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Construction of a Crucial Score to Predict the Outcome of Patients with Aluminum Phosphide Poisoning at the Poison Control Center-Ain Shams University Hospitals (PCC-ASUH)

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Abstract

Background: Acute aluminum phosphide (ALP) poisoning has become a major suicidal crisis in developing countries due to increasing mortality rate and absence of specific antidote. **Aim:** This study aimed to evaluate the value of APACHE II and SOFA scores in predicting outcomes in patients with acute ALP poisoning and construct a predictive model for ALP poisoning. **Patients and methods:** This cross sectional study included patients with history of acute ALP poisoning admitted to the Poison Control Center of Ain Shams University Hospitals (PCC-ASUH) from the beginning of August 2022 to the end of April 2023. For each patient, the demographic, intoxication and clinical data were recorded. Investigations done on admission included blood gases, serum sodium, potassium, liver enzymes, creatinine, complete blood count, and electrocardiogram (ECG). **Results:** This study included 110 patients of both sex with acute ALP poisoning. Multivariate regression analysis revealed that six factors were the most predictive factors of mortality and they were valid to construct the new predictive score at cut off value of MAP <70 mmHg, GCS ≤12, PH ≤ 7.28, HCO3 ≤ 12.6 mEq/L, PO2 < 90% mmHg and abnormal ECG. A new predictive ALP scoring system was then constructed of six parameters each taking a constant logistic score to give a total score of 33. **Conclusion:** The current study constructed a new predictive score that could be useful at the emergency department for early prediction of severity among patients with ALP toxicity based on simple, reliable, and easily obtainable parameters that are done routinely for every patient.

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Key words Poisoning, Aluminum phosphide (ALP), Predictive variables, Mortality, Scoring systems

Introduction

Aluminum phosphide (ALP) is a solid pesticide which is considered one of the leading causes of poisoning deaths worldwide (Etemadi-Aleagha et al., 2015). Due to its ideal properties; it is the most common used grain fumigants as it is toxic to all stages of insects, highly potent, does not disturb seed viability and doesn't have toxic residue that improve quantity and quality of food grains (Oghabian et al., 2016).

The incidence cases of ALP poisoning started to increase dramatically especially in developing countries due to its easily availability and cheapness. However, it is restricted in European countries under the respective national pesticide acts (Bagherian et al., 2021).

Most cases of ALP poisoning in developed countries are accidental through inhalation due to occupational exposure. However, in developing countries such as India, Iran and Egypt, suicidal attempt through ingestion is the most common manner of poisoning (Garg, 2020).

Several studies reported that mortality rate from ALP poisoning exceeds 68%, where the most common presentations of ALP toxicity are refractory hypotension and severe metabolic acidosis (Elshama, 2022). According to Poison Control Center of Ain Shams University Hospitals (PCC-ASUH) reports, there was a rise in ALP poisoning cases during the last years. It was reported that about 49, 110, 148 and 182 cases of ALP poisoning were admitted during years of 2019, 2020, 2021 and 2022 respectively (Saad et al., 2024).

Many scoring systems for toxicological emergencies have been used for assessment of multiorgan dysfunction in the critical medical conditions, such as Acute Physiology and Chronic Health Evaluation II (APACHE II) and Sequential Organ Failure Assessment (SOFA) scores (Peter et al., 2013). Referring to clinical toxicology, only a few studies had assessed the effectiveness of scoring systems in predicting the severity and outcome in patients with ALP poisoning (Mathai & Bhanu, 2010).

Aim of the Study

This study aimed to evaluate the value of APACHE II and SOFA scores in the prediction of outcome in patients with acute ALP poisoning admitted to the PCC-ASUH and construct a predictive model for ALP poisoning cases.

Patients and Methods

The current study was a prospective cross-sectional study included 110 patients of both sex presented to the Poison Control Center of Ain Shams University Hospitals (PCC-ASUH) with history of intake of aluminum phosphide tablet during the period from the beginning of August 2022 to the end of April 2023. The diagnosis was verified by history of ALP exposure and initial assessment of clinical manifestations.

Exclusion Criteria: Patients with any of the following conditions were excluded from the study:

- Age under 16 years.
- Pre-existing chronic diseases.
- Mixed intoxication.
- Pregnant females.

Ethical considerations: Approval of the Research Ethical Committee of Ain Shams University (MS 466/2022) was obtained and approval of PCC-ASUH general director was taken. All data were kept anonymous to ensure confidentiality of records.

The following data were collected from each patient:

- Sociodemographic data: age, gender and residence.
- Intoxication data: delay time, route of exposure, mode of poisoning, amount and pre-consultation treatment.
- Clinical data: general and systemic examination.
- Laboratory investigations including blood gases (ABG), Serum Sodium (Na) & Potassium (K), Serum creatinine, Liver function tests (Alanine transaminase (ALT), Aspartate aminotransferase (AST), total bilirubin), Complete blood count (Total Leukocyte Count, Platelet count & Hematocrite value).
- Electrocardiogram (ECG).
- Outcome: after the patient had received his required management in ICU, outcome was either; complete recovery and discharge from the PCC or mortality and if complications had been developed during hospital stay.
- Calculation of emergency scores:
  - **APACHE II score:** It was calculated during the first 24 hours after admission using the worst measured parameters with an integer score from 0 to 71. Its physiologic variables include temperature, mean arterial pressure, heart rate, respiratory rate, oxygenation of arterial blood, arterial PH, serum Na, serum K, serum creatinine, hematocrit, white blood cell and GCS (Knaus et al., 1985).
  - **SOFA score:** It was calculated 24 hours post-admission in the ICU and repeated on the **fourth** and sixth day. A fourth calculation was done at the time of patient‘s discharge or referral. It includes six system parameters which are partial pressure of oxygen "arterial" (PaO2)/ fraction of inspired oxygen (FiO2), mean arterial pressure, platelets, total bilirubin, serum creatinine and GCS (Vincent et al., 1998).

Statistical analysis

Data was analyzed using IBM SPSS software package version 20.0. Data were tested for normality and expressed as mean and standard deviation (SD) for parametric numerical data or median and interquartile range (IQR) for non-parametric numerical data. Comparisons between groups for categorical variables were assessed using Chi-square test. Mann Whitney Test (U test) was used to assess the statistical significance of the difference of a non-parametric variable between two study groups. Independent t-test was used to compare two groups for normally distributed quantitative variables.

Univariate and multivariate regression analysis were applied to detect variables affecting the outcome. Receiver operating characteristic (ROC) analysis was used to determine the diagnostic performance of the scores and to calculate the sensitivity and specificity. Area under the curve (AUC) more than 50% gives acceptable performance and area about 100% is the best performance for the test. P value: level of significance: $P>0.05$: Non significant (NS) , $P\leq 0.05$: Significant (S) , $P<0.01$: Highly significant (HS).

