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Estimation of plasma pseudo-cholinesterase in acute organo phosphorus poisoning and its correlation with morbidity & mortality in a tertiary care centre': A prospective study

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Abstract
Background & Objectives: Organophosphorus (OP) poisoning is the most common toxicological emergency in India. Medico legal deaths including OP poisoning claim a substantial number of lives in Karnataka. Respiratory failure is the most common complication of OP compound leading to death. The aim of the study is to know the incidence of acute OP poisoning, to correlate between the clinical score described by Peradenya Organophosphorus Poisoning (POP) scale and plasma pseudo cholinesterase levels at the time of admission, ventilator requirement and hospital mortality.
Materials and Methods: The study was conducted on patients of OP poisoning admitted to SS hospital, SSIMS & RC, Davangere for a period of three years from January 2021 to December 2023. Total number of cases studied were 150. At the time of admission blood was drawn for estimation of plasma pseudo cholinesterase estimation. The patients were clinically divided into 3 grades according to Peradenya Organophosphorus Poisoning (POP) scale. Analysis was performed by cobas integra 400 cholinesterase Calorimetric assay system. All patients were followed-up for 3 days to know the outcome and results were analyzed.
Results: Majority of the cases (40%) belong to 21 to 30 years age group and predominantly belonged to male sex (73%). All the cases were farmers by occupation. Average time taken to reach hospital was 5 hours (+/- 2.54 hours). Commonest poison consumed in the study was Malathion (18.67%) followed by dimethoate (17.33%) and dichlorvos (DDVP) (14%). According to POP scale 78 cases (52%) had severe poisoning, 40 cases (26.67%) had moderate poisoning and 32 cases (21.33%) had mild poisoning. 60 cases (40%) had fatal outcome. Suicidal consumption was seen in 128 cases (85.33%). Plasma pseudo cholinesterase levels associated with all fatalities which were seen in the group with severe poisoning and was found to range from 912 U/L to 2,490 U/L which accounts to suppression of plasma pseudo cholinesterase levels by 84.04% to 93.19%.
Conclusion: Plasma pseudo cholinesterase levels equal to less than 1,390.35 U/L (+/- 200.68 U/L) were proved to be fatal. This amounts to suppression of plasma pseudo cholinesterase by 90.414% (+/- 1.384%). The POP scale and cholinesterase level at presentation appeared useful to assess the severity of poisoning, particularly in terms of need for ventilator and prolonged duration of hospital stay.

Keywords: Organophosphate poisoning, POP Scale, Plasma pseudo cholinesterase

Introduction
Organophosphates are a group of compounds with various toxicities to different form of life. The widest use of these compounds is as insecticides. The incidence of poisoning is constantly increasing in all civilised countries [1]. However, there is a progressive shift towards suicidal poisoning and accidental poisoning in the household and in agriculture. Accidental poisoning is common among children is ascribed to the increased use of numerous chemical articles in the household [2].
WHO estimates that approximately 3 million pesticide poisoning occur worldwide and causing more than 2, 20,000 deaths every year [3]. Developing countries like India and Srilanka report alarming rates of toxicity and death [4]. OP acts by inhibiting the enzyme cholinesterase, results in accumulation of acetylcholine at synapses and myo neural junction leading to cholinergic overactivity [5]. Respiratory Failure is most common complication of OP poisoning leading to death. Early recognition and prompt ventilator support may improve survival [6].

According to Callaway *et al*., the red cell choline esterase level in good health ranges between 75 and 142 units [7]. Mild symptoms occur when acetylcholine esterase activity reduces to 20-25% of normal. If moderate poisoning occurs, the activity of AchE decreases to 10-20% of normal. Severe poisoning results in an activity of less than 10% of normal [8].

Serum cholinesterase level is depressed after OP poisoning, as also reported by previous studies done. Peradenya OP compound scale has not been studied much in Indian scenario [9]. It could be a simple and effective system to determine the need for ventilator support early on in the course. In a study by Senayeke *et al*, patients with a high score on the POP scale & both extremes of age had a high rate of morbidity and mortality [10].

