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ORIGINAL ARTICLE

Role of Total Antioxidant Capacity and Troponin I in Predicting Outcome of Acute Zinc Phosphide Poisoning: A Prospective Study

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ABSTRACT:

Background: Zinc phosphide (Zn3P2) is cheap, easily available, highly potent rodenticide. Zinc phosphide toxicity is considered one of the most common poisonings, particularly in developing countries, with multiorgan toxicity that deeply affects the poisoned patient outcome.

Aim: The study aimed to assess the effectiveness of total antioxidant capacity (TAC) and Troponin I for early prediction of acute (Zn3P2) toxicity outcome.

Methods: This prospective cohort study was conducted on 53 cases of acute (Zn3P2) toxicity presented at Zagazig University Hospitals (emergency room and intensive care units) over the period from July 2023 to January 2024. Patients were evaluated by a thorough history, clinical assessment, routine laboratory investigations, focusing attention to the role of TAC, Troponin I in predicting severity.

Results: This study included patients with an age range from 17 to 57 years. Females were more than males representing 67.9% of patients. Regarding the clinical picture, 73.6% of patients were symptomatic, abdominal pain was the most, representing 61.5% of cases followed by vomiting 59% respectively. The Receiver operator characteristic curve (ROC) curve for Troponin I and TAC showed that Troponin I had better validity as a severity predictor of Zn3P2 poisoning followed by TAC according to their AUC.

Conclusion: TAC and Troponin I are simple, easy and reliable markers that save time. They could be good predictors of poor outcomes in zinc phosphide poisoning.

Recommendations: It is recommended to use TAC and Troponin I as predictors for severity and need for ICU admission in acute (Zn3P2) poisoning.

Keywords: Zinc phosphide; Acute Toxicity; Total Antioxidant Capacity; Troponin I; Outcome.

INTRODUCTION

Zinc phosphide is one of the most common, highly potent rodenticides, which has been used since 1940 in agricultural, urban and industrial environments [1]. Because of its potent garlic-like scent, which attracts mice but repels other animals, it is used to control rodents like rats, ground squirrels, prairie dogs, nutria, and muskrats [2]. These days, zinc phosphide poisoning, whether accidental or suicidal, is regarded as a health risk in Egypt because it is an inexpensive, readily accessible toxin with a high fatality rate of 37–100% and no laws regulating its purchase [3]. Zinc phosphide reacts with the acid of the stomach or its water content leading to the release of phosphine gas (PH3) [4]. Because it inhibits cytochrome C oxidase, phosphine gas disrupts oxidative phosphorylation and is quickly absorbed by the stomach and lungs, resulting in

acute poisoning [1]. This causes lipid peroxidation, protein denaturation, and the production of extremely reactive oxygen molecules, which harm cells and cause damage to multiple organs [5].Congestive heart failure, severe metabolic acidosis, cardiac arrhythmia, liver necrosis, nausea, vomiting, and abdominal discomfort are the typical clinical signs of zinc phosphide overdose [1]. Cardiovascular collapse is the primary cause of mortality.

Treatment for zinc phosphide poisoning is supportive and symptomatic since there is no specific antidote for the condition [6]. Since cardiac troponins are very sensitive and specific biomarkers that can forecast the prognosis of cardiotoxicity, they are the most suitable biomarkers for the diagnosis of heart damage [7]. Furthermore, the entire antioxidant status in biological samples is referred to as total antioxidant capacity (TAC). It is among the most significant bio-analytical indicators of the body's oxidative stress [8]. Initial TAC values in patients with acute metal phosphide poisoning may help predict the onset of cardiotoxicity and oxidative damage, which could lower mortality and improve patient outcomes [9]. The purpose of the study was to evaluate Troponin I and total antioxidant capacity (TAC) as predicting tools for acute zinc phosphide toxicity outcome.

