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Neurocognitive And Psychiatric Assessment Following Recovery From Acute Organophosphate Poisoning

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Abstract
Background: *Organophosphate (OP) exposure can have long-term consequences, including cognitive abnormalities. The purpose of this study was to evaluate if acute OP poisoning was related with neurocognitive and/or mental sequelae following clinical recovery from the acute cholinergic phase, using follow-up examination. Methods: This prospective cohort research included 32 patients (group 1), both sexes, aged 18 to 60 years old, who had acute OP poisoning. Healthy volunteers (group 2) were also included, who were matching in age and sex to group 1.*
Results: *Regarding neurocognitive and psychiatric assessment, there was significant improvement after 3 months compared to that on discharge and 6 weeks. There was a significant positive correlation between Rapid emergency medicine score (REMS) and Hamilton anxiety scale on discharge and after 6 weeks and (REMS and Hamilton depression scale on discharge).*
Conclusions: *Acute OP poisoning is related with poor memory, planning, and attention, which can exist beyond clinical recovery and appear to improve after three months. Acute OP poisoning may have psychological consequences such as anxiety and depression, which appear to be reversible.*
Keywords: *Neurocognitive, Psychiatry, Acute Organophosphate Poisoning, Recovery*

INTRODUCTION:

Organophosphates (OP) refer to a group of chemicals produced from phosphoric, phosphonic, and phosphinic acids. The first OP compounds were synthesised in the nineteenth century, and they are now found in a wide range of items used across the world, including insecticides, lubricants, plasticisers, industrial solvents, fuel additives, and nerve agents [1, 2].

Farmers and children have been exposed to pesticides both accidentally and occupationally, resulting in acute or chronic poisoning. These substances rapidly and efficiently enter the human body via the skin, eye, inhalation, and ingestion [3, 4].

The OP inhibits the activity of cholinesterase enzymes, resulting in excess acetylcholine in cholinergic effector cells, skeletal neuromuscular junctions, autonomic ganglia, and the central nervous system [5, 6]. Once the patient is exposed to OP, symptoms begin to appear within 30 minutes. But it may also appear late within 24 hours in lipophilic compounds [7].

Stimulation of the muscarinic receptors causes defecation, urination, miosis, bradycardia, bronchorrhea, bronchospasm, lacrimation, emesis, and salivation. Nicotinic manifestations include mydriasis, tachycardia, hypertension, muscle fasciculations and weakness. CNS effects include headache, dizziness, restlessness, anxiety, confusion, insomnia, tremors, dysarthria, ataxia, seizures, coma, and central respiratory depression [8].

Evidence from both animal and human research indicates that the cholinergic nerve systems are critical for learning, memory, and cognition [9, 10].

Numerous studies documented neurological symptoms among individuals exposed acutely to OP poisoning, without displaying severe impairment in more objective tests that assess the deficiencies of various cognitive processes [11, 12].

These long-term neuropsychiatric and neurophysiologic effects might be serious public health issues, this results in the loss of many years of productive life and high healthcare expenses [13].
The purpose of this study was to evaluate if acute OP poisoning was related with neurocognitive and/or mental sequelae following clinical recovery from the acute cholinergic phase, using follow-up examination.

Patients and Methods:

This prospective cohort research was conducted on 32 patients with acute OP poisoning, both sexes, ages 18 to 60, based on the following diagnostic criteria according to Karki et al. [14] : history of exposure given by the patient or a witness an OP agent and examination of the container if available, characteristic clinical manifestations of OP poisoning and low serum pseudocholinesterase activity at admission (less than the minimum reference range; 1900). The control group consisted of 32 healthy adults. The study was conducted from April 2022 to March 2023, with consent from Tanta University Hospitals' Ethical Committee in Tanta, Egypt (approval code: 35368/3/22). Patients provided informed written consent.

Exclusion criteria were ingestion or exposure to other substances in addition to the OP agent, asymptomatic patients for OP poisoning, uncooperative patients as: aggressive patients ,uneducated patients who can't read or write, those with a history of head injuries with neurological damage, upper limb motor dysfunction, liver illness, renal disease, stroke, dementia, or severe uncorrected vision or hearing impairment and previous history of psychiatric disorder, alcohol dependence or substance abuse.

The study included two equal groups: Group I: poisoned with OP agents and Group II: control group.

