Original Article

Determinants of the Requirements for Ventilatory Support in Patients with Organophosphorus Compound Poisoning

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Abstract

Background: Organophosphorus (OP) compound poisoning is a common cause of medical emergency in the developing world, and it is linked to high morbidity and mortality. Respiratory failure is the critical complication in these cases and requires ventilatory support. Therefore, early identification of clinical and laboratory parameters that can predict ventilatory requirements can lead to an optimal outcome. The current study aimed to determine the determinants of ventilatory support in OP poisoning cases. **Material and Methods:** This observational study was conducted in a hospital on 40 patients with organophosphorus poisoning. At admission, clinical, demographic, and lab parameters were noted. The perspectives of severity were measured on the basis of the Glasgow Coma Scale (GCS) and Peradeniya OP Poisoning (POP) scale. The two groups of patients were classified: one required ventilatory support, and the other did not require ventilatory support. Statistical analysis was done to determine important predictors for ventilatory support. **Results:** Among 40 patients, 18(45%) patients were ventilated. Patients who needed ventilation scored considerably lower GCS scores (7.4 ± 2.1 vs 12.8 ± 1.6, $p < 0.001$) and higher POP scores (9.6 ± 1.8 vs 4.5 ± 1.4, $p < 0.001$). It also used significant predictors (GCS 8 or less, POP score of more than 7, serum cholinesterase of less than 1000 U/L, bronchorrhea, fasciculations, PaCO2 greater than 45 mmHg, respiratory rate greater than 24/min). The death rate of patients in this study was 22.2%. **Conclusion:** The important predictors of ventilatory support in OP poisoning are clinical severity parameters, particular clinical presentation, and laboratory parameters. Early identification of these determinants can help in timely intervention, better prognosis, and optimal use of critical care resources.

Keywords: Organophosphorus poisoning, ventilatory support, predictors, POP scale, GCS, respiratory failure.

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Introduction

Organophosphorus (OP) compounds are used extensively as agricultural pesticides. OP poisoning is a significant global health issue, particularly in developing countries. Because of its widespread availability and lower costs, they become a common means for accidental or suicidal poisoning. In South-East Asian countries, especially India, OP poisoning is a significant contributor to emergency admissions, and they are also associated with substantial morbidity and mortality.[1] The overall increase in mortality risk is commonly seen in limited-resource rural settings, where there is a delayed hospital presentation and a lack of awareness of the identification of symptoms of OP poisoning among the population. The toxicity of OP is mainly a result of the irreversible inhibition of the acetylcholinesterase enzyme, resulting in the accumulation of acetylcholine in cholinergic synapses. This causes prolonged stimulation of muscarinic, nicotinic, and central nervous system receptors, resulting in a characteristic clinical picture. Symptoms of this condition usually include miosis, excessive salivation, sweating, bronchorrhea, bronchospasm, bradycardia, muscle fasciculations, weakness, and change of consciousness.[2] Respiratory failure is the most fatal complication of the mentioned manifestations and is the frequent cause of death due to OP poisoning.[3] Respiratory failure in OP poisoning occurs due to a combination of central respiratory depression and neuromuscular junction dysfunction, which causes weakness or paralysis of respiratory muscles. There is an increased airway resistance caused by bronchospasm and excessive secretions.[4] There is an intermediate syndrome that develops within 24-96 hours after exposure to OP compounds. It is marked by proximal muscle weakness and respiratory muscle paralysis, and further increases the risk of ventilatory failure.[5] These pathophysiological features emphasize the significance of early diagnosis and prompt treatment for the prevention of adverse outcomes. Therefore, it is important to identify patients who require early ventilatory support so that they can be effectively managed. Various clinical and laboratory variables have been examined as predictors of respiratory failure. The severity of poisoning has been determined by the use of clinical scoring systems, including the Peradeniya Organophosphorus Poisoning (POP) scale, which determines outcomes.[6] Laboratory