METHODS

This is a prospective cohort study conducted on 53 patients with acute zinc phosphide toxicity presented at Zagazig University Hospitals (emergency room and intensive care units) during seven months' period from July 2023 to January 2024.Inclusion criteria include clear history of intake of zinc phosphide, clinical picture of acute zinc phosphide poisoning (severe vomiting, hypotension, abdominal pain, cardio-pulmonary disturbance), patient age above 16 y. Exclusion criteria include Patients with unclear history, comorbidities (such as cardiovascular disease, renal or hepatic failure), w All enrolled patients were subjected to the following:

A-History taking from which the poisoning history (including the mode of poisoning, the amount, and the interval between consumption and hospital presentation) and sociodemographic information (particularly age and sex) were gathered.

B-Clinical assessment of the Glasgow coma scale (GCS) to determine the conscious state and vital indicators (blood pressure, heart rate, respiration rate, and temperature) [10] was performed.

C-Investigatory workup:

1) Biochemical studies:

Blood samples were withdrawn as follows: About 2 cm3 of arterial blood were withdrawn in a heparinized syringe to perform arterial blood gases (ABG) with sodium (Na+) and potassium (K+) electrolytes by an automated analyzer (Cabs B 221) which is present in Zagazig University Hospitals according to the method described by [11]. Approximately 10 cm3 of blood was collected on admission from the intake, 3 cm3 were separated into an EDTA tube to perform a complete blood count (CBC) test, and 7 cm3 were moved to a plain tube. The tube was left upright to allow the blood to clot, and after 10 minutes of centrifugation at 5000 rpm, samples of the serum supernatant were taken. A portion was used for routine investigations, and the remaining portion was preserved at -80°C to be used later for specific tests. All patients were evaluated by the following tests:

A-Nonspecific (routine investigations done for all zinc phosphide poisoned cases in Zagazig University Hospitals): Complete blood picture (CBC) by using Siemens Advia 120, hematology analyzer [12], liver function tests (LFT), namely ALT, AST, Total bilirubin, Direct bilirubin were assessed according to the method described by [13], [14], [15], [16] respectively, and kidney function tests (KFT) by spectrophotometry, namely serum creatinine as described [17] and

blood urea nitrogen (BUN) by the colorimetric method [18].

B-Specific investigations:

- Plasma total antioxidant capacity (TAC): by the described colorimetric method according to [19]by spectrophotometry at wavelength 500-510 nm.
- Serum cardiac Troponin I level by Colloidal Gold Assay using the Fast Test kit (Getein Biotech. Inc.; USA) with Getein 1100 immunofluorescence quantitative analyzer [20].
- Serum creatine kinase-MB fraction level by a sandwich electrochemiluminescence immunoassay method, using Full automated cs200florometric analyzer [21].

2) Standard twelve-lead Electrocardiography (ECG) that was routinely recorded for all acute zinc phosphide poisoned cases on arrival at the university hospital ER by using CardiMax FCP-7101 ECG machine (Fukuda Denshi Co., Ltd., Tokyo, Japan) [22].

Case Management:

All cases were treated according to the management protocol adopted in Poisoning Treatment Unit (ZUH) including initial patient stabilization (ABC), decontamination was done through gastric lavage using coconut oil or castor oil along with using antioxidants such as N-acetyl cysteine (NAC) because it has been demonstrated to reduce organ toxicity, especially hepatotoxicity, by acting as a precursor or restorer of glutathione (GSH), and it has also been proven to be helpful in treating Zn3P2 poisoning. Additional supportive therapies included intravenous fluids, vasopressors, infusions of sodium bicarbonate (NaHCO3), antiemetic, antispasmodics, proton pump inhibitors, and H2 blockers. omen who were pregnant and those with co ingestion.

Statistical Methods

The Statistical Package for Social Science (SPSS) program version 28.0 (IBM, 2021) IBM crop was used to do the statistical analysis. Released in 2021: Version 28.0 of IBM SPSS statistics for Windows. NY: IBM crop in Armonk. The chi-square test, Mann Whitney (MW) test, Fisher's Exact Test, Pearson's and spearman's correlation coefficients, the receiver operating characteristic (ROC) curve analysis, the independent-samples T-test, and other tests were used.

