

Life-Saving Resin: Hemoperfusion's Role in Overcoming Acute Organophosphate and Carbamate Poisoning

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Abstract:

Background: Acute poisoning from organophosphates and carbamates is a major public health concern. These poisons inhibit acetylcholinesterase, leading to severe clinical manifestations. Traditional treatments, such as atropine and oximes, often fall short in severe cases, necessitating alternative therapeutic approaches. Hemoperfusion, an extracorporeal blood purification technique, has shown promise in improving outcomes for poisoning cases. This study aimed to estimate the clinical outcomes of resin-based HOD in individuals with acute organophosphate and carbamate poisoning admitted to a South Asian tertiary care hospital.

Methods: A prospective observational study was carried out involving 50 patients diagnosed with acute organophosphate (n=30) or carbamate (n=20) poisoning. Patients underwent standard treatment protocols, and eligible individuals received resin-based hemoperfusion. Data on demographic details, clinical outcomes, complications, and biochemical parameters were collected and analysed using SPSS version 25.0.

Results: The study found an overall recovery rate of 84%, with 80% recovery in the organophosphate group and 90% in the carbamate group. The complication rate was 12%, and the mortality rate was 4%. Cholinesterase levels significantly increased post-hemoperfusion, with a mean rise of 600 U/L. Time to treatment was a significant predictor of positive outcomes (p=0.011).

Conclusion: Resin-based hemoperfusion is effective in treating acute organophosphate and carbamate poisoning, significantly improving recovery rates and reducing mortality. Early intervention is crucial for optimal outcomes. This treatment modality should be considered a valuable component of poisoning management protocols, especially in resource-limited settings.

Recommendations: Further research with larger sample sizes and randomized controlled trials is recommended to confirm these findings and explore additional factors influencing treatment outcomes. Implementation of resin-based hemoperfusion in standard treatment protocols for severe poisoning cases is advised to enhance patient care and survival rates.

Keywords: Organophosphate poisoning, Carbamate poisoning, Hemoperfusion, Clinical outcomes

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Introduction

Acute poisoning due to organophosphates and carbamates remains a significant public health issue, particularly in developing regions of South Asia where agriculture is a primary occupation. Organophosphates and carbamates are commonly used as pesticides, and their widespread availability increases the risk of accidental or intentional poisoning. According to the World Health Organization (WHO), pesticide poisoning is a leading cause of morbidity and mortality globally, with millions of cases reported annually, many of which occur in low- and middle-income countries [1].

The toxic effects of organophosphates and carbamates are primarily due to their inhibition of acetylcholinesterase, leading to the accumulation of acetylcholine in synapses and neuromuscular junctions. This results in a range of symptoms, from mild (nausea, vomiting) to severe (respiratory distress, seizures, and death) [2]. Immediate and effective medical intervention is crucial to reduce mortality and long-term morbidity associated with these poisonings.

Traditional treatments for organophosphate and carbamate poisoning include the administration of atropine and oximes, alongside supportive care. However, these treatments may not be sufficient in severe cases, necessitating alternative or adjunctive therapies. Hemoperfusion, an extracorporeal blood purification technique, has emerged as a promising treatment for severe poisoning. This technique involves passing blood through a cartridge containing a resin or activated charcoal that adsorbs toxins, thereby reducing the toxic load in the patient's body [3].

Recent studies have demonstrated the efficacy of hemoperfusion in various types of poisonings, including those caused by pesticides. For instance, a study showed

that hemoperfusion significantly improved clinical outcomes in patients with severe organophosphate poisoning [4]. Similarly, research indicated that early initiation of hemoperfusion could reduce the duration of intensive care unit (ICU) stay and improve survival rates in carbamate poisoning cases [5].

Despite these promising findings, the use of resin-based hemoperfusion in acute organophosphate and carbamate poisoning is not yet widely adopted, particularly in resource-limited settings.

This study aims to evaluate the clinical outcomes of resin-based hemoperfusion in patients with acute organophosphate and carbamate poisoning.

Methodology:

Study Design

A prospective observational study.

Study Setting

The study was conducted at the tertiary care hospital. The study spanned a period of six months.

Participants

A total of 50 patients presenting with acute organophosphate and carbamate poisoning were enrolled in the study.

Inclusion Criteria

- Individuals aged 18 years and above.
- Confirmed diagnosis of acute organophosphate or carbamate poisoning based on clinical presentation and laboratory results.

Exclusion Criteria:

- Patients with chronic organophosphate or carbamate exposure.
- Pregnant or lactating women.
- Patients with pre-existing chronic illnesses that could confound the results.

Sample size:

To calculate the sample size for this study, the following formula was used for estimating a proportion in a population:

$$n = \frac{Z^2 \times p \times (1-p)}{E^2}$$

Where:

- n = sample size
- Z = Z-score corresponding to the desired level of confidence
- p = estimated proportion in the population
- E = margin of error

Bias

To minimize selection bias, consecutive sampling was used, enrolling all eligible patients who presented during the study period. Efforts were made to ensure data collection and analysis were blinded to treatment outcomes to reduce observer bias.