Results

A total of 110 cases of acute ALP poisoning were enrolled in the current study and classified based on their outcome into two groups; Survivors: included 52 patients and Non-survivors: included 58 patients.

The median age of studied patients was 22.5 years (18–31) and more than half of cases were males (51.8%) while females represented 48.2%. Most of the studied patients were from Elfayoum (34.5%), 27.3% from Cairo, 18.2% from Elkalyoubia, 14.5% from Beni-Suef and 5.5% only from Giza. More than half of cases (59.1%) ingested one tablet, 20.9% half tablet, 7.3% two tablet and 12.7% ingested unknown amount with a highly statistical significant difference between survivors and non survivors with p value <0.001. All patients took ALP orally and the majority of them (95.5%) were suicidal attempts.

The median delay time was 4 hours (2-5) ranged from 1-30 hours with a non-statistical significant difference between survivors and non survivors. The majority of patients (86.4%) stayed in ICU less than or equal to one day with mean ICU stay 1.05±0.79 days with a highly statistical significant difference between both groups with P-value < 0.01.

Table (1) showed that 58.2% had normal pulse, while 36.3% were tachycardic and 7.27% only had bradycardia. Most of the studied patients (87.3%) were tachypnic. Half of patients (50.9%) had normal temperature and 46.4% of them were hypothermic. There was a highly statistical significant decrease in blood pressure (systolic, diastolic and mean arterial blood pressure) and temperature and increase in respiratory rate in non survivors.

In the present study, nearly half of cases had pallor and cold extremities. The most common gastrointestinal symptoms were vomiting and colic that occurred in 89.1% and 52.7% of the studied patients respectively. Respiratory distress was observed in 16.4% of the studied cases and coarse crepitations in 8.18% that were found only in non survivors. More than half of patients (59.1%) had shock. The majority of patients (72%) were conscious. The mean Glasgow coma scale (GCS) was 14.34±0.95 ranged from 12 to 15. There was a statistical significant difference between both groups regarding all clinical manifestations (table 2).

Table (3) revealed that non survivors had decrease in PH, HCO3, PaO2 and serum sodium values and significantly higher values of serum creatinine, ALT, total bilirubin, total leuckocyte count and platelet count than survivors.

Electrocardiographic abnormalities were observed in 68.2% of the studied patients. The most common ECG abnormalities were sinus tachycardia 30%, followed by ventricular tachycardia (28.2%),

prolonged QTc (23.6%) and wide QRS complex (14.5%). Statistical analysis revealed that there was a statistical significant difference between survivors and non survivors as regards sinus bradycardia, prolonged QTc, wide QRS complex, ST segment depression, inverted T wave, supraventricular tachycardia, ventricular tachycardia, ventricular fibrillation, atrial fibrillation and right bundle branch block (table 4).

As regards complications developed among the studied patients, more than half of cases (59.1%) had cardiogenic shock, 52.7% developed cardiac arrest, 43.6% needed mechanical ventilation and 22.7% developed myocardial infarction and 3.6% had pericarditis. There was a highly statistical significant difference between survivors and non survivors as regards all complications except pericarditis.

The median of APACHE II score was 9 (4-13) and ranged from 0 to 24 while the median of SOFA score was 5 (0-8), ranged from 0 to 11. There was a highly statistical significant increase in the median and range of APACHE II and SOFA scores in non survivors when compared with survivors with P-value <0.01.

Table (5) revealed that the cut-off point of APACHE II score was >6 and area under the curve was 0.969 with 98.28% sensitivity and 86.54% specificity with positive predictive value of 89.1% and negative predictive value of 97.8%, while the cut-off point of SOFA score was >2 and area under the curve was 0.983 with 100% sensitivity and 86.54% specificity with positive predictive value of 89.2% and negative predictive value of 100%. Receiver operating characteristic (ROC) curve for APACHE II and SOFA scores to predict mortality in patients with acute ALP poisoning is illustrated in figure (1).

Univariate logistic regression analysis revealed that GCS, MAP, respiratory rate, PH value, HCO_3 level, PO_2, serum creatinine, AST, ALT, total bilirubin, TLC values and abnormal ECG findings were significant for predicting mortality. Moreover, a multivariate logistic regression analysis revealed that GCS, MAP, PH value, HCO3 level, PO2 and abnormal ECG findings were the most predictive factors of mortality (table 6).

According to the results of multivariate regression analysis and beta (β) coefficient, each risk index was assigned to make logistic scoring system including PO_2, PH, GCS, MAP, HCO_3 and abnormal ECG findings. The new predictive ALP scoring system was then constructed of six parameters each took a constant logistic score to give a total score of 33. It consisted of PO_2< 90% which took 8 points, PH ≤ 7.28 took 7 points, GCS ≤12 took 6 points, MAP <70 took 5 points, HCO_3≤ 12.6 took 4 points and abnormal ECG took 3 points (table 7).

This new predictive score was applied on 110 patients with acute ALP poisoning. The median of new predictive score was 20 (0-27), ranged from 0 to 33 with a highly significant increase in the median and range of the new predictive score in non survivors 27 (24-33) when compared with survivors 0 (0-3) with P-value < 0.01. Table (8) revealed that the cut-off point of the new predictive score was >19 with 96.55% sensitivity and 100% specificity with positive predictive value of 100% and negative predictive value of 96.3%. Figure 2 showed that the new predictive score had a high AUC (0.999).

Table (1): Independent t-test showing comparison between the studied groups (110 patients) of acute ALP poisoning as regards vital data.

Vital data		Patients group (N =110)	Survivors (N = 52)	Non-survivors (N = 58)	Test value	P-value	Sig.
Pulse (beat/min)	Normal	67 (60.9%)	39 (75%)	28 (48.3%)	-0.682	0.496	NS
	Bradycardia	8 (7.3%)	1 (1.9%)	7 (12%)			
	Tachycardia	35(31.8%)	12 (23.1%)	23 (39.6%)			
	Mean ± SD	92.90±20.60	91.48±16.29	94.17±23.89			
Blood pressure (mmHg)	Normal	30(27.3%)	30(57.7%)	0(0.0)%	84.941	0.000	HS
	Hypotension	80(72.7%)	22(42.3%)	58(100%)			
	Systolic blood pressure Mean ± SD	76.8±28.8	102.5±18.4	58.3±19.1			
	Diastolic blood pressure Mean ± SD	55.3±14.7	66.7±17.8	42.4±12.5			
	Mean arterial pressure (MAP) Mean ± SD	75.41±9.2	75.44±8.41	62.1±2.2			
Respiratory rate (breath/min)	Normal	13(12.7%)	11 (21.1%)	2 (3.4%)	-10.712	0.000	HS
	Tachypnea	97(87.3%)	41 (78.8%)	56 (96.5%)			
	Mean ± SD	29.25±7.58	23.54±3.73	34.38 ± 6.38			
Temperature (ºC)	Normal	56(50.9%)	49 (94.2%)	7 (12.1%)	-6.287	0.000	HS
	Hypothermia	51(46.4%)	1 (1.9%)	50 (86.2%)			
	Fever	3 (2.7%)	2 (3.8%)	1 (1.7%)			
	Mean ± SD	36.8 ± 0.4	37 ± 0.3	36.6 ± 0.4			

SD=standard deviation, N=Number, P-value >0.05: Non-significant; P-value <0.05: Significant; P-value <0.01: Highly significant

Table (2): Chi-square test and independent t-test showing comparison between the studied groups (110 patients) of acute ALP poisoning as regards the clinical manifestations.

