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Original Article

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Epidemiological Study of Aluminum Phosphide Poisoning Mortality in Tohid Hospital, Sanandaj, from 2010 to 2018

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Abstract

Background: Aluminum Phosphide (ALP) is a highly toxic inorganic compound, widely used as a rodenticide and insecticide during grain storage and transportation in developing countries. The present study investigated the aluminum phosphide poisoning mortality in Tohid Sanandaj Hospital from 2010 to 2018.

Methods: In this cross-sectional descriptive-analytical study, the medical records of 76 aluminum phosphide-poisoned patients admitted to Tohid Hospital in Sanandaj between 2010 and 2018 were studied. The data were analyzed through SPSS-20 software, using frequency, percentage, the mean and standard deviation for descriptive variables, and t-test and chi-squared for analytical variables. Using the relative risk index, the strength of the relationship was assessed.

Results: This study showed that 21.1% of the patients died of poisoning, and 76.9% were discharged. The highest mortality rate was associated with the oral administration and intact tablet form. In this study, 56.6% of participants were men, and the mortality rate due to pill poisoning was the same in both sexes (p=0.55). The results also demonstrated that majority of the individuals studied had a diploma (56.6%; p=0.566), and in terms of occupation, the highest frequency was related to self-employment (56.6%; p=0.472), but the highest mortality rate was observed in the unemployed groups (43.8). In this study, 59.2% of the participants were single, and the highest mortality rate was related to the single group (p=0.763).

Conclusion: Considering that administration to the treatment time interval and the number of pills consumed is associated with higher patient mortality, these components can be studied as an estimate of prognosis more thoroughly and accurately in ALP poisoning.

Keywords: Aluminum phosphide, Complications, Poisoning, Rice tablets

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Introduction

Aluminum Phosphide (ALP) is a highly toxic inorganic compound, widely used as a rodenticide and insecticide during grain storage and transportation in developing countries (1). ALP, a sublimation or edible pesticide, is known by various trade names such as Quickphos, Celphos, Fostox, Fumitoxin, Phostek, Phostoxin, Talunex, Fieldphos, and in Iran, it is known as rice pill. The rice tablets available in Iran, with the brand name phostoxin, containing ALP as its main active agent (55%), available in the form of 3-*g* dark gray tablets in cylindrical packages, can be readily accessed at low prices (2,3). The lethal dose of ALP ranges from 0.15 to 0.5 *g* (4).

Pesticide poisoning, whether accidental, occupational, or suicidal, is a social health problem globally, and constitutes a third of all suicide cases worldwide (5). Every year, approximately 300,000 deaths occur due to pesticide poisoning worldwide (6). Organophosphates-organochlorine compounds and ALP are the most commonly used pesticides. Due to being cheap, effective, not leaving toxic residues, and not affecting the crops, ALP is a common pesticide used in both open and closed spaces in developing countries (7). Since the first report of ALP poisoning in India in the 80s, until now, it has been one of the most common causes of poisoning among agricultural pesticides (8-11). In Iran, in a survey in Babol, the third cause of suicide was attributed to rice tablets. ALP poisoing is responsible for 8% of all poisonings and 12% of deaths due to poisoning in iran (12) and mortality rate of this poisoning was estimated to be 27.3% (13).

The ALP pills release phosphine gas, ammonia, and carbon dioxide upon contact with water or steam which has no skin absorption, and the primary way of poisoning is through oral intake and inhalation, both of which are highly poisonous. After oral consumption and in contact with moisture and reaction with gastric acid, this substance releases phosphine gas which can be absorbed through the epithelium of digestive and respiratory system and it plays an essential role in toxicity of this substance (14,15). Phosphine, a cytotoxic compound, releases free radicals and prevents the activity of vital cell enzymes, harming body cells and thus causing multiple organ failures (15) which include heart, lungs, kidneys, and liver damage and leading to symptoms such as cardiac arrhythmias, acidosis, and pulmonary edema which mainly occurs during the first 24-48 *hr* after poisoning (16,17). Toxicity features and clinical findings such as vomiting, abdominal pain, restlessness, tachycardia, tachypnea usually begin within minutes of ingestion and can be followed acidosis, and marked hypotension. These findings are non-specific and depend on the dose, method of use, and time elapsed after sunstance consumption (18).

Usually, the main fatal consequence of ALP is the direct effect of phosphine gas on the myocardium, leading to arrhythmia and disturbances in the cardiovascular system (19). In severe cases of poisoning by inhalation, patient develops acute respiratory distress syndrome (20). Cardiovascular failure, hypotension, severe acidosis, and acute kidney failure are the most common complications of ALP poisoning, which all can have devastating effects (21). Since there is no specific antidote for ALP poisoning, ALP poisoning is managed only through supportive treatment; therefore, poisoning with ALP is highly lethal (22,23). Various social, cultural, and geographical components and the aluminum availability of phosphide have contributed to the increased ALP poisoning cases (24).