RESULTS

This was a prospective cohort study of acute zinc phosphide (Zn3P2) poisoning cases that were brought to Zagazig University Hospitals' poison treatment unit and intensive care units through the period from the beginning of July 2023 to the end of January 2024 and fulfilled the inclusion criteria. Fifty-three patients, ages ranging from 17 to 57 years, with a median age of 23 years, were included in this study. females were more than males representing 67.9% of patients. About 71.7% of patients came from rural areas. About 67.9 % of patients were students and 90.6% of patients were intentionally poisoned. All patients exposed to (Zn3P2) via ingestion. Most patients 71.7% were presented early <5 hours. As regard the amount of (Zn3P2), it ranged from 0.25 –4 sachets with mean 2(1-3) (Table 1). Regarding the clinical picture, 73.6% of patients were symptomatic, abdominal pain was the most, representing 61.5% of cases followed by vomiting 59%, dyspnea, hypotension and drowsiness representing 35.9%, 33.3% and 25.6 % of cases respectively (Table 1).

Regarding the vital data, mean systolic, diastolic and man arterial blood pressure were105.57, 67.64 and 79.94mmHg respectively. Mean heart rate and respiratory rate were 79.08 beat/minute and 13.45 breath /minute respectively. Mean temperature was 37.1^{o}c and mean peripheral oxygen saturation was 98.79%. The mean arterial PH was 7.34, with 69.8% of cases had normal acid base

balance,17% had metabolic acidosis, 7.5% had respiratory alkalosis and 5.7% had respiratory acidosis (Table 2). Normal sinus rhythm was recorded in 77.4% of cases, the most frequent abnormal ECG finding among the studied cases was sinus tachycardia in 13.2% of cases, sinus bradycardia represented 5.7% and Wide QRS was 3.8 % (Table 2).

Regarding routine investigations, WBCs, RBCs and platelet count were 8.4 (103/mm3), 4.67 (106/mm3) and 4.9 (103/mm3) respectively. Mean hematocrit was 39.16%. The mean serum sodium was 143.06 mmolⱠL and the mean serum Potassium was 3.7 mmolⱠL. This study revealed that PT, PTT was 12.38 sec and 33.27 sec respectively and the mean INR was 1.21. Regarding liver and kidney functions, the median ALT and AST was 12 (U/L) and 17.1(U/L) respectively. The median creatinine and urea was 0.59 (mg/dl) and 8.3(mg/dl) respectively. Mean GCS was 14.67 (Table 2).

Median total antioxidant capacity (TAC) was 0.35 mm/L. Median troponin I and CK -MB were 0.25 ng/ml and 2.23 ng/ml. There was statistically high significant relation($p<0.001$) between ICU admission and all of TAC, Troponin I and CK-MB. TAC, Troponin I and CK-MB were in high significant relation with the outcome of the patients. TAC (AUC 0.829,80% sensitivity and 86% specificity), Troponin I (AUC 0.907, 90% sensitivity and 88.4% specificity) and CK-MB (AUC 0.814,70% sensitivity and79.1 % specificity) respectively. (Tables 3,4 Figures 1,2,3). In terms of fatality, only 18.9% of patients were admitted to the intensive care unit, and no deaths were reported in the current study.

Table (1): Statistical analysis of demographic data and poisoning history in acute zinc phosphide-poisoned patients admitted to Zagazig University Hospitals (ZUH) from the beginning of July **2023** to the end of January **2024**

	No ICU admission	**ICU admission**	**χ2**	**p**
	N=43(%)	N=10 (%)		
Sex:				
Female	29 (67.4%)	7 (70%)	Fisher	>0.999
Male	14 (32.6%)	3 (30%)		
Residence				
Rural	32 (74.4%)	6 (60%)	Fisher	0.442
Urban	11 (25.6%)	4 (40%)		
Education				
Illiterate	2 (4.7%)	10 (100%)	Fisher	>0.999
Educated	41 (95.3%)	0 (0%)		
Occupation				
Not worker	3 (7%)	0 (0%)		
Student	29 (67.4%)	7 (70%)		
Worker	1 (2.3%)	1 (10%)	0.025§	0.873
Farmer	1 (2.3%)	0 (0%)		
Employee	9 (20.9%)	2 (20%)		
Mode of exposure				
Suicidal	35 (81.4%)	8 (80%)	Fisher	>0.999
Accidental	8 (18.6%)	2 (20%)		
Clinical picture				
Asymptomatic	13 (30.2%)	1 (10%)	Fisher	0.258
Symptomatic	30 (69.8%)	9 (90%)		
	Median(IQR)	Median(IQR)	Z	p
Age (year)	19 (18 – 37.2)	18 (17.75 – 30.5)	-0.368	0.713
Came within (hour)				
Early (<5 hours)	38 (62.8%)	0 (0%)	31.225	<0.001**
Late (>5 hours)	5 (37.2%)	10 (100%)		
Amount (sachet)				
0.25 – 0.5	12 (28%)	0 (0%)		