Clinical manifestations			Patients group (N=110)	Survivors (N= 52)	Non-survivors (N= 58)	Test value	P-value	Sig.
Skin	Pallor		60 (54.5%)	3 (5.8%)	57 (98.3%)	94.634*	0.000	HS
	Cold extremities		59 (53.6%)	2 (3.8%)	57 (98.3%)	98.315*	0.000	HS
	Cyanosis		5 (4.5%)	0 (0.0%)	5 (8.6%)	4.696*	0.030	S
Gastrointestinal	Vomiting		98 (89.1%)	40 (76.9%)	58 (100.0%)	15.024*	0.000	HS
	Colic		58 (52.7%)	12 (23.1%)	46 (79.3%)	34.784*	0.000	HS
	Diarrhea		9 (8.2%)	1 (1.9%)	8 (13.8%)	5.142*	0.023	S
Respiratory	Respiratory distress		18 (16.4%)	0 (0.0%)	18 (31.0%)	84.294*	0.000	HS
	Coarse crepitations		9 (8.18%)	0 (0.0%)	9 (15.5%)	7.045*	0.011	S
Cardiovascular	Shock		65 (59.1%)	7 (13.5%)	58 (100%)	84.294*	0.000	HS
	Chest pain		11 (10.0%)	1 (1.9%)	10 (17.2%)	7.149*	0.008	HS
Neurological	Fully conscious		79 (71.8%)	51 (98.1%)	28 (48.2%)	50.552*	0.000	HS
	Disturbed conscious level		31 (28.2%)	0 (0.0%)	31 (53.4%)	20.591*	0.000	HS
	Agitaion		16 (14.5%)	1 (1.9%)	15 (25.9%)	12.641*	0.000	HS
	Glasgow coma scale (GCS)	Mean ± SD	14.34±0.95	15.00 ± 0.00	13.74 ± 0.98	9.225•	0.000	HS
		Range	12 – 15	15 – 15	12 – 15			

SD =standard deviation, N= Number, P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant, *: Chi-square test; •: Independent t-test

Table (3): Mann-Whitney test and independent t-test showing comparison between the studied groups (110 patients) of acute ALP poisoning as regards laboratory investigations.

Parameter		Patients group (N =110)	Survivors (N = 52)	Non-survivors (N = 58)	Test value	P-value	Sig.
PH	Normal	43 (39.1%)	42 (80.8%)	1 (2%)	13.755•	0.000	HS
	Metabolic acidosis	67 (60.9 %)	10 (19.2%)	57 (98%)			
	Mean ± SD	7.19 ± 0.20	7.36 ± 0.07	7.04 ± 0.15			
	Range	6.74 – 7.48	7.07 – 7.48	6.74 – 7.37			
HCO_3 (mEq/L)	Median (IQR)	12.3 (9 – 18)	18.25 (14.9 – 22.5)	9.35 (7.7 – 10.8)	-7.622≠	0.000	HS
	Range	2 – 30.3	7.5 – 30.3	2 – 17.3			
PCO_2 (mmHg)	Median (IQR)	26.6 (24 – 38)	27.3 (26 – 36)	26.2 (22 – 32)	1326.0≠	0.376	NS
	Range	10 – 71.1	12.7 – 40.8	10 – 71.1			
PO_2 (mmHg)	Mean ± SD	89.51 ± 10.39	99.10 ± 2.13	80.91 ± 6.60	18.995•	0.000	HS
	Range	60 – 100	90 – 100	60 – 94			
Serum sodium (mEq/L)	Mean ± SD	139.95 ± 4.82	138.88 ± 2.87	140.91 ± 5.92	-2.246•	0.027	S
	Range	129 – 155	129 – 149	130 – 155			
Serum potassium (mEq/L)	Mean ± SD	3.83± 0.36	3.88 ± 0.31	3.79 ± 0.39	1.309•	0.193	NS
	Range	2.6 – 4.8	3 – 4.5	2.6 – 4.8			
Serum creatinine (mg/dL)	Mean ± SD	1.04 ±0.49	0.80 ± 0.33	1.25 ± 0.52	-5.319•	0.000	HS
	Range	0.1 – 2.5	0.1 – 1.5	0.4 – 2.5			
Aspartate aminotransferase (U/L)	Median (IQR)	22 (15 – 34)	20(16 – 26.5)	25.5 (13 – 63)	-1.447≠	0.148	NS
	Range	6 – 447	10 – 145	6 – 447			
Alanine aminotransferase (U/L)	Median (IQR)	17 (11 – 34)	16.5 (11 – 22)	24 (11 – 59)	-2.139≠	0.032	S
	Range	3 – 476	5 – 197	3 – 476			
Total bilirubin (mg/dL)	Median (IQR)	0.6 (0.3 – 0.9)	0.45(0.3 – 0.7)	0.7 (0.4 – .9)	-2.769≠	0.006	HS
	Range	0.2 – 2	0.2 – 1.3	0.2 – 2			
Total leukocytic count (/µL)	Median (IQR)	11 (8.5 – 13)	9.45 (7.15–1.4)	11.05 (9 – 15)	-3.016≠	0.003	HS
	Range	3.9 – 28	3.9 – 27	5.2 – 28			
Platelet count (/µL)	Median (IQR)	257 (211-313)	243.5(199 –0.5)	266.5(223 –335)	-2.000≠	0.046	S
	Range	31 – 690	31 – 465	108 – 690			
Hematocrite %	Mean ± SD	40.87 ± 4.87	40.59 ± 4.71	41.12 ± 5.04	-0.563•	0.575	NS
	Range	32 – 50	32 – 49	33 – 50			

N= Number, IQR= Interquartile range, P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant, ≠: Mann-Whitney test; •: Independent t-test

Table (4): Chi-square test showing comparison between the studied groups (110 patients) of acute ALP poisoning as regards the ECG abnormalities.