History taking, physical examination and laboratory tests, including complete blood count (CBC), arterial blood gases (ABG), serum sodium (Na) and potassium levels (K), random blood glucose (RBG), serum aspartate transaminase (AST) and alanine transaminase (ALT), blood urea, serum creatinine, serum pseudocholinesterase, partial pressure of carbon dioxide (PCO2), partial pressure of oxygen PO2, bicarbonate (HCO3), and O2 saturation, as well as electrocardiography (ECG), were performed on all patients.

Assessment of severity of poisoning according to Rapid Emergency Medicine Score (REMS):[15]

Rapid Emergency Medicine Score consisted of 6 items; age, mean arterial pressure (MAP), pulse rate, respiratory rate (RR), peripheral oxygen saturation and GCS. All items were assigned a score from 0 (normal) to 4 (the most abnormal) except age was scored from (0 to 6) giving a score ranges from 0 to 26; < 6 indicates mild, > 6 and < 13 indicates moderate and > 13 indicates severe

Score							
Variable	0	+1	+2	+3	+4	+5	+6
Age (years)	<45		45–54	55–64		65–74	>74
MAP (mmHg)	70–109		110-129 50–69	130–159	>159 ≤49		
Heart rate (beat/minute)	70–109		110-139 55–69	140–179 40–54	>179 ≤39		
RR (cycle/minute)	12–24	25–34 10–11	6–9	35–49	>49 ≤5		
O2saturation (%)	>89	86–89		75–85	<75		
GCS	14 or 15	11–13	8–10	5–7	3 or 4		

Assessment of neurocognition and psychiatry after clinical recovery (on discharge), 6 weeks and 3 months later:

The Mini-mental state examination (MMSE), in its original form, is the most widely used cognitive screening test globally. Numerous studies have shown that valid and concise tests can effectively screen for cognitive impairments and assess their severity at assessment [16].

The exam typically takes between 7 and 10 minutes to finish. Scores for the Mini-Mental State Examination (MMSE) were documented, ranging from 0 to 30, involving individual scores for seven distinct domains: registration (0-3 points), attention and calculation (0-5 points), recall (0-3 points), temporal awareness (0-5 points), spatial awareness (0-5 points), language skills (0-8 points), and drawing ability (0-1 point).

The digit span test consists of two sets of random sequences of non-repeating digits, each with a length ranging from 3 to 9 digits. In the forward condition, participants were given the opportunity to view a sequence of progressively longer digits, one per second, and were subsequently required to recall them in the same order immediately. Correct recall of both sequences in a trial earned two points, correct recall of only one sequence earned one point, and no points were awarded if neither sequence was correctly recalled. Individuals were shown different strings of numbers, one at a time, at a rate of 1 per second, and were then asked to recall them in reverse order, with accuracy ranging from 0 to 14 points [17].

The Trail Making Test (TMT) is comprised of two components, TMT-Part A (TMT-A) and TMT-Part B (TMT-B). In TMT-A, participants were tasked with quickly arranging in ascending sequence a set of 25 numerals encircled on a sheet of paper. Similar to TMT-B's requirements, TMT-B's test entailed connecting numbers and letters in a series, alternating between them (1–A–2–B–3–C, etc.) as quickly as possible. It appears TMT-A relies mainly on the speed and efficiency of visual scanning and psychomotor abilities. In contrast, TMT-B is thought to engage more complicated cognitive processes, assessing skills such as visual-conceptual and visual-motor tracking, and focusing on psychomotor speed, divided attention, mental flexibility, and the ability to switch between tasks. TMT-A is considered deficient if it takes longer than 78 seconds, and TMT-B is considered deficient if it takes more than 273 seconds [18].

The Arabic version of the Hamilton rating scale (HARS) for anxiety:

The HARS assessment consists of 14 items, classifying a range of symptoms to evaluate mental agitation and psychological distress, alongside anxiety-related physical symptoms. Symptoms were rated using a 5-point Likert scale with scores ranging from 0 (no symptoms) to 4 (very severe symptoms), including 1 (mild symptoms), 2 (moderate symptoms), and 3 (severe symptoms). The total score was determined by adding up the 14 items, with scores ranging from 17 or less being considered normal to mild, scores of 18-24 indicating mild to moderate, and scores of 25-30 denoting moderate to severe [19, 20].

The Arabic version of the Hamilton rating scale for depression:

The final four items on the 21-item Hamilton Depression Scale (HDRS)—diurnal variation, depersonalization/derealization, paranoid symptoms, and obsessive-compulsive symptoms—are not included in the final score because they offer extra clinical information and are either rare or do not accurately represent the severity of depression. Consequently, the remaining 17 HDRS items are evaluated to assess the intensity of depression symptoms [19, 21, 22].