The concentration of AchE at myoneuronal junction acts as a guide to determine. i) The severity of toxicity, ii) The therapeutic dose of atropine and iii) PAM (Pyridine *Aldoxime ethiodide*), so that these antidotes can be used more cautiously. In the present study the concentration of AchE was estimated in the plasma in order to assess the severity and mortality [11]. The present study aims to know the incidence of acute OP poisoning, to correlate between the clinical score described by Peradenya Organophosphorus Poisoning (POP) scale and plasma pseudo cholinesterase levels at the time of admission, the severity of poisoning with need for ventilator support [12, 13].

Factors influencing toxicity [2, 3]

1. Dose: Lethal effects due to the severe cholinergic effects are due to the inhibition of acetylcholinesterase enzyme. Larger the dose more severe the manifestations.

2. Age and Sex: Young children have low levels of metabolizing enzymes, increased mortality. Lethal dose for male is greater than that for females.

3. Malnutrition: Due to decreased activity of enzyme the fatal dose needed is less.

4. Effects of impurities and storage: Impurities in the insecticide may be of low toxicity or more toxic than the major compound or they may be potentiator of toxicity of other components. Toxicity of some organophosphorus compounds increase when they are stored in tinned steel container.

Methodology

The study was conducted on patients with history of OP poisoning admitted to SS hospital, SSIMS & RC, Davangere for a period of three years from January 2021 to December 2023. Total number of cases studied were 150. The cases were diagnosed with history, symptoms, signs, kerosene like smell & few with alleged poison bottle they brought to the casualty. At the time of admission 5ml blood was drawn in EDTA tube for estimation of plasma pseudo cholinesterase estimation. Apart from the routine and detailed clinical examination, assessment was also done based on the Peradenya Organophosphorus scaling system [13], which included pupil size, respiratory rate, pulse rate, level of consciousness of the patient and the presence or absence of convulsion and fasciculation.

Table 1: Peradenya Organophosphorus Poisoning Scale [13]

Pupil Size	>2 mm	0
	<2 mm	1
	Pin point	2
Respiratory rate	<20/min	0
	>20/min	1
	>20/min with central cyanosis	2
Heart rate	>60/min	0
	41-60/min	1
	<40/min	2
Fasciculation	None	0
	Present generalized or continuous	1
	Both generalized and continuous	2
Level of Consciousness	Conscious and rationale	0
	Impaired response to verbal commands	1
	No response to verbal commands	2
Seizures	Absent	0
	Present	1

According to Callaway *et al.* [2], the red cell choline esterase level in good health ranges between 75 and 142 units. Mild symptoms occur when acetylcholine esterase activity reduces to 20-25% of normal. If moderate poisoning occurs, the activity of Ache decreases to 10-20% of normal. Severe poisoning results in an activity of less than 10% of normal According to pseudo cholinesterase activity the OP poisoning was graded as follows

Table 2: Grade of poisoning based on pseudo cholinesterase level [2]

Grade of Poisoning	Cholinesterase activity
Normal	>50%
Mild	20-25%
Moderate	10-20%
Severe	<10%

At the time of admission pseudo cholinesterase was measured by drawing 5ml of blood from the patient, collected in EDTA tube and forwarded in vacutainer tube with EDTA as preservative and subjected it to analysis by Cobas Integra 400 cholinesterase assay system which works on the principle of calorimetric method of Ellman [14]. The principle of the method is the measurement of the rate of production of thiocholine as acetylthiocholine is hydrolyzed. This is accomplished by the continuous reaction of the thiol with Sdithiobis-2-nitrobenzoate ion (I) to produce the yellow anion of 5-thio-2-nitro-benzoic acid (II). The rate of color production is measured at 412 rnp in a photometer. The reaction with the thiol has been shown to be sufficiently rapid so as not to be rate limiting in the measurement of the enzyme, and in the concentrations used does not inhibit the enzymic hydrolysis. By recording the output of the photometer continuously, records of the complete assay can be obtained [12].

The range of values in 3 control patients, who were admitted with history of poisoning other than OP compound was found to be 13,400 U/L to 15,600 U/L at room temperature (37ºC). All patients were followed-up after 3 days to know the outcome. In fatal cases the Regional Forensic Science Laboratory, Port Blair reports were used for confirmation of organophosphorus poisoning and Results were analyzed.