		Patients group (N =110)	Survivors (N = 52)	Non-survivors (N = 58)	Test value	P-value	Sig.
Normal ECG		35 (31.8%)	31 (59.6%)	4 (6.9%)	35.126	0.000	HS
Sinus tachycardia		33 (30%)	13 (25.0%)	20 (34.5%)	1.174	0.279	NS
Sinus bradycardia		8 (7.3%)	1 (1.9%)	7 (12.1%)	4.185	0.041	S
Prolonged QTc		26 (23.6%)	4 (7.7%)	22 (37.9%)	13.890	0.000	HS
Wide QRS complex		16 (14.5%)	1 (1.9%)	15 (25.9%)	12.641	0.000	HS
ST segment and T- wave changes	Elevated	4 (3.6%)	0 (0.0%)	4 (6.9%)	3.398	0.065	NS
	Depressed	11 (10%)	2 (3.8%)	9 (15.5%)	7.003	0.008	HS
	Inverted T-wave	10 (9.1%)	2 (3.8%)	8 (13.8%)	6.702	0.010	S
Premature ventricular contraction (PVC)		16 (14.5%)	4 (7.7%)	12 (20.7%)	3.726	0.054	NS
Supraventricular tachycardia (SVT)		15 (13.6%)	1 (1.9%)	14 (24.1%)	11.489	0.001	HS
Ventricular tachycardia (VT)		31 (28.2%)	2 (3.8%)	29 (50.0%)	28.857	0.000	HS
Ventricular fibrillation (VF)		15 (13.6%)	0 (0.0%)	15 (25.9%)	15.572	0.000	HS
Atrial fibrillation (AF)		14 (12.7%)	0 (0.0%)	14 (24.1%)	14.382	0.000	HS
Right bundle branch block (Rt BBB)		8 (7.3%)	0 (0.0%)	8 (13.8%)	7.735	0.005	HS
Left bundle branch block (Lt BBB)		3 (2.7%)	0 (0.0%)	3 (5.1%)	2.731	0.165	NS

N= Number, IQR= Interquartile range, P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value <0.01: Highly significant

Table (5): Cut-off points, sensitivity, specificity and AUC of APACHE II and SOFA scores for assessing mortality in 110 ALP intoxicated patients.

Variable	Cut off point	AUC	Sensitivity	Specificity	PPV	NPV
APACHE II Score	>6	0.969	98.28%	86.54%	89.1%	97.8%
SOFA Score	>2	0.983	100%	86.54%	89.2%	100%

AUC= area under the curve, PPV= Positive predictive value, NPV=Negative predictive value

Table (6): Univariate and multivariate logistic regression analysis of variables associated with mortality in 110 ALP intoxicated patients.

Variable	Univariate				Multivariate				
	P-value	Odds ratio (OR)	95% C.I. for OR		β	P-value	Odds ratio (OR)	95% C.I. for OR	
			Lower	Upper				Lower	Upper
Mean arterial pressure <70 mmHg *	**0.000**	180.000	35.632	4909.296	**5.193**	**0.000**	28.8914	13.014	876.098
Respiratory rate >26 breath/minute *	**0.000**	55.714	17.446	177.929	–	–	–	–	–
Glasgow coma scale ≤12 *	**0.000**	467.68	25.546	5873.135	**5.834**	**0.000**	31.5460	17.670	897.045
PH ≤ 7.28 *	**0.000**	684.000	73.941	6327.424	**6.828**	**0.000**	34.060	1.279	906.854
HCO_3 ≤ 12.6 mEq/L *	**0.000**	47.917	15.452	3548.587	**3.869**	**0.012**	22.982	8.0951	576.912
PO_2 <90% mmHg *	**0.000**	2907.000	177.229	47682.057	**7.975**	**0.000**	376.854	19.502	7282.200
Serum creatinine >0.8 mg/dL *	**0.000**	4.587	2.039	10.320	–	–	–	–	–
AST >30 U/L *	**0.001**	4.870	1.882	12.604	–	–	–	–	–
ALT >31 U/L *	**0.001**	5.223	2.021	13.502	–	–	–	–	–
Total bilirubin >0.5 mg/dL *	**0.003**	3.284	1.501	7.185	–	–	–	–	–
TLC >11.5 /µL *	**0.007**	3.111	1.363	7.103	–	–	–	–	–
Abnormal ECG *	**0.000**	19.929	6.267	3163.372	**2.992**	**0.032**	18.9530	5.3467	519.034

OR=Odd`s ratio; CI=Confidence interval; AST=aspartate aminotransferase; ALT= alanine transaminase; TLC= total leukocyte count, *: Statistically significant at P ≤ 0.05.

Table (7): Scoring system for predicting mortality in 110 ALP intoxicated patients.

	Parameters	Logistic score
1	**PO_2 < 90% (mmHg)**	8
2	**PH <= 7.28**	7
3	**Glasgow coma scale <=12**	6
4	**Mean arterial pressure <70 (mmHg)**	5
5	**HCO_3 <= 12.6 (mEq/L)**	4
6	**Abnormal ECG**	3
	Total score	**33**

Table (8): Cut-off point, AUC, sensitivity and specificity for assessing mortality of the new predictive ALP score.

	Cut off point	AUC	Sensitivity	Specificity	PPV	NPV
New predictive score	>19	0.999	96.55%	100.0%	100.0%	96.3%

AUC= area under the curve, PPV= Positive predictive value, NPV=Negative predictive value

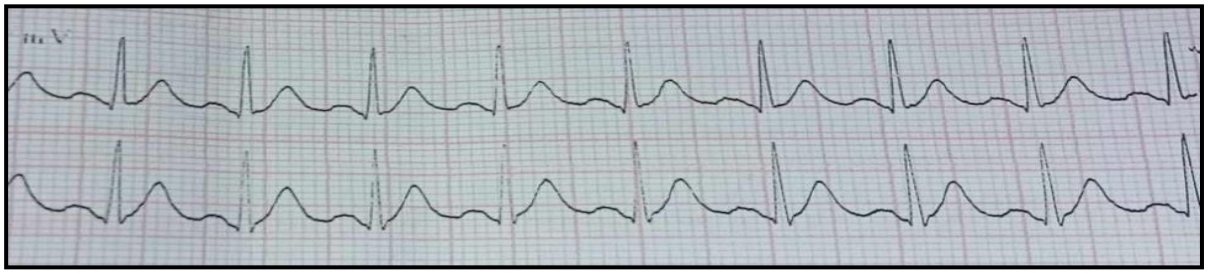

Figure (1): Lead II and III showing sinus tachycardia in a female patient, 26 years old in group I in the current study with acute ALP poisoning