	No ICU admission	ICU admission	$\chi 2$	p
1 – 1.5	12 (28%)	2 (20%)		
2 – 2.5	10 (23.3%)	4 (40%)	4.861§	0.027*
>2.5	8 (16.3%)	3 (30%)		
Unknown	3 (9.3%)	1 (10%)		

Non-significant (p>0.05), *: Significant (p<0.05), **: Highly significant (p<0.001)
Mann Whitney test(Z) Chi square test($\chi 2$) interquartile range (IQR) Monte Carlo test (MC) Chi square for trend test (§) Intensive Care Unit (ICU), Zagazig University Hospitals (ZUH).

Table (2): Statistical analysis of vital data, Arterial Blood Gases (ABG), Electrocardiogram (ECG) and laboratory data in acute zinc phosphide- poisoned patients admitted to Zagazig University Hospitals from the beginning of July **2023** to the end of January **2024**

	No ICU admission	ICU admission	t	p
	Mean ± SD	Mean ± SD		
Systolic blood pressure (mmHg)	110.12± 9.03	86.00± 2.108	8.334	<0.001**
Diastolic blood pressure (mmHg)	71.05± 7.83	53.00± 3.49	7.081	<0.001**
Mean arterial blood pressure (mmHg)	83.72± 8.02	63.67± 3.04	7.730	<0.001**
Heart rate (beat/minute)	77.0 ± 6.66	88.0 ± 15.13	-2.249	0.049*
Respiratory rate (/min)	13.4 ± 1.87	13.7 ± 2.11	-0.454	0.652
Temperature	37.1 ± 0.18	37.12 ± 0.27	-0.275	0.788
PaO2	88.23 ± 9.3	81.2 ± 8.7	2.177	0.034*
Arterial PH	7.37 ± 0.04	7.21 ± 0.08	6.056	<0.001**
Peripheral oxygen saturation	98.93 ± 1.06	98.16 ± 1.09	2.066	0.044*
ABG			$\chi 2$	
Normal acid balance	37 (86%)	0 (0%)		
Metabolic acidosis	3 (7%)	6 (60%)		
Respiratory alkalosis	1 (2.3%)	3 (30%)	16.641	<0.001**
Respiratory acidosis	2 (4.7%)	1 (10%)		
ECG			$\chi 2$	
Normal sinus rhythm	38 (88.4%)	3 (30%)		
Sinus bradycardia	3 (7%)	0 (0%)		
Sinus tachycardia	2 (4.7%)	5 (50%)	25.504	<0.001**
Wide QRS	0 (0%)	2 (20%)		
WBCs (103/mm3)	**4.83 ± 0.67**	**5.19 ± 1.02**	**-1.154**	**0.254**
RBCs (106/mm3)	**4.67 ± 0.44**	**4.69 ± 0.42**	**-0.142**	**0.887**
Hemoglobin (g/dl)	**13.4 ± 1.87**	**13.7 ± 2.11**	**-1.371**	**0.176**
Platelet count (103/mm3)	**243.98 ± 39.76**	**237.4 ± 23.37**	**0.501**	**0.619**
HCT	**38.95 ± 3.53**	**40.03 ± 3.89**	**-0.853**	**0.398**
PT (sec)	**12.3 ± 2.04**	**12.75 ± 1.47**	**-0.664**	**0.51**
PTT (sec)	**33.59 ± 7.67**	**31.92 ± 4.34**	**0.66**	**0.512**
INR	**1.22 ± 0.3**	**1.19 ± 0.23**	**0.327**	**0.745**
Sodium	**143.09 ± 5.59**	**142.9 ± 6.32**	**0.096**	**0.924**
Potassium	**3.73 ± 0.43**	**3.53 ± 0.76**	**1.153**	**0.254**
GCS	**14.98 ± 0.15**	**13.40 ± 0.69**	**13.832**	**<0.001****
	Median (IQR)	**Median (IQR)**	**Z**	**p**
ALT (U/L)	**12(10 – 16)**	**305(230.88 – 477.75)**	**-4.876**	**<0.001****
AST (U/L)	**16.8(15 – 27)**	**202.7(117.38–263.75)**	**-4.753**	**<0.001****
Direct bilirubin (mg/dl)	**0.17(0.12 – 0.24)**	**0.15(0.12 – 0.33)**	**-0.205**	**0.837**
Total bilirubin (mg/dl)	**0.42(0.32 – 0.64)**	**0.55(0.25 – 0.78)**	**-0.148**	**0.882**
Creatinine (mg/dl)	**0.57(0.49 – 0.73)**	**0.88(0.52 – 1.32)**	**-2.108**	**0.035***
Urea (mg/dl)	**8.1(6.5 – 10.2)**	**10.3(7.68 – 19.95)**	**-1.968**	**0.049***

