(1):29-34.
21. Vincent JL, Dubois MJ, Navickis RJ, Wilkes MM. Hypoalbuminemia in acute illness: is there a rationale for intervention? A meta-analysis of cohort studies and controlled trials. Ann Surg. 2003;237(3):319-334.
22. Yokus O, Sunger E, Cinli T A, Goze H *et al*. Serum albumin and ferritin levels: a practical indicator of prognosis in acute myeloid leukemia over 50 years of age. Am J Blood Res 2022;12(3):97-104.
23. Grange, S. *et al*. The use of ferritin to identify critically ill patients with secondary hemophagocytic lymphohistiocytosis. Crit .Care Med. 44(11), e1045–e1053 (2016).
24. Israel, A. *et al*. Clinical and prognostic significance of elevated ferritin levels in hospitalised adults. Postgrad. Med. J. (2021); 98(1162):622–625.

****