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parameters acting as predictors are low levels of serum cholinesterase, deranged arterial blood gas parameters, altered level of consciousness, generalized fasciculations, and hypotension at presentation.[7,8] The predictive power of these parameters does vary, however, and there is no single parameter that has been agreed upon as a predictive factor. Mechanical ventilation is necessary not only because the poisoning is severe but also because it is a significant factor in patient outcomes. The complications associated with delayed ventilatory support initiation may include: hypoxic brain injury, aspiration pneumonia, and increased hospital stay.[9] On the other hand, timely airway management, subsequent triage to intensive care units, and optimum utilization of healthcare resources can be achieved because of early prediction. This is especially important in limited-resource settings, where intensive care units are usually scarce and must be distributed wisely. Although progress has been made in the understanding of OP poisoning and its management, more analytical studies are still required to determine credible determinants of ventilatory support need. These studies can be used to improve clinical decision-making, prognostication, and eventually lower mortality. Thus, this study aimed to evaluate different clinical and biochemical predictors of ventilatory support in patients with organophosphorus compound poisoning that can be used to improve early intervention strategies and the overall patient outcomes.

Materials and Methods

This cross-sectional observational study was done in the Department of General Medicine, Medical College and Hospital. Institutional Ethical approval was obtained for the study. Written consent was obtained from accompanying persons/relatives of the cases included in the study after explaining the nature of the study and possible outcomes in the vernacular language. Appropriate MLC sheets were incorporated as per protocol.

Study Design and Sample Size: A hospital-based analytical study was carried out on 40 consecutive patients diagnosed with OP compound poisoning. Patients were enrolled after obtaining informed consent from the patient or their legally authorized representative.

Inclusion Criteria

1. Patients aged ≥18 years
2. History of exposure to organophosphorus compounds (accidental or intentional)
3. Clinical features consistent with OP poisoning (e.g., miosis, salivation, fasciculations, bronchorrhea)
4. Patients presenting within 24 hours of exposure

Exclusion Criteria

1. History of chronic respiratory diseases
2. Unknown poisoning cases
3. History of neuromuscular disorders
4. Pregnant women

Based on the inclusion and exclusion criteria during the duration of the study, a total of n=40 consecutive cases of poisoning reporting to our institute were included in the study. Demographic profile information, including age, sex, and residence, was included. Detailed history was obtained regarding the type and amount of poison and the approximate time lapse since exposure was recorded in a pre-validated questionnaire. Each case was evaluated for the severity of poisoning using the Peradeniya Organophosphorus Poisoning (POP) scale. Vital parameters, including pulse rate, blood pressure, respiratory rate, and oxygen saturation, were recorded. Neurological status was assessed using the Glasgow Coma Scale (GCS).

Laboratory Investigations for the patients were performed at the time of admission, which included serum cholinesterase levels, Arterial blood gas (ABG) analysis, Renal function tests, including serum electrolytes and complete blood count.

Outcome analysis was done based on the requirement of ventilatory support during hospital stay. Indications for mechanical ventilation included:

1. Respiratory failure (PaO_2 <60 mmHg or $PaCO_2$ >50 mmHg)
2. Severe hypoxia or acidosis
3. Depressed level of consciousness (GCS ≤8)
4. Excessive bronchial secretions are compromising the airway
5. Development of intermediate syndrome with respiratory muscle weakness

Patients were categorized into two groups based on whether ventilatory support was required or not for analysis of the results. Statistical Analysis: All the available data were refined, segregated, and uploaded to an MS Excel spreadsheet and analyzed by SPSS version 26 in Windows format. The continuous variables were recorded as mean, standard deviation, frequency, and percentage. The categorical variables were analyzed by using the chi-square test for differences between the two groups. Values of p (0.05) were considered significant.

Results

The baseline characteristics of the cohort are given in [Table 1]. Analysis of the table shows that the mean age of the cohort was 32.5 ± 12.4 years, which shows that most of the population is a relatively younger age group. Male predominance was present, with 55% of cases being male patients. The majority of cases were due to intentional (suicidal) poisoning 87.5% and the remaining 12.5% were due to accidental exposure. The mean duration of exposure and presentation to the hospital was 8.6 ± 5.2 hours. The organophosphorus compounds commonly used were chlorpyrifos (35%), which was the most commonly involved, followed by dimethoate (25%), malathion (20%), monocrotophos (15%), and others (5%).