The fact that grain cultivation in Kurdistan province is high, and ALP being easily accessible as a pesticide, high lethality of this substance, high prevalence of poisoning especially for suicide, and also due to the lack of accurate reports on the mortalities associated with this substance in the city of Sanandaj, this study was aimed to comprehensively show the ALP poisoning picture in Sanandaj in a descriptive study.

The aim of this study is investigation of the ALP poisoning mortality in Tohid Sanandaj Hospital from 2010 to 2018.

Materials and Methods

This original descriptive-analytical study which was approved by the ethics code IR.MUK.REC.1400.097, was conducted as a cross-sectional and retrospective study on 76 hospitalized patients due to ALP poisoning in Tohid Hospital in Sanandaj from 2010 to 2018. First, a checklist of the study variables including demographic variables (gender, age, education and job), method of exposure, form of consumption,

cause of poisoning, history of psychiatric disorders and history of drug/alcohol abuse was designed and the 'results' section of this checklist was divided into 2 categories of death or the patient being discharged from hospital. Then, admission and archived documents of the patients who were hospitalized due to ALP poisoning in Tohid Hospital from 2010 to 2018 were studied and the documents which were deficient and did not met the needed criteria were excluded from the study. The required data were extracted and included in the checklist and then was analyzed through SPSS-20 software (IBM Corp., Armonk, Ny, USA). For descriptive variables, frequency, percentage, mean and standard deviation, and for analytical variables, t-test and chi-square were used. Using the relative risk index, the strength of the relationship was assessed.

Results

No specific antidote for ALP poisoning exists, and treatment is primarily supportive. However, some cases have shown favorable outcomes with various approaches. Activated charcoal may be considered for oral ALP ingestion if a patient presents within an *hr* with no contraindications. Nonetheless, activated charcoal and potassium permanganate may have limited benefits due to the lack of molecular interaction in metal phosphide poisoning. Emergency physicians should be vigilant for ALP poisoning in patients with intentional overdose, rapid deterioration, multiorgan failure, and shock. Physicians should be prepared for rapid patient decompensation and be ready to provide aggressive resuscitation and a higher level of care.

The present study investigated the medical documents of 76 patients with ALP poisoning from 2010 to 2018 admitted to Tohid Hospital in Sanandaj. Descriptive analysis indicated that 56.6% of the studied subjects were men, and 43.4% were women. Regarding age, patients were mainly in the 20-30 age group (43.4%), and the lowest frequency was related to the over 60 age group (3.95%). Regarding the education level, the highest frequency was related to high school diploma (34.2%), and the lowest was associated with postgraduate education (2.6%). Regarding the occupation, the highest frequency was related to self-employment (36.8%), and the lowest was related to employee jobs (1.3%). Regarding the marital status, 59.2% of the patients were single, and 40.8% were married. Regarding the average age, the minimum age was 11 years, and the maximum age was 70 years with an average age of 21.59 years, the average dosing (*i.e.*, number of pills consumed) was 1.3, and the duration between the administration and the start of treatment was 2.67 *hr* (Table 1).

Table 1. Frequency distribution of demographic variables in Aluminum phosphide poisoning

Variable		Frequency	Percentage
Gender	Men	43	56.6
	Women	33	43.4
Age group (years)	<20	13	17.1
	20-30	33	43.4
	30-40	16	21.05
	40-50	6	7.9
	50-60	5	6.6
	>60	3	3.95
Education	Primary school	11	14.5
	Middle school	24	31.6
	High school diploma	26	34.2
	Associate degree	2	2.6
	Bachelor's degree	4	5.3
	Uneducated	9	8.11

Contd. table 1.

Job	Self-employed	28	36.8
	Governmental employee	1	1.3
	Unemployed/housewife	20	26.3
	Student	16	21.1
	Others	11	14.5
Marital status	Single	45	59.2
	Married	31	40.8

In terms of methods of administration, 93.4% of the patients were poisoned through oral intake, and 6.6% were poisoned through inhalation. The pills taken at the time of consumption were most frequently taken in powder form (39.5% of cases) and were least frequently inhalated through the phosphine gas (6.6% of the cases). The cause of poisoning was mainly related to suicide (90.8% of cases); also, in 9.2% of the cases, the poisonings were accidental. While 68.4% had no prior history, 31.6% had a history of psychiatric diseases. 22.4% of the cases had a history of drug/alcohol abuse, and 77.6% had none. 21.1% of the patients died, and 76.9% were discharged (Table 2).