Exclusion Criteria: The victims with age less than 14 years were excluded from the study.

- Patients with history of COPD, uncontrolled diabetes, Cardio vascular disease & other related co morbidities were excluded from the study.

Results

Out of the 150 cases included in the study, 21 patients (14.00%) were in the age group of 14 to 20 years, 60 patients (40%) were in the age group of 21 to 30 years, 23 patients (15.33%) were in the age group of 31 to 40 years, 28 patients (18.67%) were in the age group of 41 to 50 years, 10 patients (6.67%) in the age group of 51 to 60 years, 6 patients (4.00%) in the age group of 61 to 70 years and 2 patients (1.33%) were in the age group of 71 to 80 years. Maximum number of cases were seen in the 21 to 30 years age group. Youngest patients were 2 females of age 14 years each and oldest patient was a male of age 76 years. Eighteen victims belong to more than 50 yrs. of age group & they were on regular medications for Diabetes & Hypertension, no one had history of COPD & heart ailments. The victims with related co-morbidities like COPD, Heart ailments, uncontrolled hypertension, diabetes & so on were not included in the study to avoid bias in the biochemical results. Sex distribution of the cases studied had a male predominance with 109 (73%) male patients to 41 (27%) female patients with a male-female ratio of 2.66:1.

Table 3: Age wise distribution of cases

Age group	Number of cases	Percentage
14-20	21	14.00%
21-30	60	40.00%
31-40	23	15.33%
41-50	28	18.67%
51-60	10	6.67%
61-70	6	4.00%
71-80	2	1.33 %

Chart 1

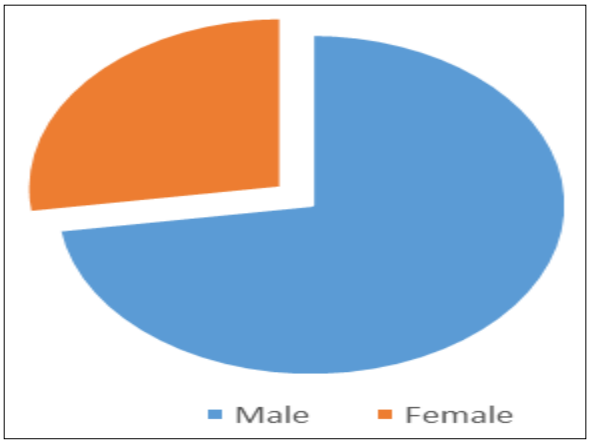

Fig 1: Show Sex Distribution

The commonest poison consumed in the study was Malathion, 28 patients (18.67%). Second common was dimethoate, 26 patients (17.33%). Third common was dichlorvos, 21 patients (14.00%). Fourth common was parathion, 20 patients (13.33%). Fifth common was TEPP, 18 patients (12.00%). Followed by chlorthion (9 patients, 6%), paraoxon (9 patients, 6%), chlorpyrifos (8 patients, 5.33%), TIK 20 (7 patients, 4.67%) and monochrotophos (4 patients, 2.67%). All of them were organophosphorus compounds.

Chart 2

Among all patients, 65 patients (43.33%) had consumed 101ml to 200ml of organophosphorus compound. 38 patients (25.33%) had consumed 30ml to 100ml of organophosphorus compound. 31 patients (20.67%) had consumed 201ml to 300ml of organophosphorus compound. Very high doses of consumption i.e. > 300ml were seen in 16 patients (10.67%). The quantity consumed approximately estimated by stomach wash sample. More than 90% of cases victim has consumed the poison diluted with diluents & some with alcohol. With respect to the severity of poisoning the average quantity of poison consumed in mild, moderate and severe groups were found to be 80ml, 150ml and 240ml respectively.