Positive and Negative Syndrome Scale (PANSS) includes thirty things with a rating of seven points. A thorough description and comprehensive anchoring criteria for each of the seven rating points—which stand for enhancing levels of psychopathology—are included with every question on the PANSS: Absent is denoted by 1, minimum by 2, mild by 3, moderate by 4, moderate-to-severe by 5, severe by 6, and extreme by 7. Thirteen of the thirty psychiatric criteria evaluated on the PANSS were selected to form a General Psychopathology Scale, seven to form a Positive Scale, and seven to form a Negative Scale. The total of the ratings for each item was used to assess the PANSS: 58-75 indicates minimal, 76-95 indicates mild, 96-116 indicates moderate and 117-210 indicates severe [23].

The outcomes were affection of neurocognitive functions and psychiatric problems (anxiety, depression, or psychosis).

Sample Size Calculation:

The sample size calculation was done by G*Power 3.1.9.2 (Universitat Kiel, Germany). We performed a pilot study (five cases in each group), and we found that the mean (± SD) of MMSE was 27.8 ± 1.10 in group 1 and 31.8 ± 7.22 in group 2. The sample size was based on the following considerations: 0.775 effect size, 95% confidence limit, 80% power of the study, group ratio 1:1, and four cases were added to each group to overcome dropout. Therefore, we recruited 32 patients in each group.

Statistical analysis

SPSS v27 was used for statistical analysis (IBM©, Chicago, IL, USA). The normality of the data distribution was assessed using histograms and the Shapiro-Wilks test. ANOVA (F) test with post hoc test (Tukey) was used to analyse quantitative parametric data, which were shown as mean and standard deviation (SD). The interquartile range (IQR) and median of quantitative non-parametric data were displayed, and each group was compared using the the Mann Whitney test. The Chi-square test was used to analyse the qualitative variables, which were shown as frequency and percentage (%). The Pearson moment correlation equation was used to correlate several variables. Statistical significance was defined as a two-tailed P value < 0.05.

RESULTS:

Age, gender and marital state were insignificantly different between both groups. Residence, occupation and neurocognitive assessment were significantly different between both groups (P<0.05). **Table 1**

Table 1: Socio-demographic data and neurocognitive assessment on discharge of the studied groups

	OP poisoned patients (n = 32)	Control(n=32)	Test	P
Age (years)	33.25±14.17	35.06±12.29	t= 0.547	0.587

18 – 20 21 – 40 41 – 60		9(28.1%) 13(40.6%) 10(31.3%)	4(12.5%) 17(53.1%) 11(34.4%)	χ^2= 2.504	0.286
Gender	**Male**	21(65.6%)	15(46.9%)	χ^2=2.286	0.131
	Female	11(34.4%)	17(53.1%)		
Marital state	**Single**	13(40.6%)	14(43.8%)	χ^2=0.064	0.800
	Married	19(59.4%)	18(56.2%)		
Residence	**Rural**	28(87.5%)	12(37.5%)	χ^2=17.067	**<0.001***
	Urban	4(12.5%)	20(62.5%)		
Occupation	**Housewife**	6(18.8%)	9(28.1%)	χ^2=13.310*	MC**P= 0.004***
	Student	9(28.1%)	7(21.9%)		
	Farmer	9(28.1%)	0(0.0%)		
	Worker	8(25.0%)	16(50.0%)		
Neurocognitive assessment on discharge					
MMSE		28.19±1.06	29.03±1.0	U=292.500*	**0.002***
Digit forward (digit)		4.19±0.97	6.03±0.78	t=8.395*	**<0.001***
Digit backward (digit)		1.91±1.12	4.0±0.76	t=8.756*	**<0.001***
TMT A (sec) Min		90.75±26.86	63.81±6.56	U=145.500	**<0.001***
TMT B (sec)		277.6±49.74	207.5±23.74	U=133.000	**<0.001***

Data are presented as mean ± SD or frequency (%). * Significant P value <0.05. t: Student t-test, χ2: Chi square test, MC: Monte Carlo test, U: Mann Whitney test, MMSE: mini-mental state examination, TMT: trail making test, OP: organophosphates.