Table 1: Baseline Characteristics of the Study Population (N=40)

Characteristic	Category/ Value
Age (Years) (Mean ± SD]	32.5 ± 12.4
Gender [n (%)]	
Male	22 (55.0%)
Female	18 (45.0%)
Mode of Poisoning n (%)	
Intentional (Suicidal)	35 (87.5%)

Accidental	5 (12.5%)
Time Elapsed Since Exposure (Hours) (Mean ± SD]	8.6 ± 5.2
Type of OP Compound [n (%)]	
Chlorpyrifos	14 (35.0%)
Dimethoate	10 (25.0%)
Malathion	8 (20.0%)
Monocrotophos	6 (15.0%)
Others	2 (5.0%)

Ventilatory Support Requirement in the cohort is presented in [Table 2]. Out of the 40 patients, 18 (45%) required ventilatory support during hospitalization, while 22 (55%) did not require mechanical ventilation.

Table 2: Distribution of Patients Based on Ventilatory Support Requirement

Parameter	Number of Patients (n)	Percentage (%)
Patients Requiring Ventilatory Support	18	45.00%
Patients Not Requiring Ventilatory Support	22	55.00%
Total	40	100.0%

Comparison of clinical and demographic parameters between the two groups of cases is given in [Table 3]. Analysis of the table showed that there was no statistically significant difference between the two groups based on age or time elapsed for presentation to the hospital. However, it is found that the patients requiring ventilatory support had significantly lower GCS scores compared to non-ventilatory support patients (7.4 ± 2.1 vs 12.8 ± 1.6, $p < 0.001$). It was also found that higher Peradeniya OP Poisoning (POP) scale scores in patients requiring ventilatory support (9.6 ± 1.8 vs 4.5 ± 1.4, $p < 0.001$). The assessment of vital parameters showed that patients requiring ventilatory support had higher pulse rates, lower systolic blood pressure, and increased respiratory rates compared to the non-ventilatory support cases, and all the statistical values were significant (< 0.001).

Table 3: Comparison of Clinical and Demographic Parameters Between Groups

Parameter	Patients Requiring Ventilatory Support (n=18)	Patients Not Requiring Ventilatory Support (n =22)	P Value
Age (Years)	34.2 ± 13.1	31.1 ± 11.8	0.43
Time Elapsed Since Exposure (Hours)	7.2 ± 4.8	9.8 ± 5.4	0.12
Glasgow Coma Scale (GCS) Score	7.4 ± 2.1	12.8 ± 1.6	<0.001*
Peradeniya OP Poisoning (POP) Scale Score	9.6 ± 1.8	4.5 ± 1.4	<0.001*
Pulse Rate (beats/min)	118.5 ± 14.2	96.3 ± 11.6	<0.001*
Systolic Blood Pressure (mmHg)	98.4 ± 12.5	118.6 ± 10.3	<0.001*
Respiratory Rate (breaths/min)	28.6 ± 5.4	18.4 ± 3.2	<0.001*
*Significant			

Comparison of Laboratory Parameters between the two groups of cases is presented in [Table 4]. Overall analysis of the table showed that patients requiring ventilatory support had markedly lower serum cholinesterase levels compared to those not requiring ventilatory support (850.5 ± 320.4 vs 2150.8 ± 580.6, $p < 0.001$). They also exhibited severe metabolic and respiratory derangements, including lower arterial pH (7.21 ± 0.11 vs 7.36 ± 0.08), reduced PaO_2 (58.4 ± 12.5 vs 82.6 ± 10.2), elevated $PaCO_2$ (52.3 ± 8.6 vs 38.4 ± 4.5), and lower bicarbonate levels (18.2 ± 3.4 vs 22.5 ± 2.8), all statistically significant ($p < 0.001$). Serum creatinine was also significantly higher in the ventilated group (1.4 ± 0.6 vs 0.9 ± 0.3, $p = 0.003$). This indicates that there were associated organ dysfunctions in ventilatory support cases.