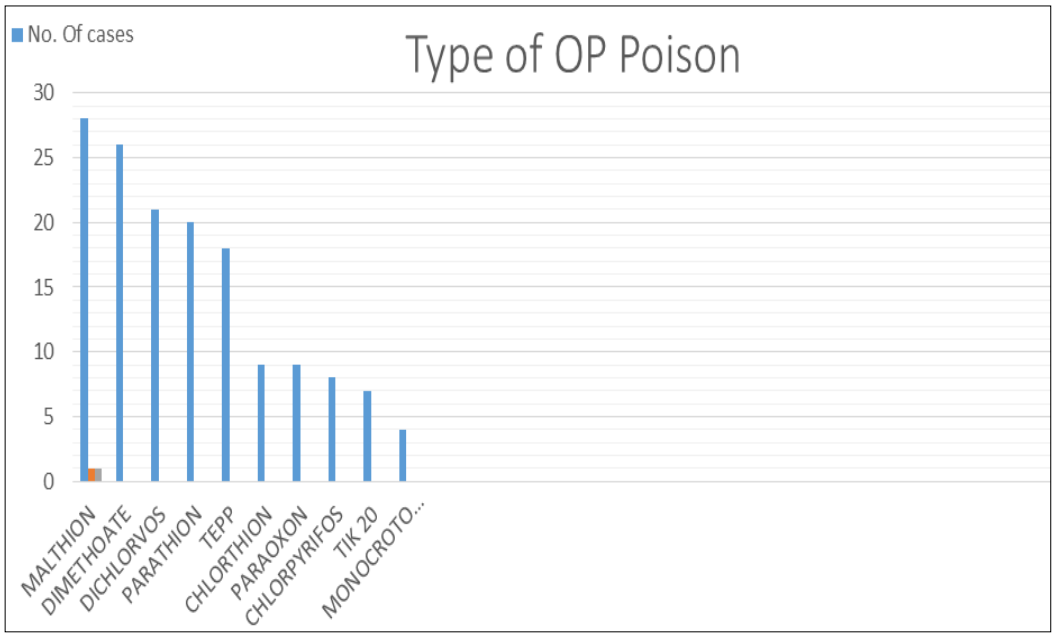

Fig 1: Show type of OP Poison

Table 4: Amount consumption of OP Poison

Quantity of poison consumed (mL)	Number of cases	Percentage (%)
30-100	38	25.33
101-200	65	43.33
201-300	31	20.67
>300	16	10.67

Table 5: Severity of poisoning v/s average quantity of poison consumed

Clinical severity of poisoning	Average quantity of poison consumed (ml)
Mild	80
Moderate	150
Severe	240

78 patients (52%) had sever poisoning, 40 patients (26.67%) had moderate poisoning and 32 patients (21.33%) had mild poisoning.

Chart 3

Severity of poisoning: Clinical features of cases studied, nausea and vomiting was one of the earliest symptoms and was seen in 142 patients (94.67%), gastric irritation was seen in 135 patients (90%), defecation was seen in 125 patients (83.33%), urination and lacrimation was seen in 123 patients each (82%), salivation was seen in 120 patients (80%), bradycardia was seen in 118 patients (78.67%) of which 78 patients (52%) had severe poisoning and 40 patients (26.66%) had moderate poisoning. Fasciculation, tremors and anxiety was seen in 116 patients each (77.33%) of which 78 patients (52%) had severe poisoning and 38 patients (25.33%) had moderate poisoning. Restlessness was seen in 115 patients (76.67%) of which 78 patients (52%) had severe poisoning and 37 patients (24.67%) had moderate poisoning. Dyspnea was seen in 102 patients of which 78 patients (52%) had severe poisoning and 42 patients (28%) had moderate poisoning. Areflexia was seen in 83 patients (55.33%) of which 78 patients (52%) had severe poisoning and 5 patients (3%) had moderate poisoning. Convulsion and coma was seen in 78 patients each (52%) all of whom had severe poisoning