The analytical assessment demonstrated a significant difference between the average dose and administration to treatment duration in discharged patients and those who died (Table 3). There was no significant relationship between gender, education level, occupation, marital status, method of administration, pill form and cause of poisoning, history of psychiatric diseases, and history of drug/alcohol use with the outcome (Table 4).

Discussion

Due to the high incidence of poisoning with rice tablets in iran, this study was conducted with the aim of epidemiological investigation of deaths caused by

Table 2. Frequency distribution of Method of exposure, The form of pill at the time of administration, The cause of poisoning, History of psychiatric disease, History of drug/alcohol abuse, Outcomes of Aluminum phosphide poisoning

Variable		Frequency	Percentage
Method of exposure	Oral	71	93.4
	Aspiration	5	6.6
The form of consumption	Intact pill	21	27.6
	Shattered/powdered	30	39.5
	Solution	20	26.3
	Gas	5	6.6
Cause of poisoning	Suicidal	69	90.8
	Accidental	7	9.2
History of psychiatric disease	Yes	24	31.6
	No	52	68.4
History of drug/alcohol abuse	Yes	17	22.4
	No	59	77.6
Outcomes	Death	16	21.1
	Discharge	60	76.9

Table 3. The relationship between the average Age, Dosage, and Administration to treatment time interval with the outcome of Aluminum phosphide poisoning

Variable	Outcome	Frequency	Mean	Standard deviation	t-statistic	p-value
Age (year)	Discharged	60	28.53	12.38	-1.3	0.196
	Died	16	33.19	13.7		
Dosage	Discharged	51	1.14	0.69	-3.12	0.003
	Died	14	1.89	1.11		
Administration of treatment time interval	Discharged	60	1.74	1.43	-3.02	0.002
	Died	16	6.18	2.81		

Table 4. The relationship between demographic and background variables with the outcome of Aluminum phosphide poisoning

		Outcome				
		Discharge frequency (%)	Death frequency (%)	Sum	t-statistic	p-value
Gender	Man	35(58.3%)	8(50%)	43(56.6%)	0.357	0.55
	Woman	25(41.7%)	8(50%)	33(43.4%)		
Education	No education	7(11.7%)	2(12.5%)	9(56.6%)	3.88	0.566
	Primary school	7(11.7%)	4(25%)	11(43.4%)		
	Middle school	18(30%)	6(37.5%)	24(50%)		
	High school diploma	22(36.7%)	4(25%)	26(56.6%)		
	Associate degree	2(33%)	0(0%)	2(43.4%)		
	Bachelor's degree	4(6.7%)	0(0%)	4(56.6%)		
Job	Self-employed	23(38.3%)	5(31.3%)	28(56.6%)	3.53	0.472
	Governmental employee	1(1.7%)	0(0%)	1(43.4%)		
	Unemployed/housewife	13(21.7%)	7(43.8%)	20(50%)		
	Student	14(23.3%)	2(12.5%)	16(56.6%)		
	Others	9(15%)	2(12.5%)	11(43.4%)		
Marital status	Single	35(58.3%)	10(62.5%)	45(56.6%)	0.091	0.763
	Married	25(41.7%)	6(37.5%)	31(43.4%)		
Method of exposure	Oral	56(93.3%)	15(93.8%)	71(93.4%)	0.004	0.952
	Aspiration	4(6.7%)	1(6.3%)	5(6.6%)		
The form of the pill	Intact pill	7(11.7%)	14(87.5%)	21(27.6%)	37.29	0.0001
	Shattered/powdered	29(48.3%)	1(6.3%)	30(39.5%)		
	Solution	20(33.3%)	0(0%)	20(26.3%)		
	Gas	4(6.7%)	1(6.3%)	5(6.6%)		
Cause of poisoning	Suicidal	55(91.7%)	14(87.5%)	69(90.8%)	0.262	0.609
	Accidental	5(8.3%)	2(12.5%)	7(9.2%)		
History of psychiatric disease	Yes	22(36.7%)	2(12.5%)	24(31.6%)	3.14	0.065
	No	38(63.3%)	14(87.5%)	42(68.4%)		
History of drug/ alcohol abuse	Yes	16(26.7%)	1(6.3%)	17(31.6%)	3.032	0.082
	No	44(73.3%)	15(93.8%)	59(68.4%)		

ALP poisoning at Tohid Hospital in Sanandaj from 2010 to 2018. The documents of 76 patients poisoned with ALP were studied. 21.1% of the patients died due to pill poisoning, and 76.9% were discharged. The method of ALP administration was 93.4% through the oral route and 6.6% through inhalation, and the form of administration was mostly in powder form (39.5%) and 6.6% in gas form with the lowest frequency. The highest death rate due to poisoning was related to the oral administration and intact tablet form. The results of this study showed that in terms of the number of pills administered, 60% took one pill with the highest frequency, and 1.6% took four pills with the lowest frequency. The highest death rate was observed in patients who had taken one pill and had the shortest time between substance administration and the start of treatment.