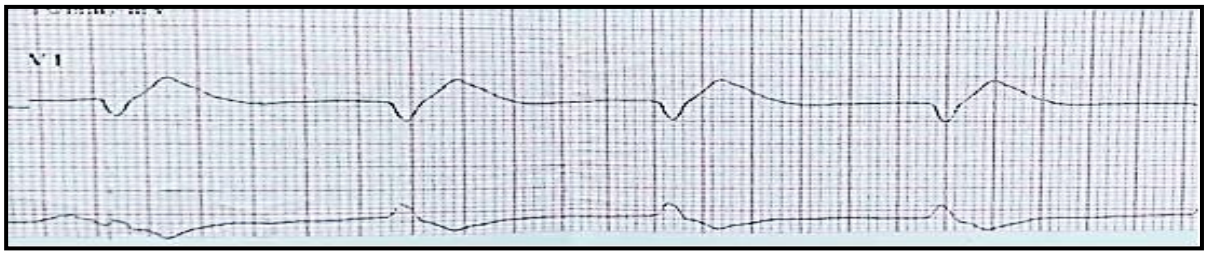

Figure (2): Lead II and VI showing wide QRS complex in a male patient, 47 years old in group II in the current study with acute ALP poisoning

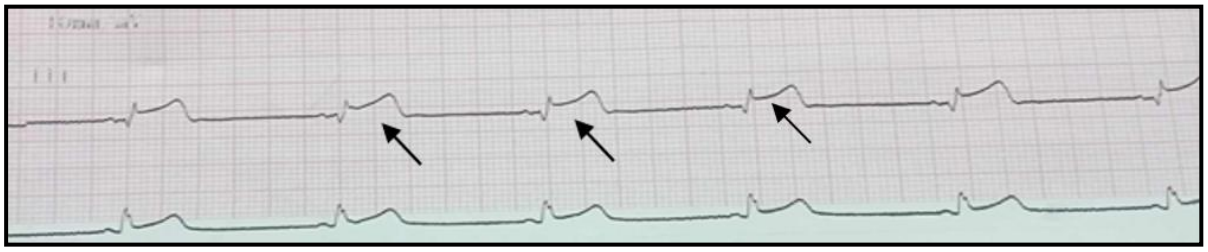

Figure (3): Lead II and III showing ST segment elevation in a male patient, 36 years old in group II in the current study with ALP poisoning

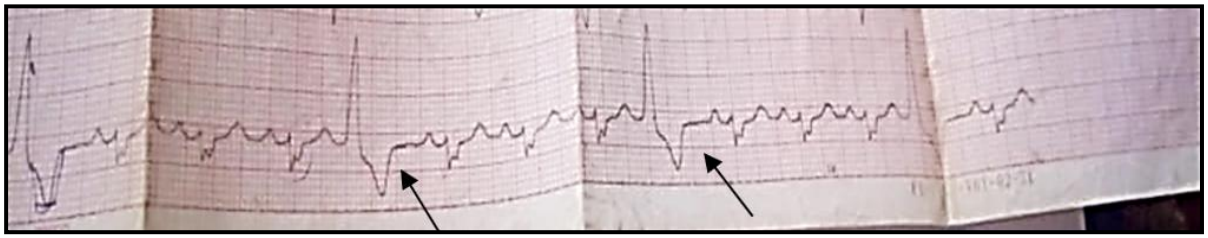

Figure (4): Lead II showing multiple PVCs in a male patient, 42 years old in group I in the current study with acute ALP poisoning

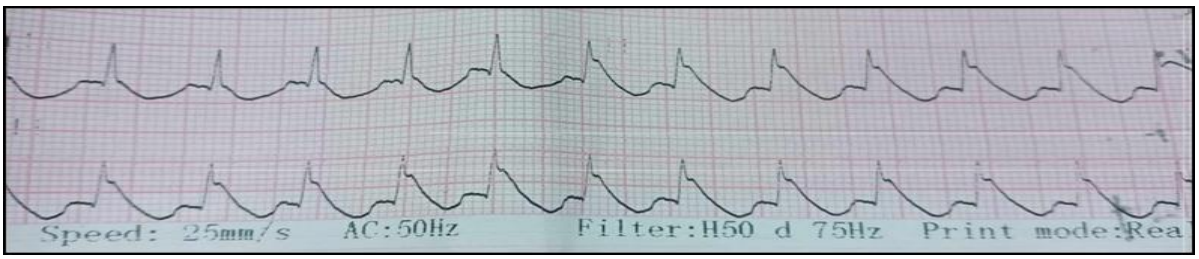

Figure (5): Lead II and III showing ventricular tachycardia in a male patient, 54 years old in group II in the current study with acute ALP poisoning

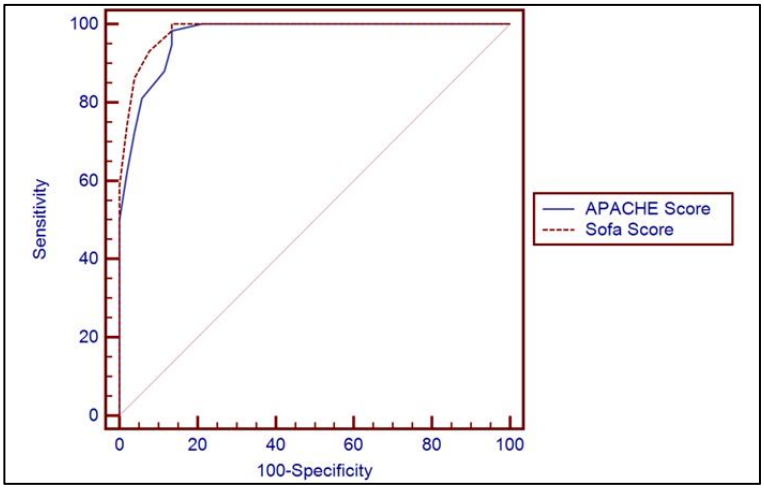

Figure (6): Receiver operating characteristic (ROC) curve for assessing mortality of APACHE II and SOFA scores in 110 ALP intoxicated patients

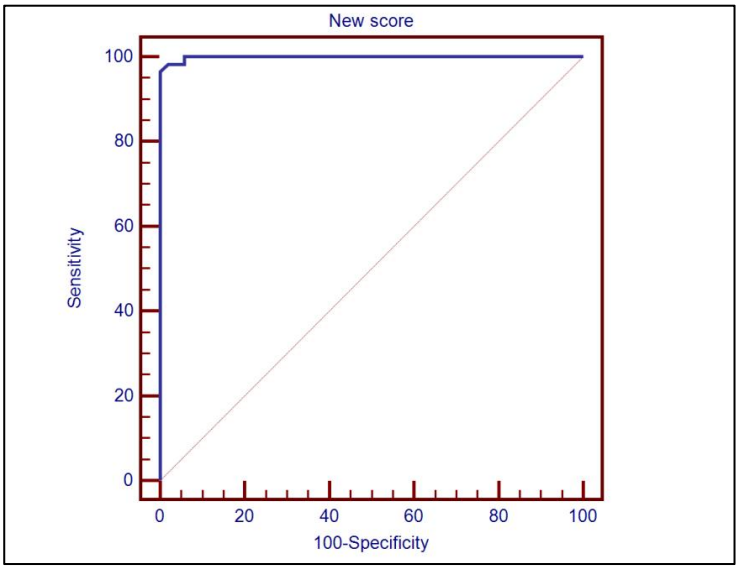

Figure (7): Receiver operating characteristic (ROC) curve for assessing mortality of the new predictive ALP score

Discussion

According to records from the Poison Control Center of Ain Shams University Hospitals and other Poison Control Centers all over Egypt, there was an increase in ALP intoxicated cases with a high mortality rate. It became a challage because of its widespread use and high toxicity over the last years (Deraz et al., 2022; Elshama, 2022).