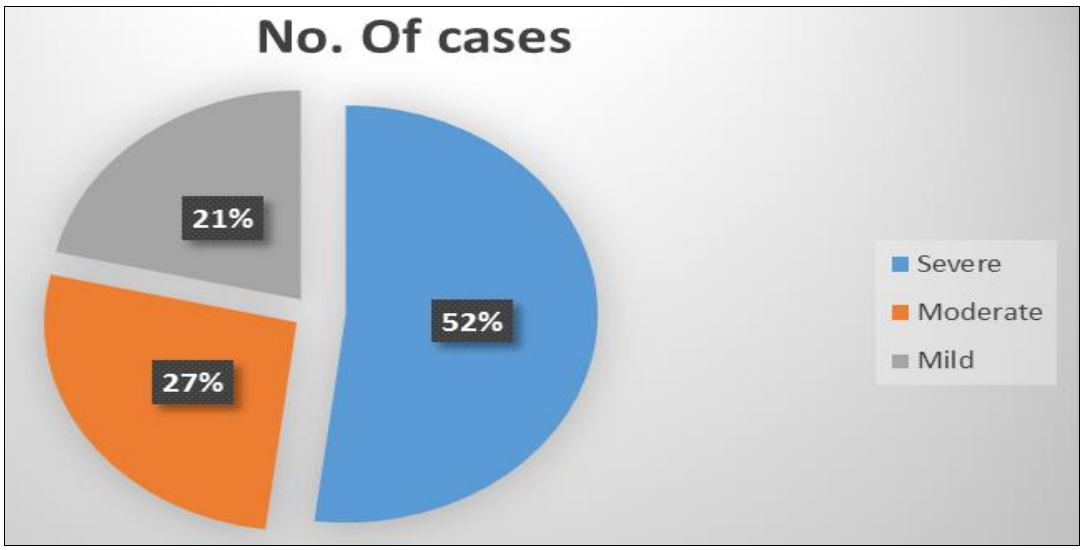

Fig 3: Show Severity of poisoning

Table 6: Clinical features

Clinical feature	Number of cases	Percentage (%)
Emesis	142	94.67
Gastric irritation	135	90.00
Defecation	125	83.33
Urination	123	82.00
Lacrimation	123	82.00
Salivation	120	80.00
Bradycardia	118	78.67
Fasciculation	116	77.33
Tremors	116	77.33
Anxiety	116	77.33
Restlessness	115	76.67
Dyspnoea	102	68.00
Areflexia	83	55.33
Convulsions	78	52.00
Coma	78	52.00

In the 3-day follow-up 60 patients (40%) had fatal outcome (including coma) and 90 patients (60%) survived with treatment. Of the 60 fatalities, 26 cases (17.33%) died within 24 hours. All the fatalities were associated with severe poisoning. Among those who survived 18 patients (12%) had severe poisoning. Reason for survival being stomach wash done with in a golden period in nearest hospital, early administration of antidote (atropine), enzyme reactivator such as oximes and timely assisted ventilation support.

Chart 4

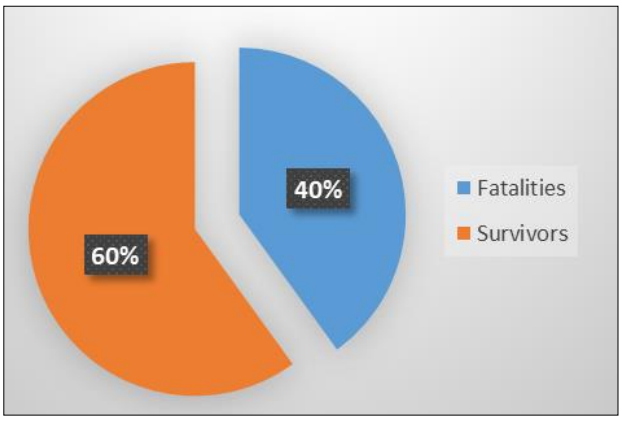

Fig 4: Show Number of Fatalities

Suicidal consumption of organophosphorus compounds was seen in 128 patients (85.33%) and accidental consumption of the same was seen in remaining 22 patients (14.67%). No homicidal consumption of organophosphorus compounds was seen during this study.