Table 4: Comparison of Laboratory Parameters Between Groups

Parameter	Patients Requiring Ventilatory Support (n=18)	Patients Not Requiring Ventilatory Support (n=22)	P Value
Serum Cholinesterase (WL)	850.5 ± 320.4	2150.8 ± 580.6	<0.001*
Arterial pH	7.21 ± 0.11	7.36 ± 0.08	<0.001*
PaO2 (mmHg)	58.4 ± 12.5	82.6 ± 10.2	<0.001*
PaCO2 (mmHg)	52.3 ± 8.6	38.4 ± 4.5	<0.001*
Bicarbonate (HCO3-) (mmoI/L)	18.2 ± 3.4	22.5 ± 2.8	<0.001*
Serum Creatinine (mg/dL)	1.4 ± 0.6	0.9 ± 0.3	0.003*

Comparison of Clinical Features of the two groups is given in [Table 5]. Analysis of the table showed that more severe clinical features including excessive salivation 94.4% vs 68.2%, $p = 0.04$), fasciculations (83.3% vs 36.4%, $p = 0.003$), bronchorrhea (77.8% vs 27.3%, $p = 0.002$), altered sensorium (100% vs 45.5%, $p < 0.001$), and intermediate syndrome (44.4% vs 0%, $p < 0.001$) were significantly more in patients requiring ventilatory support. The presence of miosis was also common in the ventilatory support group; however, the values did not reach the level of significance. The association of seizures was not significantly related to ventilatory support.

Table 5: Comparison of Clinical Features Between Groups

Parameter	Patients Requiring Ventilatory Support (n=18)	Patients Not Requiring Ventilatory Support (n=22)	P Value
Miosis (Pinpoint Pupils)	16 (88.9%)	14 (63.6%)	0.07
Excessive Salivation	17 (94.4%)	15 (68.2%)	0.04 *
Fasciculations	15 (83.3%)	8 (36.4%)	0.003*
Bronchorrhea	14 (77.8%)	6 (27.3%)	0.002*
Altered Sensorium	18 (100%)	10 (45.5%)	<0.001*
Intermediate Syndrome	8 (44.4%)	0 (0.0%)	<0.001*
Seizures	3 (16.7%)	1 (4.5%)	0.2
*Significant			

The important predictors of ventilatory support are given in [Table 6]. Analysis of the table showed that there are several predictors for ventilatory support. Among them, the strongest one is the GCS score ≤8, having the highest odds ratio (OR 12.5, $p < 0.001$). The second is a POP scale score >7 (OR 9.8, $p = 0.001$). The other factors were presence of bronchorrhea (OR 9.3), serum cholinesterase <1000 U/L (OR 8.4), fasciculations (OR 8.0), $PaCO_2$ >45 mmHg (OR 7.2), and respiratory rate >24/min (OR 5.6), all with statistically significant p-values as shown in the table.

Table 6: Predictors of Ventilatory Support Requirement

Determinant	Odds Ratio (OR)	95% Confidence Interval	P Value
GCS score ≤ 8	12.5	3.2 - 48.6	<0.001.
POP scale score >7	9.8	2.6 - 36.4	0.001*
Serum Cholinesterase <1000 U/L	8.4	2.1 - 33.2	0.003*
Presence of Fasciculations	8.0	1.9-331	0.004*
PaCO2 >45 mmHg	7.2	1.8 - 28.6	0.005*
Respiratory Rate >24/min	5.6	1.5 - 20.8	0.009*
Presence of Bronchorrhea	9.3	2.1 - 41.2	0.003*
*Significant			

Outcomes in Ventilated Patients in the study are given in [Table 7]. Among patients requiring ventilatory support, the mean duration of ventilation was 5.8 ± 2.4 days, and the mean hospital stay was 8.4 ± 3.2 days. The survival rate in this group was 77.8%, while mortality was observed in 22.2% of patients.