Construction of a simple critical predictive score can help in identifying the most severe cases of ALP poisoning for more effective intensive therapy, improved outcomes, and saving of hospital resources. Furthermore, it will be useful for standardizing research and comparing the quality of patients through continuous improvement (Pellathy et al., 2021).

In the current study, the mortality rate was 52.7%. This similir to Rahbar-Taramsari et al. (2013) study in Iran and Mathai & Bhanu (2010) study in India who reported that mortality rates of ALP poisoning were 58.6% and 60% respectively. The higher mortality rate from ALP poisoning could be due to its easy availability, cheap price, low education and the absence of specific antidote (Sulaj et al., 2015).

The median age of cases in present study was 22.5 years (18–31). This is in harmony with Abd Elghany et al. (2018) who illustrated that the majority of cases (64.7%) were in the age group between 16-20 years, followed by the age group 20-30 years. This prevalence in young age could be explained by several factors such as exposure of this age group to life stress, emotional immaturity, educational difficulties and family issues (Dadpour et al., 2016; Qureshi et al., 2018).

Majority of ALP cases in the current study (51.8 %) were males and 48.2% were females and this is in agreement with Navabi et al. (2018) and Abdelkader et al. (2023) studies. Trakulsrichai et al. (2017) referred this male predominance to the stress that they exposed to in many life activities.

The majority of ALP cases in the present study were from Elfayoum (34.5%) then Cairo (27.3%), where rural areas represented 67.2%. This is in line with several studies in India who demonstrated that

about 65% of ALP patients were from rural areas (Karamjit et al., 2003; Kapoor et al., 2006).

Concerning the amount of ALP tablets ingested by the studied patients, 59.1% ingested one tablet which is in agreement with Bogale et al. (2021). Furthermore, there was a significant statistical increase in amount of ingested ALP tablets among non-survivors compared with survivors, this is similar to other studies of ALP toxicity (Navabi et al., 2018; and Bogale et al., 2021).

In the current study, all patients were exposed to ALP through ingestion and suicide was the main mode of poisoning (95.5%). This coincides with Mwaheb and Hassan (2021) who reported that most of ALP intoxicated cases were suicidal attempt. Kumar et al. (2013) linked the high number of suicide by ALP to psychological or somatic illness.

The median delay time of ALP poisoning in the current study was 4 hours (2–5), which was nearly the similar range of delay time noticed in Khodabandeh et al. (2014) and Sagah et al. (2015) studies. Furthermore, the range of delay time in the present study among non survivors was 1-30 hours which was relatively longer than survivors (1-12) hours and this is in accordance with Abdelkader et al. (2023).

The majority of patients in the present study (86.4%) stayed in ICU less than one day while 13.6% stayed more than one day with mean 1.05±0.79 days. However, this study revealed that as the duration in the intensive care unit (ICU) increased, the chance for patients to survive was more. This is in consistency with Rahimzadeh et al. (2022) who added that there was a decrease in ICU days stay in non survivors compared with survivors and related the outcome to the duration of hospital stay.

Most of the studied cases had normal pulse (60.9%) while tachycardia was observed in 31.8% of cases and bradycardia in only 7.3% of cases. El Naggar & El Mahdy (2011) and Teimoory et al. (2013) are in accordance with the current study as ALP poisoning could cause normal pulse, tachycardia or less commonly bradycardia.

The majority of ALP patients (72.7%) in the present study developed hypotension. This is partially in line with Dadpour et al. (2016) who noted hypotension in 76% of his studied patients, while Aziz & Husain (2015) documented a higher percentage of hypotensive patients (94%). There was a highly statistical significant decrease in the mean value of systolic and diastolic bloodpressure in non survivors than survivors and this is in accordance with Wahdan & Khalifa, 2020 and Abdelkader et al., 2023 studies.

The majority of cases in the present study (87.3%) were tachypnic as there was a significant increase in respiratory rate in non survivors compared with survivors. This is similar to Abd Elghany et al. (2018) and Ghonem et al. (2020) studies who found tachypnea in most of their studied patients. Wahdan & Khalifa (2020) assumed that metabolic acidosis could be the cause of tachypnea. Moreover, Anand et al. (2011) and Singh et al. (2014) attributed tachypnea to either pulmonary edema or adult respiratory distress syndrome (ARDS). Regarding body temperature, the majority of non survivors had hypothermia (86.2%). This is similar to Ghonem et al. (2020) who stated that temperature was significantly lower in non survivors and vomiting and shock could be the cause.

Regarding skin manifestations, pallor was seen in 54.5% of the studied patients and cold extremities in 53.6% and they represented 98.3% of non survivors. This is in accordance with Sahoo et al. (2020) who reported that pallor and cold skin manifestations are the main symptoms of decrease tissue perfusion and shock. Concerning the gastrointestinal manifestations, 89.1% of the studied patients suffered from vomiting and 52.7% had colic and this is in agreement with Etemadi-Aleagha et al. (2015) and Montazer et al. (2016) studies who reported that about 85% of ALP poisoned patients presented with vomiting on admission.

Respiratory distress was noticed in 16.4% of the studied cases and coarse crepitations in 8.18%. This is in line with Farahani et al. (2016) who stated that respiratory symptoms were less common than the gastrointestinal symptoms in ALP poisoning. However, these symptoms were significantly manifested in non survivors compared with survivors. Concerning cardiovascular manifestations, more than half of the studied patients (57.3%) were shocked and most of them (98.3%) were non survivors. This is in agreement with Abd Elghany et al. (2018) who found that more than half of patients were shocked and non survivors were more hypotensive than survivors.

In the current study, most of ALP cases were fully conscious (71.8%). Meanwhile, neurological manifestation were observed in the form of disturbed conscious level (28.2%) and agitation (14.5%). This is in agreement with Sulaj et al. (2015) and El-Sarnagawy (2017) who reported that most of their studied patients were conscious but only severe cases were comatosed. The mean Glasgow coma scale in the current study was 14.34 ± 0.95 which was decreased in non survivors compared with survivors. This is in agreement with El-Sarnagawy (2017) and Ghonem et al. (2020) who found a statistical significant difference between survivors and non survivors regarding GCS in ALP poisoning.