Due to the high toxicity of this substance, even consuming a quarter of a pill can be fatal. The results obtained from Tavakolifard's study also indicated the same results, but no significant relationship was found between the number of pills taken and the patient's outcome. An increased number of pills administered was associated with a worse clinical picture (severe metabolic acidosis) upon hospital admission; however, no significant difference was observed in the patients who had taken more pills compared to those who had taken less. In a retrospective study that aimed to determine the clinical characteristics and treatment outcome of ALP poisoning at Felege Hiwot, a Referral Hospital in northeastern Ethiopia, the mean number of Alp pills consumed was 1.2 (3.6 *g*), and the mean time of arrival to hospital after AlP administration was 4.8 *hr*. In this study, more than half of the patients (51.2%) had taken only one whole tablet, while 76% of the cases had taken from half a pill to two. The average number of pills consumed was 1.2 (3.6 *g*). This study showed a significant difference in the consumption of Alp tablets between the recovered group and the expired group, which is consistent with other studies (25-27). In Khodabandeh *et al*'s study, the method of taking pills in all cases was oral, and in 61.3% of the cases (68 patients) was in the undamaged form (without breaking or dissolving). The consumption rate of 1.4 tablets was reported in 39 cases (35.1%), and the consumption of more than one tablet was reported in 32 cases (28.8%). In 36% of the cases, the elapsed time after administration was within one *hr* before going to the emergency room (28).

In the present study, an examination of the cases showed that the most common cause of poisoning was suicide (90.8%), and 9.2% were accidental. The study showed that patients who had taken pills to commit suicide had the highest death rate. Due to the high toxicity and lethality of rice tablets and the ease of access to this poison, in recent years, relatively high numbers of poisonings caused by this agent have become common in Iran, more prevalent in provinces such as Tehran, Gilan, Mazandaran, Golestan, and Lorestan. According to the results obtained from Tavakoli Far's study, the rate of poisoning with this substance is relatively high in Karaj city. Most deaths due to poisoning were reported in men, and the main intention of substance administration was a suicide attempt. It is worth noting that hospital reports show high rates of suicidal poisoning with this substance in Karaj city, even though hospital records are primarily incomplete and do not include many cases (29).

In the present study, 56.6% of the patients were men, and 43.4% were women, and the death rate due to pill poisoning was the same in both sexes. In the study by Khodabandeh *et al*, 111 cases of death due to rice pill poisoning included 60 (54.1%) men and 51 (45.9%) women (28). In the study of Shokrzadeh *et al*, out of 420 cases of death caused by poisoning, 105 cases (25%) were due to ALP, which is the second cause of death caused by poisoning after opioids. Of all 105 patients, 63.8% (67 people) were men, and 42.9% (45 people) belonged to the age group of 20-29. Also, 99% (104 people) of deaths caused by ALP were due to suicide. In this study, the death caused by ALP poisoning was more frequent in men, and similar regional and international studies also found similar results. A total of 125 patients were studied in a retrospective study aimed at determining the clinical characteristics and outcome of ALP poisoning treatment at Felege Hiwot Referral Hospital in northeastern Ethiopia. 57.6% were women, and 42.4% were men (25). In some studies, including in Tehran and Albania, women have been the dominant population in the study sample. According to researchers, despite women committing suicide about 3-5 times more than men, men have more fatal suicide attempts