Toxicological data, vital signs, clinical findings, laboratory investigations and ECG on admission, clinical outcome and REMS were enumerated in this table. **Table 2**

Table 2: Distribution of the OP poisoned patients according to toxicological data on admission, vital signs, clinical findings, laboratory investigations and ECG on admission, clinical outcome and REMS

		N=32
Toxicological data		
Mode of poisoning	**Accidental**	11(34.4%)
	Suicidal	21(65.6%)
Medical treatment before arrival		11(34.4%)
Delay time (hrs.)		4.0 (2.75 – 6.0)
Route	**Inhalation**	11(34.4%)
	Ingestion	21(65.6%)
Vital signs		
Blood pressure (mmHg)	**Systolic**	124.7 ± 16.80
	Diastolic	77.03 ± 12.11
MAP		93.06 ± 12.98
Pulse		85.19 ± 26.14
O_2 sat by pulse oximetry		94.0 ± 8.45
RR		24.53 ± 10.67
Temperature		36.82 ± 0.30
Clinical findings		
Pupil	**Miosis**	12 (37.5%)
	Mydriasis	2 (6.2%)
	Rounded regular reactive	12 (37.5%)
	Pinpoint pupil	6 (18.8%)
Crepitations		8 (25.0%)
Wheeze		2 (6.3%)
Vomiting		27 (84.4%)
Diarrhea		12 (37.5%)
Colic		16 (50.0%)
Salivation		5 (15.6%)
Sweating		9 (28.1%)

Fasciculation		11 (34.4%)
Hypotonia		12 (37.5%)
Conscious level by GCS		15.0 (15.0 – 15.0)
Laboratory investigations		
Hb (%)		12.57 ± 1.22
RBCs ($x10^3$)		4.61 ± 0.48
WBCs		9881.3 ± 3347.2
Platelets ($x10^3$)		224.6 ± 51.26
ALT		26.75 ± 12.68
AST		22.69 ± 13.26
Urea		32.09 ± 8.72
Creatinine		1.01 ± 0.19
RBS		137.6 ± 37.49
Na		139.5 ± 4.01
K		3.71 ± 0.31
PH		7.43 ± 0.06
PCO_2		35.25 ± 7.01
HCO_3		24.16 ± 2.97
PO_2		118.5 ± 65.53
O_2 sat		93.84 ± 8.56
Cholinesterase level (U/L)		1800 ± 1650
ECG	**Normal**	25 (78.1%)
	Sinus Brady	2 (6.3%)
	Sinus Tachy	5 (15.6%)
Clinical outcome		
ICU		4(12.5%)
No of Atropine amp		2.0 (1.0 – 6.50)
No of Toxogonin amp		2.0 (0.0 – 4.0)
Period of hospital Stay (hours)		18.0 (6.0 – 24.0)
REMS Score		2.0 (0.0 – 6.0)
Mild		22 (68.8%)
Moderate		5 (15.6%)
Severe		5 (15.6%)

Data are presented as mean ± SD or frequency (%) or median (IQR). OP: organophosphate, MAP: mean arterial blood pressure, RR: respiratory rate, GCS: Glasgow Coma Scale, Hb: hemoglobin, RBCS: red blood cell, WBCs: white blood cell, Alt: Alanine transaminase, AST: Aspartate transferase, RBS: random blood sugar, PCO_2: partial pressure of carbon dioxide, ECG: electrocardiogram, ICU: intensive care unit, REMS Score: Rapid Emergency Medicine Score.

The range of MMSE and digit span forward and backward were significant lower in OP poisoned patients than control group ($P< 0.05$). Trail Making Test A and B were significant higher in OP poisoned patients than control group ($P< 0.05$). Hamilton anxiety and depression scale were insignificantly different between the OP poisoned patients and control group. **Table 3**

Table 3: Neurocognitive assessment, Hamilton anxiety scale and HDRS in OP poisoned patients on discharge compared to control group

	OP poisoned patients (n = 32)	Control (n = 32)	Test of Sig	P
				Neurocognitive assessment
MMSE	28.19±1.06	29.03±1.0	U=292.500	**0.002***
Digit forward (digit)	4.19±0.97	6.03±0.78	t=8.395	**<0.001***
Digit backward (digit)	1.91±1.12	4.0±0.76	t=8.756	**<0.001***
TMT A (sec)	90.75±26.86	63.81 ±6.56	U=145.500	**<0.001***
TMT B (sec)	277.6±49.74	207.5±23.74	U=133.000	**<0.001***
Hamilton Anxiety Scale	6.19 ± 4.98	4.13 ± 1.68	U=417.000	0.197
Hamilton Depression Scale	5.31 ± 4.59	4.0 ± 1.41	t=1.546	0.131

Data are presented as mean ± SD. * Significant p value <0.05, t: Student t-test, U: Mann Whitney test, TMT: Trail making test, HDRS: Hamilton depression scale.