In the present study, 70% of patients developed metabolic acidosis and this is in harmony with Kalawat et al. (2016) and Saleh & Makhlof (2018) who documented metabolic acidosis in their studies. Mathai & Bhanu (2010) and Shadnia et al. (2010) demonstrated that a low PH value (less than 7.2) and a low serum bicarbonate value (less than 15) indicated a bad prognosis and high mortality in ALP intoxicated patients.

Regarding partial oxygen pressure (PO2), survivors had normal PO2 while non-survivors observed decrease in PO2 with mean 80.91 ± 6.6. This is in accordance with Masoud & Barghash (2013) study. Mathai & Bhanu (2010) demonstrated that ALP causes cellular hypoxia due to suppression of cytochrome C oxidase causing inhibition of ATP production and depletion of cellular energy.

Normal sodium level was noticed in 82% of the studied cases. This is in agreement with other studies (Dadpour et al., 2016 and El-Sarnagawy, 2017). However, 12.7% of patients in the present study developed hypernatremia. Abd Elghany et al. (2018) is in agreement with the current study as serum sodium was significantly increased in non survivors than survivors. Elshama (2022) found a significant relationship between hypernatremia and mortality.

Concerning serum potassium level, 87.3% of ALP patients had normal serum potassium level. Farzaneh et al. (2018) confirmed that there was no change in potassium level after acute exposure to ALP. Meanwhile, in the present study hypokalemia was noticed in 12.7% only of the studied patients and showed a non significant decrease in non suvivors than survivors. This is in agreement with Mathai & Bhanu (2010) who reported that hypokalemia showed a non statistical significant difference between the studied groups.

Regarding serum creatinine, it showed significant increase in non survivors than survivors with mean 1.04 ± 0.49 mg/dL and ranged from 0.1 to 2.5 mg/dL. This is in line with another studies of ALP poisoning (Deraz et al., 2022 and Abdelkader et al., 2023). Bhalla (2017) and El-Sarnagawy (2017) assumed that the risk of mortality could increase and the prognosis is poor in acute ALP poisoning if serum creatinine level increased above 1mg/dL.

In the current study, liver function tests revealed that ALT and total bilirubin were statistically increased in non-survivors when compared with survivors. This is in accordance with Ghonem et al. (2020) study who concluded that elevation of hepatic enzymes could predict mortality from moderate to severe ALP toxicity.

For hematological variables, total leukocyte count was significantly higher in non survivors than survivors. This is in accordance with Wahdan & Khalifa, 2020 and Majidi et al., 2021. Platelet count in the current study was normal in 88% of patients. Although, platelet count statistically increased in non survivors compared with survivors. On the contrary, Majidi et al. (2021) mentioned that platelet count did not show any significant difference between survived and non survived ALP patients. Regarding hematocrite value, it did not show any significant difference between the studied groups. Majidi et al. (2021) agreed with the current study.

In the present study, ECG was abnormal in 68% of the ALP intoxicated patients. This result correlated well with Ghonem et al. (2020) who observed ECG abnormalities in 64.5% of his studied cases. Meanwhile, Saleh & Makhlof (2018) documented a higher percentage of abnormal ECG findings in ALP poisoning (90%). On the other hand, Karami-Mohajeri et al. (2013) concluded that ECG changes were found only in 45% of ALP poisoned patients.

The current study showed that 30% of the studied patients developed sinus tachycardia while 7.3% developed sinus bradycardia. This is in consistency with Abdel Wahab et al. (2020) who found sinus tachycardia in 28.7% of his studied patients and sinus bradycardia in 5.3%. Sinus tachycardia was the most common ECG abnormality among all studied groups while other abnormalities were more common in non survivors. Wahdan & Khalifa (2020) reported similar results. The most common ECG changes in the current study was dysrhythmia which represented 82.6% of patients. Likewise, Mathai & Bhanu (2010) recorded arrhythmia in 75.5% of ALP intoxicated patients.

According to the current results, ECG changes were significantly higher in non survivors compared with survivors and this is in parallel with several studies. Moreover, they associated ALP toxicity with ECG changes (Manouchehri et al., 2019 and Wahdan & Khalifa, 2020). On the contrary, Mathai & Bhanu (2010) stated that ALP toxicity caused a non specific ECG changes and it was not useful in prediction of mortality.

Regarding complications developed in ALP intoxicated patients in the current study, there was a statistical significant increase in non survivors compared with survivors as regards cardiogenic shock, cardiac arrest, need for mechanical ventilation and myocardial infarction. This is in agreement with Saleh & Makhlof (2018) study. Taghadosinejad et al. (2014) concluded that shock was one of the most important complications of ALP poisoning with a high mortality rate. Moreover, the frequency of cardiogenic shock in acute ALP poisoning has been reported to vary from 76 to 100% (Farzaneh et al., 2018). Similar to the present study, Sheta et al. (2019) detected that 43.3% of ALP intoxicated patients needed mechanical ventilation with a significant increase in non survivors than survivors with longer mean values of mechanical ventilation days.

In the present study, APACHE II score was significantly higher in non survivors than survivors with median 12.5 in non surviviors and 3.5 in survivors. This is in consistency with Abd Elghany et al. (2018) who illustrated that there was an increase in APACHE II score values in non survivors than survivors.

The ability of APACHE II to predict ALP mortality in the current study was 89.1% and in patients who survived was 97.8% at cut off point > 6. On the other hand, Abd Elghany et al. (2018) found that APACHE II was able to predict mortality by percentage 92.9 % and 90.9% in survived cases at cut off point ≥ 9.5. Furthermore, AUC for APACHE II Score in the present study was 0.969 with 98.28% sensitivity and 86.54% specificity. Hajouji et al. (2006) illustrated that APACHE II in ALP toxicity had a positive correlation with the bad outcome.

In the present study, the median SOFA score on admission was 5 (0-8) and this is in agreement with Sheta et al. (2019) and Ahuja et al. (2015) studies while Farzaneh et al. (2018) showed a higher median SOFA score (7.34). Furthermore, there was a significant higher SOFA score value in non survivors than survivors with median 8 and 0 respectively. This is in harmony with Abd Elghany et al. (2018) who showed median 9 and 1 between non survivors and survivors respectively.

In the present study, the cut-off point of SOFA score was >2 with 100% sensitivity and 86.54%

specificity. In contrast to this study, Abd Elghany et al. (2018) showed a cut-off point ≥5.5 of SOFA score with 96.4 % sensitivity and 95.5 % specificity. However, Farzaneh et al. (2018) stated a higher cut off point of SOFA score >7.5 with 93.8% sensitivity and 77.8% specificity. Moreover, SOFA score achieved AUC (0.983) in the present study and this is in accordance with Abd Elghany et al. (2018) who claimed that SOFA score had the AUC (0.989).