Table (3): Statistical analysis of Total Antioxidant Capacity (TAC), Troponin I and Creatine Kinase-MB(CK-MB) data in acute zinc phosphide- poisoned patients admitted to Zagazig University Hospitals from the beginning of July **2023** to the end of January **2024**

	No ICU admission	ICU admission	t	p
	Mean ± SD	Mean ± SD		
TAC (mm / L)	**0.38 ± 0.11**	**0.24 ± 0.09**	**3.77**	**<0.001****
Troponin I (ng/ml)	**0.23(0.2 – 0.29)**	**0.9(0.33 – 22.59)**	**-3.988**	**<0.001****
CK-MB (ng/ml)	**1.9(1.18 – 2.78)**	**4.13(2.64 – 46.37)**	**-3.524**	**<0.001****

Mann Whitney test (Z) interquartile range(IQR) independent sample t test(t) **p≤0.001 is statistically highly significant Zagazig University Hospitals(ZUH),Total Antioxidant Capacity (TAC), Creatine kinase –MB(CK-MB), Intensive Care Unit (ICU).

Table (4): Diagnostic Validity of Total Antioxidant Capacity (TAC), Troponin I and creatine kinase-MB in prediction of need for Intensive Care Unit (ICU) admission in acute zinc phosphide- poisoned patients admitted to Zagazig University Hospital from the beginning of July **2023** to the end of January **2024** by Receiver Operating Characteristic (ROC) curve analysis

	Cutoff	AUC	Sensitivity	Specificity	PPV	NPV	Accuracy	p
TAC	**≤0.265**	**0.829**	**80%**	**86%**	**57.1%**	**94.9%**	**84.9%**	**0.001****
Troponin I	**≥0.305**	**0.907**	**90%**	**88.4%**	**64.3%**	**97.4%**	**88.7%**	**<0.001****
CK-MB	**≥6.2150**	**0.814**	**70.0%**	**79.1%**	**43.8%**	**91.9%**	**77.35%**	**<0.001****

positive predictive value (PPV) negative predictive value (NPV) area under curve (AUC) **p≤0.001 is statistically highly significant,, Intensive Care Unit (ICU), Total Antioxidant Capacity (TAC), Creatine kinase –MB(CK-MB)