Regarding neurocognitive and psychiatric assessment, there was significant improvement after 3 months compared to that on discharge and 6 weeks. **Table 4**

Table 4: Neurocognitive and psychiatric assessment using Hamilton anxiety scale, HDRS and PANSS in OP patients on discharge, 6 weeks and 3 months later

	On discharge	After 6 weeks	After 3 months	Test of Sig.	P
MMSE	28.19±1.06	28.81±0.78	29.09±0.89	Fr=11.646*	**0.003***
Abnormal	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	~
Normal	32(100.0%)	32(100.0%)	32(100.0%)	32(100.0%)	
Sig. bet. grps.	P_1=0.080, **P_2=0.003***, P_3=0.235				
Digit forward	4.19±0.97	4.28±1.28	6.19±0.74	F= 58.572*	**<0.001***
Abnormal	25(78.1%)	25(78.1%)	25(78.1%)	Q=50.000*	**<0.001***
Normal	7(21.9%)	7(21.9%)	7(21.9%)		
	P_1=1.000, **P_2<0.001***, **P_3<0.001***				
Digit backward	1.91 ± 1.12	2.13 ± 1.26	4.06 ± 0.84	F= 72.546*	**<0.001***
Abnormal	25(78.1%)	25(78.1%)	25(78.1%)	Q=50.000*	**<0.001***
Normal	7(21.9%)	7(21.9%)	7(21.9%)		
	P_1=1.000, **P_2<0.001***, **P_3<0.001***				
TMT A (sec)	90.75±26.86	66.94±16.35	57.63±9.05	Fr=34.938*	**<0.001***
Normal	7(21.9%)	28(87.5%)	32(100.0%)	Q=43.280*	**<0.001***
Prolonged	25(78.1%)	4(12.5%)	0(0.0%)		
	P_1<0.001*, **P_2<0.001***, **P_3=0.018***				
TMT B (sec)	277.6±49.74	215.6±56.50	195.9±32.31	Fr=46.397*	**<0.001***
Normal	7(21.9%)	27(84.4%)	32(100.0%)	Q=42.000*	**<0.001***
Prolonged	25(78.1%)	5(15.6%)	0(0.0%)		
	P1<0.001*, **P_2<0.001***, P_3=0.151				
Psychiatric assessment					
Hamilton anxiety scale	6.19 ± 4.98	3.50 ± 2.48	2.38 ± 2.24	Fr=45.431*	**<0.001***
Normal to mild	30(93.8%)	32(100.0%)	32(100.0%)	Q= 4.000	0.135
Mild to moderate	2(6.3%)	0(0.0%)	0(0.0%)		
Sig. bet. grps.	**P1= 0.001***, **P_2<0.001***, P_3=0.070				
Hamilton depression	5.31 ± 4.59	2.06 ± 2.14	1.63 ± 1.70	F= 29.078	**0.001***
	P1= 0.001*, P2<0.001*, P3=0.166				
Normal	25(78.1%)	32(100%)	32(100%)	Fr= 14.000	**0.001***
Mild	5(15.6%)	0(0.0%)	0(0.0%)		
Moderate	2(6.35%)	0(0.0%)	0(0.0%)		
Sig. bet. grps.	**P1=0.001*, P2<0.001***, P3=1.000				
PANSS	30.44± 0.76	30.31±0.82	30.0 ± 0.0	Fr= 14.250	**0.001***
	P_1=0.453, **P_2=0.049***, P_3=0.261				
Normal	32(100%)	32(100%)	32(100%)	Q=15.200	**0.001***
	P1=0.121, **P2<0.001*, P3=0.020***				

Data are presented as mean ± SD or frequency (%). * Significant p value <0.05, P 1: P value for comparing between on discharge and after 6 weeks, P 2: P value for comparing between discharge and after 3 months, P 3: P value for comparing between the after 6 weeks and after 3 months, Fr: Friedman test, Q: Cochran's test, F: F test (ANOVA), MMSE: mini-mental state examination, TMT: trail making test, OP: organophosphates, PANSS: Positive and negative syndrome scale, HDRS: Hamilton depression scale.