Table 5: Manner of consumption of poison

Manner of consumption	Number of cases	Percentage (%)
Suicidal	128	85.33
Accidental	22	14.67
Homicidal	00	---

Plasma pseudo-cholinesterase levels

In the group with severe poisoning the plasma pseudo-cholinesterase levels were found to be range from 912 U/L to 2,490 U/L. (mean value = 1,696.62 U/L and S.D = +/- 438.99 U/L). This group contained all the 60 fatalities (40%) observed in this study. The Plasma Pseudo cholinesterase levels of all the 60 fatal cases were compared and found to be statistically highly significant ($p<0.001$). This amounts to suppression of plasma pseudo-cholinesterase by 84.04% to 93.19%. 18 patients (12%) survived with severe poisoning but no statistical significant difference was found between those who survived and fatalities ($p>0.5$).

In the 26 patients (17.33%) who died within 24 hours of admission to hospital, the plasma-pseudo cholinesterase levels were found to be statistically highly significant ($p<0.001$) and ranged from 912 U/L to 1,678 U/L (mean value = 1,390.35 U/L and S.D = +/- 200.68 U/L) which amounts to suppression of plasma pseudo-cholinesterase by 89.24% to 93.19%.

In the group with moderate poisoning the plasma pseudo-cholinesterase levels were compared and found to be statistically highly significant ($p<0.001$) ranging from 4,128 U/L to 7,642 U/L (mean value = 5,339.40 U/L and S.D = +/- 1121.33 U/L). This amounts to suppression of plasma pseudo-cholinesterase by 51.01% to 69.19%

In the group with mild poisoning the plasma pseudo-cholinesterase levels were compared and found to be statistically highly significant ($p<0.001$) ranging from 7,654 U/L to 11,230 U/L (mean value = 9,110.38 U/L and S.D = +/- 927.29). This amounts to suppression of plasma pseudo-cholinesterase by 28.01% to 42.88%

Discussion

In the current study, out of 150 cases, highest number of poisoning was reported in the age group of 21 to 30 years (60 patients, 40%), reason being family conflicts, inflexible families generate risk for suicidal thoughts and attempts in adolescence. some other familial risk factors, such as financial crisis, academic pressure, unemployment, failures in life, stress, work pressure, personal dissatisfaction due to results and lack of social/family support may cause suicidal behavior. Underlying psychiatric illness like anxiety, depression confers a significant risk for committing self-harm. This correlates with the age groups reported by S Singh *et al*., the mean age of the patient was found to be 26.44 years. The sex incidence shows males are more affected (73%) than the females (27%). Similar observations were made by Singh *et al*., [15]. The reason for male preponderance being more accessibility to the poisons,

suicidal tendency, unemployment, failures in life, economical problem, stress, work pressure, and lack of family support. The commonest poison consumed in the study was Malathion, 28 patients (18.67%). Second common was Dimethoate, 26 patients (17.33%). In all cases the poisons were consumed via the oral route. Malathion is one of the most commonly used organophosphate insecticide and is commonly available for agricultural use. Even though it has a disagreeable taste, it is most often taken orally because of its easy availability to farmers and also lethality of its action. Other studies by Namba, Greenfield and Grob [12]; Daglia & Shaikh [16]; Wadia, Bhirud[17], Prabhu MM *et al*, [18] Joshi S *et al* [19] and Wille, Thiermann & Worek [20] also reflect similar finding. An acute case of demeton poisoning in a child was reported by Felsenstein and collegues [21] consisting of 67.95% males and still higher incidence was observed by Naravaneni R & Jamil K, [22] i.e. 72%. The most common manner of death in this study was found to be suicidal (85.33%) followed by accidental consumption (14.67%). This trend has also been observed in studies by Kar, Wadia and *et al*. [17] and by Sungur and Guven [23].