Table 7: Outcomes in Patients Requiring Ventilatory Support

Outcome	Number of Patients (n)	Percentage (%)
Duration of Ventilation (Days) [Mean± SD]	5.8 ± 2.4	-
Duration of Hospital Stay (Days) [Mean ± SD]	8.4 ± 3.2	-
Survival	14	77.80%
Mortality	4	22.20%

Discussion

Organophosphorus (OP) compound poisoning is one of the important causes of acute toxic exposure all over the world, especially in developing nations, and respiratory failure is the most frequent cause of death.[1,3] The results of this study showed that 45% of cases required ventilatory support in OP poisoning. This is in agreement with the previous studies, where they have reported about 30 – 60% of cases of OP poisoning required ventilatory support.[7,9] This underscores the critical importance of ventilatory support in OP poisoning patients to prevent respiratory compromise. The demographic profile of cases in this study showed that most of them were young adults with a small preponderance of men, which is consistent with previous research observations.[1,9] The prevalence of intentional (suicidal) poisoning (87.5%) indicates that the problem of self-harming with pesticides in rural agricultural communities has not disappeared, and the availability of harmful substances is one of the primary concerns.[10,15] The fact that chlorpyrifos and dimethoate are the most frequently implicated agents in this investigation is in line with the trends usually reported in the agricultural regions.[10] One of the key findings of this research is that there was a high correlation between the severity of clinical presentations and the requirement for ventilatory support. The patients who were under ventilation support were found to have a significantly lower Glasgow Coma Scale (GCS) score and a higher Peradeniya Organophosphorus Poisoning (POP) scale score. The strongest predictor with an OR of 12.5 was a GCS score ≤8, which is in line with the findings of other research who reported depressed consciousness to be a reliable signal of severe poisoning and poor prognosis.[8,11] Moreover, it has been confirmed that the POP scale was a useful clinical instrument in determining the level of severity and anticipating the necessity of intensive care.[6,11] The present study showed that clinical parameters like tachycardia, hypotension, and tachypnea were considerably linked with ventilatory requirement. These are indications of severe cholinergic toxicity and autonomic dysfunction.[2,4] A high respiratory rate (>24/min) became relevant as a predictor in the present study, which was consistent with previous studies showing that tachypnea is an early clinical sign of impending respiratory failure.[12,16] Laboratory parameters demonstrated significant differences between the two groups [Table 4]. It was found that patients who required ventilatory support had low levels of cholinesterase, increased

enzyme inhibition, and higher toxicity. However, despite serum cholinesterase being a commonly used diagnostic marker, its prognostic power has been questioned, although various studies have revealed that low levels correlated with a higher severity of poisoning.[7,13] The analysis of the arterial blood gas showed higher hypoxia, hypercapnia, and acidosis in the ventilated patients. High level of PaCO2 (>45 mmHg) was found to be one of the strongest predictors, which aligns with other prior research that revealed the ability of high level of PaCO2 to signal paralysis and exhaustion of respiratory muscle.[12,14] Fasciculations, bronchorrhea, excessive salivation, and sensorium changes were also observed as the clinical features, which were far more common in patients who required ventilatory support. These results indicate the nicotinic and muscarinic effects of the accumulation of acetylcholine. The fact that bronchorrhea and fasciculations are strong predictors of this study is evident in previous literature.[5,14,16] It is also important to note that intermediate syndrome was witnessed only in the patients admitted to ventilation, which supports its significance as the delayed yet severe complication resulting in respiratory muscle paralysis.[5,17] In this study, the mortality rate was found to be 22.2% and this is comparable to other mortality rates of 15-30% that were reported by previous similar studies.[3,9,18] It is important to identify high-risk patients early and start the ventilatory support in time to improve the survival outcomes. Late intervention may have complications like hypoxic brain injury and aspiration pneumonia, which will deteriorate the prognosis further.[18,19] Overall, this study found that important determinants of ventilatory support in cases of OP poisoning are low GCS score, high POP score, elevated PaCO2, bronchorrhea, and fasciculations. Early identification of these symptoms may lead to optimal utilization of resources for improving patient outcomes.

Conclusion

Organophosphorus compound poisoning is an important case of a life-threatening emergency in the rural population. It requires prompt treatment and ventilatory support in some cases, because of the high risk of respiratory failure. The present study showed that nearly 50% of the cohort required ventilatory support, showing the severity of poisoning at presentation. Some of the important determinants for ventilatory support are a low Glasgow Coma Scale score, a high POP scale score, presence of bronchorrhea, fasciculations, elevated $PaCO_2$, and reduced serum cholinesterase levels. Critical observations for the above signs and symptoms can lead to prompt management and improve the overall outcome of treatment.

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Conflicts of interest

There are no conflicts of interest.

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