There was a significant positive correlation between REMS and Hamilton anxiety scale on discharge and after 6 weeks and REMS and HDRS on discharge (P<0.05). **Table 5**

Table 5: Correlation between REMS Score on admission and mean values of different psychiatric and neurocognitive parameters on discharge, 6 weeks and 3 months later in OP poisoned patients

	REMS Score	
	Rs	**P**

Hamilton Anxiety Scale	**On discharge**	0.512	**0.003***
	After 6 weeks	0.449	**0.010***
	After 3 months	0.338	0.059
HDRS	**On discharge**	0.498	**0.004***
	After 6 weeks	0.015	0.933
	After 3 months	0.026	0.887
PANSS	**On discharge**	0.061	0.739
	After 6 weeks	0.107	0.560
	After 3 months	--	--
MMSE	**On discharge**	-0.098	0.594
	After 6 weeks	0.082	0.654
	After 3 months	0.082	0.656
Digit forward	**On discharge**	-0.048	0.794
	After 6 weeks	-0.199	0.275
	After 3 months	0.145	0.429
Digit backward	**On discharge**	-0.086	0.640
	After 6 weeks	-0.104	0.570
	After 3 months	0.063	0.730
TMT A (sec)	**On discharge**	0.276	0.126
	After 6 weeks	0.088	0.632
	After 3 months	0.194	0.287
TMT B**(sec)**	**On discharge**	0.384	0.051
	After 6 weeks	0.327	0.068
	After 3 months	0.254	0.161

rs: Spearman coefficient, * Statistically significant at $p \leq 0.05$, REMS: Rapid Emergency Medicine Score, TMT A: Treadmill Test, PANSS: Positive and negative syndrome scale, MMSE: Mini-Mental State Examination, HDRS: Hamilton depression scale.

DISCUSSION

OP poisoning is one of the most common emergencies treated at poisoning control centers worldwide [24].

Regarding the neurocognitive assessment, three tests were applied; MMSE was used for screening of cognitive deficits, digit span forward and backward were used for assessment of working memory and auditory attention and lastly TMT A and B for assessment of visuo-motor planning and attention. These tests were done on the OP poisoned patients on discharge and compared with the control group. MMSE was within the normal range with no cognitive impairment. Regarding digit span forward and backward and TMT A and B, there was impaired performance in the OP poisoned patients with significant difference between the two studied groups.

Follow up assessment of neurocognitive functions was performed for OP poisoned patients 6 weeks and 3 months later. Concerning MMSE, it was within the normal range in the 3 periods. Concerning digit span forward and backward and trail making test A & B, there was better performance in the OP poisoned patients after 3 months compared with that on discharge and after 6 weeks.

Regarding the correlation between REMS Score and the performed neurocognitive tests, no correlation was found between REMS and MMSE, digit span (forward and backward) and trail making test A and B throughout the three periods. In addition, Nishiwaki et al. [25] found a dose-effect relationship between the maximal digit number in the digit span backward test and the degree of exposure. This disagrees with the present results on comparing the severity with the outcome, using REMS for assessment of severity, as no correlation was found between REMS with MMSE, digit span (forward and backward) and trail making test A and B. The present study coincided with that of Dassanayake et al. [26] revealed that, in contrast to experimental animals exposed to high doses of extremely toxic OP nerve agents without receiving antidotes, neuropsychological tests did not reveal evidence of permanent damage after acute OP pesticide poisoning in those exposed to less toxic doses of OP and treated in accordance with standard protocol.

Psychiatric assessment of the OP patients was done for anxiety, depression, and psychosis. The current results showed that Hamilton anxiety and depression scales were affected in the OP poisoned with no

significant difference on comparison with control group. In the follow up, there were improvement after 6 weeks and 3 months in the 3 scales (Hamilton anxiety scale, Hamilton depression scale, and PANSS) on comparison with on discharge with significant difference between 3 periods.

Assessment of severity of poisoning was made according to REMS and compared with Hamilton scale for anxiety and depression and PANSS. Positive correlation was found between REMS and Hamilton anxiety and depression scale on discharge and Hamilton anxiety scale after 6 weeks, which means that the higher the REMS score, the higher the Hamilton anxiety and depression scale while, no correlation was found between REMS and PANSS.

Comparable with the present study, a study conducted by Yokoyama et al. [27] found that it was significantly affected in the victims in comparison to control group. However, the current study showed that improvement in anxiety and depression scale occurred 3 months post exposure. Roldan-Tapia et al. [28] observed that when evaluated three months later, acutely poisoned individuals had substantially higher scores than control participants. After a year, a reassessment revealed that the acutely exposed participants' previously elevated anxiety scores were improved.