In this study severe poisoning accounted for all the 60 victims' fatalities (40%), they were apparently healthy individuals, had no relative comorbidities as such. 18 patients (12%) with severe poisoning survived due to early stomach wash, antidote, oximes administration and also timely assisted ventilation support. The Plasma Pseudo cholinesterase levels of all the 60 fatal cases were compared and found to be statistically highly significant ($p<0.001$). No statistically significant difference was found between those who survived and those who died with severe poisoning ($p>0.5$). Therefore, the pseudo cholinesterase levels estimated at the time of admission to the hospital serves as a very good prognostic indictor and also helps in dose adjustment of various drugs for treatment. Severe poisoning was associated with suppression of plasma pseudo cholinesterase by 84.04% to 93.19% where death occurred over a 3-day duration following admission to hospital. If plasma pseudo cholinesterase was suppressed by 89.24% to 93.19% (as seen in those who died within 24 hours of admission) then it is associated with 100% mortality. This shows that there is a direct correlation between plasma pseudo cholinesterase and severity of poisoning and suppression of this enzyme by more than 89.24% (i.e. plasma pseudo cholinesterase levels < 1,678 U/L) is associated with fatal outcome. This is in agreement with a study by Xu, Zhang, yang [24] which states that when the plasma pseudo cholinesterase levels reach 10% then severe acute organophosphorus poisoning occurs. A cohort study done by Eddleston and colleagues [25] found plasma pseudo cholinesterase activity of < 600 U/L on admission was highly sensitive in chlorpyrifos and specific for dimethoate poisoning which is also in agreement with this study. Sunder Ram *et al*. also states that plasma pseudo cholinesterase level below 10% of normal were associated with poor prognosis which is in agreement with this study. Studies by Pillay [3] and Sozmen and collegues [26] are all in acceptance with this study. Kukde and colleagues [27] have found no significant difference of pseudo cholinesterase levels between postmortem samples of brought dead cases and partially treated cases. The levels of plasma pseudo cholinesterase in mild and moderate poisoning were also found to be statistically highly significant ($p<0.001$) and hence the observed levels can be effectively used in assessing the patient outcome and also for calibration of dose of pralidoxime which is the specific antidote.

Malathion and parathion were top killers (15% each) followed by Dimethoate (13.33%), TEPP (13.33%), Chlorthion (11.67%), Chlorpyrifos (10%), Dichlorvos (10% each), Paraoxon (5%), Monocrotophos (3.33%) and TIK-20 (3.33%). Even though Malathion has a relatively higher lethal dose (<1000mg/kg) compared to higher compounds since it is easily available to farmers, it has emerged as one of the top killers.

Conclusion

The study group included 150 cases in the age group above 14 years. The patients were included with relevant clinical examination and investigation, which included Plasma Pseudo cholinesterase level estimation at the time of admission.

The commonest symptoms were nausea and vomiting followed by gastric irritation and the commonest signs were bradycardia followed by fasciculation, tremors and anxiety. And the most fatal poisons were found to be Malathion and Parathion. With an average time of 5 hours to reach the hospital the study finds that plasma pseudo cholinesterase levels equal to less than 1,390.35 U/L (+/- 200.68 U/L) was proved to be fatal. This amounts to suppression of plasma pseudo cholinesterase by 90.414% (+/-1.384%) which shows that there is fairly good correlation between clinical severities of poisoning and plasma pseudo cholinesterase level.

There was significant correlation between the severity of poisoning categorized by the POP scale and the serum cholinesterase at the time of initial presentation of the patients ($P<0.001$). There was also positive relationship between POP scoring and lower pseudo cholinesterase level to that of need for ventilation. Incidence of mortality was significantly associated with lower pseudo cholinesterase level ($P<0.001$) and POP Scoring ($p<0.001$). The time interval between consumption and presentation to hospital was positively associated with mortality and need for ventilation. Thus, our study concludes that there is a very good correlation between the levels of plasma pseudo cholinesterase and mortality as well as morbidity. This study helps not only in predicting the outcome of the patient with organophosphate poisoning based on plasma pseudo cholinesterase levels but also can be retrospectively used to plan the treatment of such patients and dosage calibration of antidotes such as pralidoxime.

Limitations of the study

1. The victims with age less than 14 years were excluded from the study
2. Poisoning other than organophosphate whether taken independently or along with organophosphates (E.g. Alcohol) were not included in this study.
3. Serial monitoring of cases could not be done due to poor patient compliance and also due to economic limitations and only follow-up to know the outcome was performed.
4. **Ethical Clearance:** Ethical clearance is obtained from Institutional Ethics Committee, SSIMS & RC, Davangere.

Source of funding: Self

Conflict of interest: Nil

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