Variables

Variables included type of poisoning (organophosphate or carbamate), time from ingestion to treatment initiation, dose and duration of hemoperfusion, clinical outcomes (recovery, complications, mortality), duration of ICU stay, biochemical parameters (cholinesterase levels, electrolyte levels).

Data Collection:

Data were collected using a standardized data collection form. Information included demographic details, clinical presentation, type and amount of poison ingested, time to treatment initiation, details of hemoperfusion therapy, and clinical outcomes.

Procedure:

Upon presentation, patients were assessed and diagnosed with organophosphate or carbamate poisoning through clinical evaluation and laboratory tests. Standard treatment protocols were initiated,

including gastrointestinal decontamination and supportive care. Patients eligible for hemoperfusion underwent the procedure using a resin-based hemoperfusion cartridge. The duration and frequency of hemoperfusion sessions were determined based on the patient's clinical condition and response to treatment.

Statistical Analysis:

SPSS version 21.0 was used to analyse the data. The variables were presented as percentages, frequencies, and mean \pm standard deviation. For categorical data, chi-square tests were utilised, and for continuous variables, t-tests. Statistical significance was attained when the p-value was less than 0.05. The study employed multivariate regression analysis to ascertain the independent components that are linked to clinical outcomes.

Ethical considerations:

The study protocol was approved by the Ethics Committee and written informed consent was received from all the participants.

Result:

A total of 50 patients were comprised in the study, with 30 individuals in the organophosphate poisoning group and 20 in the carbamate poisoning group. The mean age of participants was 35.3 years (\pm 12.2), with 60% being male and 40% female. The mean time from ingestion to treatment initiation was 3.8 hours (\pm 1.3). Initial cholinesterase levels averaged 1180 U/L (\pm 335) across both groups. The mean duration of ICU stay was 7.4 days (\pm 3.2) (Table 1)

Table 1: Demographic and Baseline Characteristics

Characteristic	Organophosphate Group	Carbamate Group	Total
Mean Age (years)	34.2 \pm 12.5	36.7 \pm 11.8	35.3 \pm 12.2
Gender, n (%)			
- Male	18 (60%)	12 (60%)	30 (60%)
- Female	12 (40%)	8 (40%)	20 (40%)
Time to Treatment (hours)	3.5 \pm 1.2	4.1 \pm 1.5	3.8 \pm 1.3
Initial Cholinesterase (U/L)	1200 \pm 350	1150 \pm 320	1180 \pm 335
ICU Stay (days)	7.8 \pm 3.5	6.9 \pm 2.8	7.4 \pm 3.2

The primary outcomes assessed were recovery, complications, and mortality. Full recovery was observed in 24 patients (80%) in the organophosphate group and 18 patients (90%) in the carbamate group, yielding an overall recovery rate of 84%. Complications were reported in 4 patients

(13.3%) in the organophosphate group and 2 patients (10%) in the carbamate group. The mortality rate was 6.7% (2 patients) in the organophosphate group, with no deaths in the carbamate group, resulting in an overall mortality rate of 4% (Table 2).

Table 2: Clinical Outcomes

Outcome	Organophosphate Group	Carbamate Group	Total	p-value
Full Recovery, n (%)	24 (80%)	18 (90%)	42 (84%)	0.324
Complications, n (%)	4 (13.3%)	2 (10%)	6 (12%)	0.723
Mortality, n (%)	2 (6.7%)	0 (0%)	2 (4%)	0.512
Mean Duration of Hemoperfusion (hours)	5.2 ± 1.1	4.8 ± 1.3	5.0 ± 1.2	0.237

Biochemical parameters, specifically cholinesterase levels, were measured before and after hemoperfusion. The initial mean cholinesterase levels were 1180 U/L

(± 335), which increased to 1780 U/L (± 410) post-hemoperfusion, reflecting a mean increase of 600 U/L (± 115) (Table 3).

Table 3: Cholinesterase Levels Before and After Hemoperfusion

Time Point, (U/L)	Organophosphate Group	Carbamate Group	Total	p-value
Initial Cholinesterase	1200 ± 350	1150 ± 320	1180 ± 335	0.4445
Post-Hemoperfusion	1800 ± 420	1750 ± 400	1780 ± 410	0.522
Change in Cholinesterase	600 ± 120	600 ± 110	600 ± 115	0.986

The multivariate regression analysis revealed that the time to treatment was significantly associated with clinical outcomes ($p = 0.011$). Other factors,

including age, gender, initial cholinesterase levels, and duration of hemoperfusion, were not statistically significant predictors of outcomes (Table 4).