This disagrees with the current findings as after 3 months anxiety was improved. Harrison and Ross [29] stated that level of depression and anxiety were generally higher in the exposed than in the control group with significant differences for anxiety only. This agrees with the present study for depression as there was a higher score with no significant difference but disagrees with the results for anxiety as there was no significant difference.

Concerning the association between severity of OP poisoning and psychiatric sequelae, a study was conducted by Suarez-Lopez et al. [30] stated that there was positive correlation between REMS and Hamilton anxiety scale on discharge and after 6 weeks, they investigated chronic exposure and also, difference in age group as their study included adolescents and in the present study adults were included. Another study was done by Zheng et al. [31] stated that on comparing AChE and BuChE activity in farmers according to the level of depression, a significant higher decrease in AChE activity was observed in farmers with moderate/severe depression than in those with minimal/mild depression symptoms.

The comparatively small sample size was one of the study's limitations. Therefore, we suggested future studies to employ neurophysiological and neuroimaging methods to investigate if OP pesticides result in structural and functional alterations at the brain level. longer-term prospective research to ascertain if persistent cognitive impairments resulting from OP pesticide exposure are irreversible. Establishing or disproving a causal relationship requires careful assessment of the degree and biomarkers of acute intoxication as well as investigation of a dose-response relationship.

CONCLUSIONS:

Even though these deficits may not affect routine clinical assessments of cognition, acute OP poisoning is linked to memory, planning, and attention impairments that may persist beyond clinical recovery and seem to improve three months after poisoning. In critical situations where the situation requires quick stimulus evaluation and response, sensory information processing speed may be crucial. These deficiencies may affect those patients' day-to-day functioning. Slow answers on sustained attention exercises might make everyday tasks like handling machinery and driving more dangerous. Anxiety and depression are two psychological side effects of acute OP poisoning that seem to be curable.

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Conflict of Interest: Nil

REFERENCES:

1. Costa LG. Organophosphorus compounds at 80: Some old and new issues. Toxicol Sci. 2018;162(1):24-35.
2. Naughton SX, Terry AV, Jr. Neurotoxicity in acute and repeated organophosphate exposure. Toxicol. 2018;408(20):101-12.
3. Bashir S, Khan F, Bashir M. Correlation of oxidative stress to severity of acute organophosphorus poisoning. Toxicol Rep.178(23):89-100.
4. Regmi G, Arjyal B, Khanal K, Pyakurel K, Shahi R. Correlation of PeradeniyaOrganophosphorus Poisoning Scale (POP) and outcome of organophosphorus poisoning. BJHS. 2020;5(1):986-9.
5. Jokanović M. Neurotoxic effects of organophosphorus pesticides and possible association with neurodegenerative diseases in man: A review. Toxicol. 2018;410(21):125-31.
6. Mostafalou S, Abdollahi M. The link of organophosphorus pesticides with neurodegenerative and neurodevelopmental diseases based on evidence and mechanisms. Toxicol. 2018;409(200):44-52.
7. Ivanović SR, Dimitrijević B, Ćupić V, Jezdimirović M, Borozan S, Savić M, et al. Downregulation of nicotinic and muscarinic receptor function in rats after subchronic exposure to diazinon. Toxicol Rep. 2016;3(1):523-30.
8. King AM, Aaron CK. Organophosphate and carbamate poisoning. Emerg Med Clin North Am. 2015;33(1):133-51.