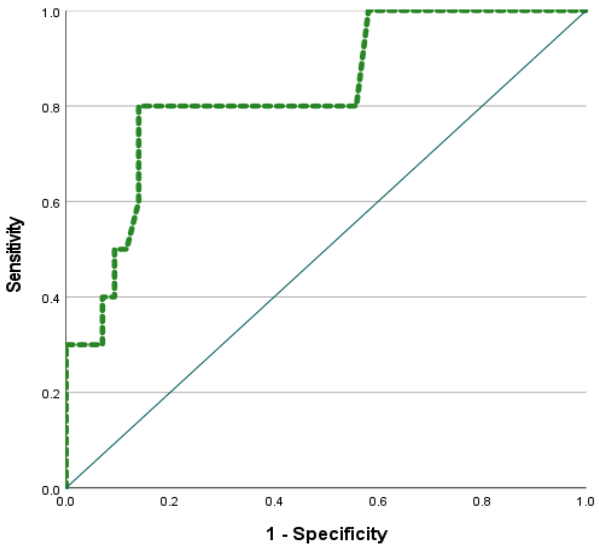

Figure (1): Receiver operating characteristic (ROC) curve showing validity of Total Antioxidant Capacity (TAC) in diagnosis of need for Intensive Care Unit (ICU) admission in zinc phosphide (Zn3P2) poisoned patients admitted to Zagazig University Hospitals (ZUH) from the beginning of July 2023to the end of January 2024.

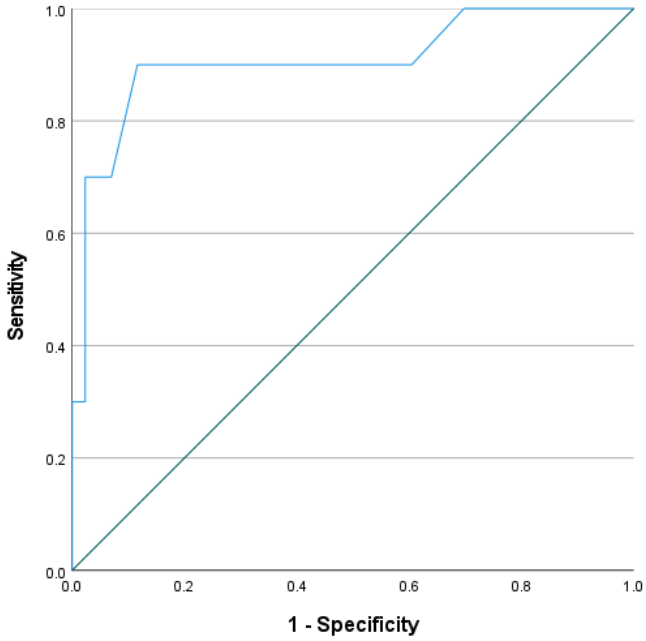

Figure (2): Receiver operating characteristic (ROC) curve showing validity of troponin I in diagnosis of need for Intensive Care Unit (ICU) admission in zinc phosphide (Zn3P2) poisoned patients admitted to Zagazig University Hospitals (ZUH) from the beginning of July 2023 to the end of January 2024

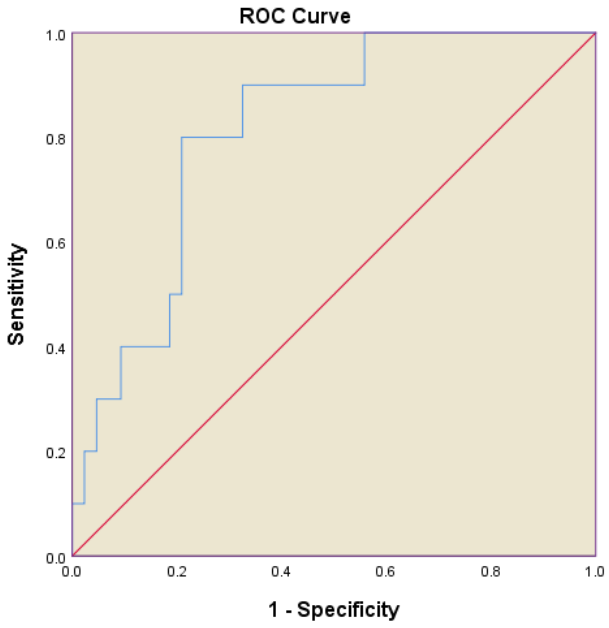

Figure (3): Receiver operating characteristic (ROC) curve showing validity of Creatine Kinase Myocardial Band (CK-MB) in diagnosis of need for intensive care unit (ICU) admission in zinc phosphide (Zn3P2) poisoned patients admitted to Zagazig University Hospitals (ZUH) from the beginning of July 2023 to the end of January 2024.

DISCUSSION

In Egypt, zinc phosphide-containing rodenticides are frequently employed as grain preservatives. Because they are inexpensive and readily available, they are also frequently used as a potent suicidal tool, contributing to one-third of suicides globally. Zinc Phosphide is a highly toxic rodenticide with a high mortality rate between 37-100% [6, 23].