On comparison between APACHE II and SOFA scores, the present study found that SOFA score demonstrated a better discriminatory power compared with APACHE II. This is in agreement with Sheta et al. (2019) who stated that SOFA score had best discriminatory power with higher sensitivity and specificity over the other scores. However, Farzaneh et al. (2018) noted that SOFA score demonstrated a less discriminatory power than APACHE II score while Abd Elghany et al. (2018) showed a non significant differences between AUC values of APACHE II and SOFA scores.

By applying univariate and multivariate logistic regression analysis on APACHE II and SOFA Score variables with ECG assessment. It was concluded that Glasgow coma scale, mean arterial pressure, respiratory rate, PH value, HCO_3 level, PO_2, serum creatinine, AST, ALT, total bilirubin, TLC values and abnormal ECG were statistically significant for predicting mortality in ALP poisoned patients ($P \leq 0.05$). Wahdan & Khalifa (2020) reported a significant relationship between mortality and ECG abnormalities, GCS, blood pressure, respiratory rate, PH, HCO3, serum potassium level, serum creatinine level and total leukocytic count based on univariate regression analysis. Ghonem et al. (2020) applied multivariate regression analysis on multiple ALP variables and detected that systolic blood pressure ≤85 mmHg, central venous pressure >22 cmH_2O and PH value ≤7.33 were the most significant variables of acute ALP outcome.

The current study constructed and assessed a simple outcome prediction score for acute ALP poisoning. This score combined six parameters based on multivariate regression analysis: PO2, PH value, glasgow coma scale, mean arterial pressure, HCO3 and ECG abnormalities. The main causes of death in ALP toxicity are refractory cardiogenic shock, cardiac dysrhythmia and metabolic acidosis that could support the presence of PH value, mean arterial pressure, HCO3 and ECG abnormalities in the new ALP predictive score (Taghaddosinejad et al., 2016).

According to ROC curve analysis of these six parameters, the cut off value of PO2 was < 90% mmHg, PH ≤7.28, Glasgow coma scale ≤12, mean arterial pressure <70 mmHg, HCO3 ≤ 12.6 mEq/L were able to predict mortality in this study. Similarly, Masoud &Barghash (2013) reported that the cut off value of PH was <7.27, while Sagah & Elhawary (2022) found that the cut off value of HCO3 <12.6 mEq/L and PH <7.33 had showed acceptable sensitivity and specificity to predict mortality in acute ALP poisoning.

On applying the new predictive score on 110 ALP poisoned patients, it was concluded that there was a highly statistical significant increase in the score value in non survivors compared with survivors with median of 0 (0-3) and 27 (24-33) respectively. Furthermore, the ability and accuracy of this new predictive score to predict the outcome of patients with acute ALP poisoning was assessed and evaluated by ROC curve. High sensitivity and specificity values with excellent AUC value reflect the usefulness of this new predictive score and it could be used as a simple method to predict the outcome of ALP poisoned cases on admission for lowering hospital morbidity and mortality. It can be assessed early at the emergency department as it is quick and easy to use and applicable even in small hospitals.

Conclusion

The current study constructed a new ALP predictive score that could be useful at the emergency department for early prediction of mortality among patients with ALP poisoning based on simple, reliable and easily obtainable parameters that are done routinely for every patient. These parameters were the presence of metabolic acidosis, ECG abnormalities and decrease in GCS, MAP and PO2. Patients with new ALP predictive score >19 on admission are considered critical cases and need careful monitoring in the ICU until full recovery.

Recommendations

The present study recommends application of this new ALP predictive score for all patients with acute ALP poisoning on admission for better outcome.

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بناء مقياس هام للتنبؤ بنتائج مرضى التسمم بفوسفيد الألومنيوم في مركز علاج التسمم - مستشفيات جامعة عين شمس

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الملخص العربي

المقدمة: أصبح التسمم الحاد بفوسفيد الألومنيوم تحديًا طبيًا كبيرًا في البلاد النامية بسبب زيادة معدل الوفيات وغياب الترياق المحدد .

الهدف من الدراسةً: هدفت هذه الدراسة إلى تقييم قيمة نتائج APACHE II و SOFA في التنبؤ بالنتائج لدى المرضى الذين يعانون من التسمم الحاد بـفوسفيد الألومنيوم و بناء نموذج تنبؤي لتسمم فوسفيد الألومنيوم.

المرضى وطرق البحث: شملت هذه الدراسة المستقبلية مرضى التسمم الحاد بـفوسفيد الألومنيوم والذين تم إدخالهم مركزعلاج التسمم بمستشفيات جامعة عين شمس خلال الفترة من أغسطس ٢٠٢٢إلى أبريل ٢٠٢٣ .وقد تم جمع البيانات السكانية و السمية و كذلك الإكلينيكية لكل مريض. وقد تم إجراء الفحوصات التالية لكل مريض عند الدخول : غازات الدم الشرياني ، مستويات الصوديوم والبوتاسيوم في الدم، الكرياتينين في الدم، إنزيمات الكبد (الألانين ترانساميناز ، أسبارتات ترانساميناز والبيليروبين الكلي)، صورة الدم الكاملة (كرات الدم البيضاء ، الصفائح الدموية وقيمة الهيماتوكريت) بالإضافة إلى رسم القلب الكهربائي.

نتائج البحث: تم اجراء هذه الدراسة على ١١٠ مريض بالتسمم الحاد بفوسفيد الالمونيوم من كلا الجنسين. كشف تحليل الانحدار متعدد المتغيرات أن ستة عوامل كانت أهم العوامل التنبؤية للوفيات وكانت صالحة لبناء نتيجة تنبؤية جديدة : متوسط الضغط الشرياني <٧٠مم زئبق ، مقياس غيبوبة غلاسكو≤ ١٢ ، درجة حموضة الدم ≤ ٧,٢٨ ، مستوى البيكاربونات ≤ ١٢,٦ملي مكافئ / لتر، ضغط الأكسجين بالدم > 90٪ مم زئبق ، ورسم القلب الكهربائي الغير طبيعى . تم إنشاء نظام تسجيل النقاط من هذه العلامات الستة التي يأخذ كل منها درجة لوجستية ثابتة لإعطاء مجموع نقاط ٣٣ .

الخلاصة: خلصت هذه الدراسة إلى أن النتيجة التنبؤية الجديدة قد تكون مفيدة كطريقة بسيطة للتنبؤ بنتائج مرضى التسمم بفوسفيد الألومنيوم في غرفة الطوارئ تعتمد على علامات بسيطة وموثوقة ويمكن الحصول عليها بسهولة ويتم إجراؤها بشكل روتيني لكل مريض.

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