9. Ridley RM, Murray TK, Johnson JA, Baker HF. Learning impairment following lesion of the basal nucleus of Meynert in the marmoset: modification by cholinergic drugs. Brain Res. 1986;376(1):108-16.
10. Mesulam MM, Volicer L, Marquis JK, Mufson EJ, Green RC. Systematic regional differences in the cholinergic innervation of the primate cerebral cortex: distribution of enzyme activities and some behavioral implications. Ann Neurol. 1986;19(2):144-51.
11. Steenland K, Dick RB, Howell RJ, Chrislip DW, Hines CJ, Reid TM, et al. Neurologic function among termiticide applicators exposed to chlorpyrifos. Environ Health Perspect. 2000;108(4):293-300.
12. Kamel F, Hoppin JA. Association of pesticide exposure with neurologic dysfunction and disease. Environ Health Perspect. 2004;112(9):950-8.
13. Dassanayake T, Weerasinghe V, Dangahadeniya U, Kularatne K, Dawson A, Karalliedde L, et al. Long-term event-related potential changes following organophosphorus insecticide poisoning. Clin Neurophysiol. 2008;119(1):144-50.
14. Karki P, Ansari JA, Bhandary S, Koirala S. Cardiac and electrocardiographical manifestations of acute organophosphate poisoning. Singapore Med J. 2004;45(8):385-9.
15. Imhoff BF, Thompson NJ, Hastings MA, Nazir N, Moncure M, Cannon CM. Rapid Emergency Medicine Score (REMS) in the trauma population: a retrospective study. BMJ Open. 2014;4(5):e004738.
16. Albanna M, Yehya A, Khairi A, Dafeeah E, Elhadi A, Rezgui L, et al. Validation and cultural adaptation of the Arabic versions of the Mini-Mental Status Examination - 2 and Mini-Cog test. Neuropsychiatr Dis Treat. 2017;13(5):793-801.
17. Abou-Mrad F, Chelune G, Zamrini E, Tarabey L, Hayek M, Fadel P. Screening for dementia in Arabic: normative data from an elderly Lebanese sample. Clin Neuropsychol. 2017;31(1):1-19.
18. Abdul Razzak R. A preliminary study on the Trail-making Test in Arabic-English bilingual young adults. Appl Neuropsychol Adult. 2013;20(1):53-60.
19. Hamilton M. Rating depressive patients. J Clin Psychiatry. 1980;41(12):21-4.
20. Hallit S, Haddad C, Hallit R, Akel M, Obeid S, Haddad G, et al. Validation of the Hamilton anxiety rating scale and state trait anxiety inventory a and B in Arabic among the Lebanese population. Clinical epidemiology and global health. 2020;8(4):1104-9.
21. Obeid S, Abi Elias Hallit C, Haddad C, Hany Z, Hallit S. Validation of the hamilton depression rating scale (hdrs) and sociodemographic factors associated with lebanese depressed patients. Encephale. 2018;44(5):397-402.
22. Zimmerman M, Martinez JH, Young D, Chelminski I, Dalrymple K. Severity classification on the Hamilton Depression Rating Scale. J Affect Disord. 2013;150(2):384-8.
23. Kay SR, Fiszbein A, Opler LA. The positive and negative syndrome scale (panss) for schizophrenia. Schizophr Bull. 1987;13(2):261-76.
24. Amir A, Raza A, Qureshi T, Mahesar GB, Jafferi S, Haleem F, et al. Organophosphate poisoning: Demographics, severity scores and outcomes from National Poisoning Control Centre, Karachi. Cureus. 2020;12(5):83-97.
25. Nishiwaki Y, Maekawa K, Ogawa Y, Asukai N, Minami M, Omae K. Effects of sarin on the nervous system in rescue team staff members and police officers 3 years after the Tokyo subway sarin attack. Environ Health Perspect. 2001;109(11):1169-73.
26. Dassanayake TL, Weerasinghe VS, Gawarammana I, Buckley NA. Subacute and chronic neuropsychological sequalae of acute organophosphate pesticide self-poisoning: a prospective cohort study from Sri Lanka. Clin Toxicol (Phila). 2021;59(2):118-30.
27. Yokoyama K, Araki S, Murata K, Nishikitani M, Okumura T, Ishimatsu S, et al. Chronic neurobehavioral effects of Tokyo subway sarin poisoning in relation to posttraumatic stress disorder. Arch Environ Health. 1998;53(4):249-56.
28. Roldan-Tapia L, Nieto-Escamez FA, del Aguila EM, Laynez F, Parron T, Sanchez-Santed F. Neuropsychological sequelae from acute poisoning and long-term exposure to carbamate and organophosphate pesticides. Neurotoxicol Teratol. 2006;28(6):694-703.
29. Harrison V, Mackenzie Ross S. Anxiety and depression following cumulative low-level exposure to organophosphate pesticides. Environ Res. 2016;151(21):528-36.
30. Suarez-Lopez JR, Nguyen A, Klas J, Gahagan S, Checkoway H, Lopez-Paredes D, et al. Associations of acetylcholinesterase inhibition between pesticide spray seasons with depression and anxiety symptoms in adolescents, and the role of sex and adrenal hormones on gender moderation. Expo Health. 2021;13(1):51-64.
31. Zheng R, Romero-del Rey R, Ruiz-Moreno F, Garcia-Gonzalez J, et al. (2024): Depressive symptoms and suicide attempts among farmers exposed to pesticides. Environmental Toxicology and Pharmacology; 108: 104461.