This work aimed to evaluate the most common prognostic parameters in acutely (Zn3P2) poisoned cases, over the period from the beginning of July 2023 to the end of January 2024 which can help the physicians evaluate the cases, predict the prognosis and decide the best plan of care, and so improving outcome of patients. The tested parameters included are total antioxidant capacity (TAC), troponin I, creatine kinase myocardial band (CK-MB), ABG, electrolytes, CBC, PT, PTT, INR, liver functions, kidney functions and ECG. Fifty-three cases were included in this prospective cohort study with inclusion and exclusion criteria.

In terms of baseline patient characteristics, the included cases' ages ranged from 17 to 57 years. A similar prevalent age group was reported by previous studies [9, 24, 25, 26] that explained this age may be more susceptible to social, occupational and economic stresses.

The majority of poisoned cases in the current study were females (67.9%) which is consistent with similar studies done by [9, 26, 27, 28] they explained this by higher liability of female to stress. On the contrary, Etemadi-Aleagha et al. [29] and Trakulsrichai et al. [30] revealed that compared to females, males were more exposed to acute phosphide poisoning.

According to the current study's findings, the majority of patients (71.7%) came from rural areas, which is consistent with research by Tassew et al. [26] and El Gendy et al. [31] who reported that most of the patients under study were from rural areas, which were agricultural communities with easy access to harmful pesticides. However, Chaudhary et al. [32] and El Masry and Tawfik [33] discovered that the majority of their patients came from cities and explained this by globalization and migration of people to these areas leading to overcrowding and exposure to more social stress.

Most included cases gave a history of suicidal exposure (90.6 %). Similarly, Abdel Wahab et al. [9] and Trakulsrichai et al. [30] reported that suicide was the most common manner of poisoning with (Zn3P2).

The estimated amount ingested ranged from 0.25 sachet to 4 sachets, with a mean value of 2(1-3), This finding was like those recognized by Abdel Wahab et al. [9] who stated that most individuals with (Zn3P2) poisoning had only been exposed to one sachet. Additionally, a statistically significant correlation has been found between the quantity of zinc phosphide and the patients' outcomes, as reported by Mashali et al. [7] who reported that the patient with acute (Zn3P2) poisoning is considered at risk if the ingested amount > 2.5 sachets.

The current study illustrated that 67.9% of our cases were students. This agrees with various studies done by Akhtar et al. [34], Sagah et al. [35] and Abdel Wahab et al. [9] who discovered that most patients with acute phosphides poisoning were students, and they attributed this to teacher scolding and low exam scores.

The time lag between ingestion and hospital presentation, less than 5h, was also reported by Wahdan and Elmadah [36] and Shahin et al. [37] who clarified that most people who attempt suicide do not truly mean to die; rather, they seek medical assistance quickly in an attempt to attract compassion and support from their loved ones. Furthermore, there was a statistically significant correlation between the patients' outcomes and the delay time. These findings align with those published by Mashali et al. [7] who reported that zinc phosphide poisoned patient is considered at risk if time till hospitalization > 5 h.

In this study, there was no statistical relationship between ICU admission and either respiratory rate and temperature, However, there was a statistically significant correlation between

patients' outcomes and heart rate. Additionally, there was a statistically significant correlation between the patients' outcomes and their systolic, diastolic, and mean arterial blood pressure. Prasad et al. [38] and Yogendranathan et al. [39] found that vital signs may be used to predict the fate of Zn3P2 poisoning at presentation. However, Hassanian-Moghaddam et al. [28] claimed that the prognosis for Zn3P2 poisoning has little to do with vital signs.

Moreover, there was a statistically highly significant relation between PH and the outcome of patients as PH was significantly lower among patients who needed ICU admission, Wahdan and Elmadah [36] found that metabolic acidosis was present in 32% of cases included in their study.

In the current study, most patients were fully conscious with GCS ranged between 13 and 15 and a mean value of 14.67± 0.70 and there was a statistical high significant relation between GCS and outcome of patients. These findings were in accordance with Khater and Sarhan [27] who found that all (Zn3P2) studied patients were oriented and fully conscious.