Table 4: Multivariate Regression Analysis

Variable	Coefficient (B)	Standard Error	p-value
Age	-0.012	0.045	0.798
Gender (Male vs. Female)	0.157	0.223	0.485
Time to Treatment (hours)	-0.187	0.073	0.011*
Initial Cholinesterase (U/L)	0.003	0.002	0.095
Duration of Hemoperfusion (hours)	0.158	0.093	0.086

*Significant at $p < 0.05$

Discussion

In the study, participants were divided into two groups: 30 patients with organophosphate poisoning and 20 with carbamate poisoning. The mean age of the patients was 35.3 years, with a majority (60%) being male. The mean time from ingestion to treatment initiation was 3.8 hours. Initial cholinesterase levels were similar across both groups, averaging 1180 U/L. The duration of ICU stays averaged 7.4 days.

The study found that 84% of patients achieved full recovery following hemoperfusion. Complications were reported in 12% of the patients, with no substantial difference between the organophosphate and carbamate groups. The overall mortality rate was low at 4%, with two deaths occurring in the organophosphate group. The mean duration of hemoperfusion was approximately 5 hours, and this did not differ substantially between the groups.

A significant increase in cholinesterase levels was observed post-hemoperfusion, indicating effective detoxification. The mean increase in cholinesterase levels was 600 U/L, further supporting the efficacy of hemoperfusion in reducing the toxic burden of organophosphates and carbamates.

Time to treatment was identified as a significant predictor of positive clinical outcomes, highlighting the critical importance of early intervention. Other factors such as age, gender, initial cholinesterase levels, and duration of hemoperfusion were not significantly associated with clinical outcomes.

The study demonstrates that resin-based hemoperfusion is an effective treatment for acute organophosphate and carbamate poisoning, with a high recovery rate and a low incidence of complications and mortality. The significant increase in cholinesterase levels post-hemoperfusion confirms its efficacy in detoxification. The critical factor influencing outcomes was the

time to treatment, emphasizing the necessity for prompt medical intervention.

Recent studies have highlighted the potential benefits of hemoperfusion in the treatment of acute organophosphate and carbamate poisoning. A randomized controlled study demonstrated that early hemoperfusion/hemadsorption (HA) therapy suggestively reduced ICU length of stay, duration of mechanical ventilation, and the combination of day 28 mortality and severe complications compared to standard care [6]. This underscores the importance of HA therapy in improving outcomes for critically ill patients with organophosphate and carbamate poisoning.

In addition to hemoperfusion, research has focused on identifying biomarkers to better predict the severity of poisoning. A study found that liver transaminases (AST and ALT) and bilirubin levels are useful biomarkers for assessing the severity of acute organophosphate and carbamate poisoning. Higher levels of these markers were associated with more severe poisoning and poorer treatment outcomes [7].

A retrospective study analyzed factors affecting mortality in patients with organophosphate and carbamate poisoning. The study found that combined treatment with atropine and pralidoxime (PAM) resulted in lower days of ventilation and intubation requirements compared to other treatment regimens. This highlights the effectiveness of specific treatment combinations in managing poisoning cases [8].

Furthermore, an observational study found that hemoperfusion significantly improved the condition of critically ill patients with organophosphorus poisoning. The treatment led to better serum inflammatory factor levels and overall treatment effects compared to conventional treatments [9]. This provides additional evidence

supporting the use of hemoperfusion in severe poisoning cases.

A systematic review identified additional biomarkers such as β -glucuronidase, neuropathy target esterase, amylase, and lipase that could improve the diagnosis of organophosphate and carbamate poisoning. These biomarkers can aid in better management and early identification of patients at risk of severe outcomes, thereby enhancing treatment effectiveness [10].

Conclusion

This study demonstrates the significant efficacy of resin-based hemoperfusion in treating acute organophosphate and carbamate poisoning, achieving a high recovery rate of 84% and a low mortality rate of 4%. The treatment's ability to significantly increase cholinesterase levels post-hemoperfusion underscores its effectiveness in detoxification. A key finding is the critical importance of early intervention, as time to treatment significantly predicted positive outcomes, emphasizing the need for prompt medical response in acute poisoning cases. No significant differences were found between organophosphate and carbamate poisoning outcomes, suggesting resin-based hemoperfusion is beneficial for both. These findings support its use as a standard treatment option in acute poisoning cases, especially where quick and effective detoxification is needed. Further research with larger sample sizes and randomized controlled trials is recommended to validate these results. Overall, resin-based hemoperfusion offers a promising approach to managing acute organophosphate and carbamate poisonings, potentially improving patient care and outcomes in similar emergencies.

Limitations: The limitations of this study include a small sample population who were included in this study. Furthermore, the lack of comparison group also poses a limitation for this study's findings.

Recommendation:

Further research with larger sample sizes and randomized controlled trials is recommended to confirm these findings and explore additional factors influencing treatment outcomes. Implementation of resin-based hemoperfusion in standard treatment protocols for severe poisoning cases is advised to enhance patient care and survival rates.

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List of abbreviations:

ALT: Alanine Transaminase
AST: Aspartate Transaminase
HA: Hemadsorption
ICU: Intensive Care Unit
PAM: Pralidoxime
WHO: World Health Organization

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Conflict of interest: The authors have no competing interests to declare.

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