than women. Considering that ALP is mostly used to commit suicide, on the other hand, with its high lethality, it seems that men are more likely to commit suicide due to the easy availability of this substance and their more serious suicide attempts. Therefore, it is necessary to take more preventive measures in this group (30). In the current study, patients were mostly in the 20-30 age group (43.4%), and the lowest frequency was related to the over 60 age group (3.95%). The average age of the people who died was lower than those who were discharged. The Tavakoli Far *et al*'s study showed that most poisoned patients were under 21 years of age (30). In the study of Khodabandeh *et al*, 111 cases died due to rice pill poisoning, with an average age of 29±8.6 years (28). In a study that aimed to evaluate the prognostic factors and outcome of acute ALP poisoning at the Main University Hospital of Alexandria for six months (from November 1, 2017, to the end of April 2018), 30 patients were admitted during the study period. The frequency of women was more than men in all age groups with a gender ratio of 2.75:1. The average age of the patients was 22.77±12.79 years. 93.3% of the cases were exposed to domestic poisoning, of which suicide poisoning comprises (86.7%) of the case. 43.3% of the patients died (n=13) (31). In the Mahmudi *et al*'s study, the average age of poisoning was 32.56 years, and the highest rate of poisoning was observed in the age group of 20-29 years, which indicates a high poisoning rate in young people. The relatively high prevalence of poisoning in youth can be due to the young age pyramid of the population as well as high emotional sensitivity and personal and social problems common in young people (32). In some studies, including Jordan and India, the common age of poisoning with ALP was 15-19 and 16-20, respectively, highlighting the need for more preventive measures in the younger generation (33). On the other hand, the fact that the demographic pyramid is young should also be addressed. In general, the youth period is one of the most important periods of suicide tendency in certain socio-psychological conditions. Suicide in young people is mainly due to the issues they face dealing with their social life, relationship with parents, physical transformation associated with puberty, feelings of loneliness, and issues related to identity expression and personality crisis (33). In the present study, most subjects had a high school diploma education. Regarding occupation, the highest frequency was related to self-employment with 36.8%, and the lowest was associated with governmental employment (1.3%). The results showed that the highest death rate due to ALP poisoning was in people with primary education and the unemployed. In the study of Shokrzadeh *et al,* the majority of people had secondary education. A higher number of people with this level of education in the society and issues that this spectrum of society faces may play a considerable role in this process. Also, the fact that in the current study, the majority of poisoning cases occurred with the intention of suicide is consistent with Kaplan's theory that the higher the level of education in society, the higher the probability of suicide (30). In the population studied by Mahmudi *et al*, the highest prevalence, in terms of education level, was high school diploma (43.5%), followed by middle school education (28.2%). Overall, the results of this study demonstrated that more than 97% of the patients who died due to poisoning had at least a high school diploma or lower education (32).

In this study, 59.2% of patients were single, 40.8% were married, and the highest death rate was in the single patients. In the study of Shokrzadeh *et al*, 46.7% of cases (46 people) were married, and 40% of them (42 people) had education up to secondary level. According to the study by Mahmudi *et al*, out of 124 patients studied, 51.6% were single, 44.4% were married, and 4% were dead or divorced, which indicates that the rate of suicide is high in single people, and married reduces the risk of poisoning. The lower level of poisoning among married people can be attributed to their responsibility toward family and the self-care associated with this responsibility (32).

Conclusion

ALP is one of the toxic substances with a significantly high mortality and morbidity rate. Poisoning with this substance is mainly observed in suicide, unmarried, low education, and the 20-30 age group. Poisoning with rice tablets is a common cause of poisoning in Iran, associated with a high mortality rate. This becomes a severe health issue, especially in societies where rice tablets are easily accessible. Therefore, this

substance is recommended to be taken off the market and replaced with other safer pesticides. Considering the high mortality caused by ALP poisoning and the lack of a specific antidote, the best approach to reduce the morbidity and mortality caused by this substance is to prevent such an incident from happening at the first place. In the case of inhalation poisoning, appropriate clothing, gloves, proper ventilation, and respiratory protective devices play an essential role. Therefore, it is necessary to consider preventive measures, including increasing public awareness, reducing access through restrictions and regulations on supply and sale, and encouraging alternative safer pesticides for household and agricultural purposes.

One of the strong points of this study is collecting a wide range of demographic variables, methods of poison consumption, cause of exposure, history of psychiatric diseases or addiction. Considering the importance of this issue on the society, these data can be used to design more studies in the future. One of the limitations of the present study would be the lack of information in some incomplete archived files. Emergency physicians should be vigilant for ALP poisoning in patients with intentional overdose, rapid deterioration, multiorgan failure, and shock. Physicians should be prepared for rapid patient decompensation and be ready to provide aggressive resuscitation and a higher level of care.

Ethical approval and consent to participate

The Ethics Committee of Kurdistan University of Medical Sciences (IR.MUK.REC.1400.097) reviewed and approved this study. The relevant guidelines and regulations performed all the methods. In this study, ethical considerations were considered as follows:

The information regarding the identity of the deceased cases, including their first and last name, was not collected. In the case of non-deceased, the required information was extracted from their documents after obtaining the informed consent. The confidentiality of the information of all the patients was maintained. Participation in the research caused no financial burden for the participants. This study had no contradictions with the society's religious, moral and cultural standards.

Consent for publication

Not applicable.

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Conflict of Interest

The authors declare that they have no competing interests.

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