The current study's findings demonstrated a statistically significant increase in ALT and AST levels among ICU patients, as well as a statistically significant relationship between the two parameters and the outcome since they are much higher among patients who required ICU care. Elevated ALT, a sign of hepatotoxicity, was discovered in numerous research by [7,27 ,40].

The result of this study revealed that serum creatinine level ranged from (0.44-1.32) mg/dl with a median value of 0.61 and serum urea between (4-78.6) mg/dl with a median value of 8.3. There was a significant relation between serum urea and creatinine level and the outcome, as it was significantly higher among patients needed ICU admission. This was in harmony with Yogendranathan et al. [39] who stated that repeated hemodialysis helped the patients recover from severe acute renal damage induced by zinc phosphide poisoning, with blood creatinine levels exceeding 1000 μmol/L.

The ECG findings among studied patients in this study revealed normal sinus rhythm (77.4%), sinus tachycardia (13.2%), sinus bradycardia (5.7%) and wide QRS complex (3. 8%). There was statistically high significant relation between ECG findings of patients and the outcome as 50% of patients admitted to ICU had sinus tachycardia and 20% had wide QRS complex. Khater and Sarhan [27] matched with our research as they discovered that 50% of their patients with (Zn3P2) intoxication showed dysrhythmia and roughly half had normal ECGs.

Regarding total antioxidant capacity (TAC), in this study the median TAC was 0.35 (0.26-0.43) mm / L, which decreased in most patients. This result is in accordance with Abdel Wahab et al. [9] who discovered that acute phosphide poisoning was associated with a drop in TAC. The current study's optimal TAC cutoff point was ≤0.265 mM/L, with an area under the curve (AUC) of 0.829, 80% sensitivity, and 86% specificity. Since TAC significantly dropped among ICU patients, there was a strong correlation between it and patient outcomes. Abdel Wahab et al. [9] said that their study's optimal TAC cutoff point was ≤0.07 mM/L, and that it was 100% sensitive and 63.54% specific for mortality. However, Halvaei et al. [41] found no difference in the value of TAC between control and treatment group with antioxidant after ALP exposure.

Troponin I is one of the excellent markers for myocardial injury. In the present study, there was a statistically significant increase in troponin I found among the ICU cases and a highly significant correlation between the cardiac troponin I and the outcome. This was consistent with study done by Abdel Wahab et al. [9] who found that individuals with severe zinc phosphide poisoning had significantly higher serum troponin I levels than patients with mild or moderate intoxication.

In the present study, there was a statistical increase in CK-MB found among the poisoned cases and a highly significant correlation between the CK-MB and the outcome. This is consistent with studies done by Mashali et al.

[7], Khater and Sarhan [27] and El-Nahhal [42] who reported that cardiac enzymes were elevated and significant for prediction of the outcome in acute (Zn3P2) poisoning. Mostafalou et al. [43] and Hakimoğlu et al. [44] are against the current work because they found that while elevated levels of several cardiac enzymes, such as CK-MB or troponin T (Tn T), might confirm cardiotoxicity and fatality, their absence did not rule out cardiotoxicity following acute exposure to zinc phosphides.

Thankfully, the current study found no fatalities and only 18.9% of patients were admitted to the intensive care unit. The appropriate supportive therapy that was started upon arrival of (Zn3P2) intoxicated patients may have contributed to this positive outcome. This was consistent with the findings of Abdel Wahab et al. [9], who reported that every (Zn3P2) intoxicated patient recovered fully and was discharged**.**

CONCLUSIONS

In conclusion, Troponin I, TAC and CK-MB respectively are good predictors for severity and need for ICU admission in acute zinc phosphide (Zn3P2) poisoning. They are quick, easy, reliable, and useful markers that save time so they might be useful tools for determining the prognosis of zinc phosphide**.**

Ethical Considerations: The study was performed after approval from the ethical committee of scientific research (Institutional Research Board "IRB" number ZU-IRB #10545/7-3-2023. Written informed consent was obtained from the patient, if they were conscious, or from their family members if unconscious. Throughout the whole trial, patient records were kept private

Conflict of interest: The authors declare that they have no competing interest.

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