Predictive value of Arterial Blood Gases in Patients with Acute Aluminum Phosphide Poisoning Admitted to Poison Control Centre –Ain Shams University Hospitals

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Abstract	**Background**: Aluminum phosphide (ALP) poisoning causes severe fatal complications as it affects vital organ functions, which could be assessed by arterial blood gases analysis. **Aim of work:** is to investigate the role of arterial blood gases level in prediction of the severity of acute aluminum phosphide poisoning. **Subjects and Methods:** The study data were collected from hospital admission records of 30 adult acutely ALP intoxicated cases at PCC-ASU, grouped into minor, moderate, severe and fatal groups according to PSS. **Results:** A Highly significant difference was found between the groups regarding blood pH, serum bicarbonate and lactate levels, mean arterial blood pressure, body temperature. A significant difference was revealed regarding cold extremities, pallor, peripheral cyanosis, irritability, Post hoc test showed significant difference between minor and severe, minor and fatal, moderate and fatal groups regarding blood pH, HCO$_3$ level and serum lactate, severe and fatal groups regarding serum lactate. **Conclusion:** Arterial blood gases parameters including serum bicarbonate, lactate and blood pH has predictive value for severity in acute ALP cases. **Recommendations:** Further studies are needed on larger samples studying other predictive factors.
Key words	

Introduction

Aluminium phosphide (ALP) is a fumigant used in agriculture for pest control. Aluminum phosphide, a common and inexpensive insecticide, is highly poisonous and a significant cause of severe poisoning in developing countries (Ali et al., 2023). When exposed to moisture, ALP releases a highly toxic gas called phosphine, which interferes with mitochondrial protein synthesis and enzyme function in different organs (Nakhaee et al., 2017).

Arterial blood gas analysis is a commonly used diagnostic tool to evaluate the partial pressures of gases in blood and acid-base status. Understanding and using blood gas analysis enables providers to interpret respiratory, circulatory, and metabolic disorders (Gattinoni et al., 2018). Acid-base balance can be affected by the respiratory system abnormalities causing respiratory acidosis and alkalosis with generalized hypoxia which leads to anaerobic metabolism, causing metabolic acidosis that results in acidemia. Metabolic system abnormalities also affect acid balance, as acute metabolic acidosis and alkalosis (Yee et al., 2022).

Aim of the Work

The aim of this study was to investigate the role of arterial blood gases level in prediction of severity in acute aluminum phosphide poisoning.

Subjects and Methods

The current study is a retrospective study done at the Poison Control Centre of Ain Shams University Hospitals; the data were collected from hospital admission sheets of thirty aluminum phosphide acutely poisoned adult patients (> 18 years old)

Inclusion criteria:
The current study included all adults of both sex who presented to PCC-ASUH with history of acute ALP intoxication.

Exclusion criteria:
Patients with co-ingested drugs or toxins which affect cardiovascular function, patients with history of previous cardiac, respiratory, hepatic, renal, neurological diseases, endocrinal, pregnancy and associated trauma.

Subjects groups:
Patient group and criteria of severity: ALP acutely intoxicated patients were classified according to Poison Severity Score into: (Persson et al., 1998).
- Group I (minor) transient and spontaneously resolving symptoms.
- Group II (moderate) Pronounced or prolonged symptoms.
- Group III (severe) Severe or life-threatening symptoms.
- Group IV (fatal)
- For each patient the following data was collected
Socio-demographic data, intoxication data, clinical examination data and investigations.

Ethical Considerations:
An official permission was taken from the Local Research Ethics Committee. Also, an informed valid consent was taken from patients or their legal guardians and all personal data were kept anonymous to ensure confidentiality of records.

Results

Table 1 showed non-significant differences between the groups regarding age, sex and residence distribution, it showed also non-significant difference between the groups regarding amount of poison and time delay. All patients ingested the poison orally by suicidal mode.

Table 2 showed high significant difference between the groups regarding mean arterial blood pressure and body temperature; mean arterial blood pressure was 80.45±11.21, 68.89±10.18, 63.33±3.33 and 39±22.82 mmHg in minor, moderate, severe and fatal cases respectively. Body temperature was 37.05±0.12, 37±0, 36.87±0.12 and 36±0.51° C in minor, moderate, severe and fatal cases respectively. Non-significant difference was found regarding pulse and respiratory rate.

Table 3 shows that there was significant difference between the groups regarding cold skin (76.9% of fatal cases), pallor (61.5% of fatal cases) and irritability (46.2% of fatal cases).

On the other hand, non-significant difference was found regarding other neurological manifestations, palpitation, peripheral cyanosis, tachypnea and bradypnea.

Table 4 showed highly significant difference between the groups regarding blood pH. The mean in minor group was 7.38±0.07, in moderate group was 7.36±0.03, and in severe group was 7.21±0.15, in fatal group was 7±0.08 (figure 1).

A highly significant difference was detected regarding serum HCO_3 level. The range in minor group was 12 – 28mEq/L, in moderate group was 12.6 – 22mEq/L, in severe group was 12 – 16.7mEq/L, and 7.6 – 18.8 mEq/l in fatal group (figure 2).

Serum lactate level also showed high significant difference; median was 12 mmol/L in fatal group, 9.3 mmol/L in severe group, 2 mmol/L in moderate cases and 1.5 mmol/L in minor cases, while there was no significant difference detected regarding PCO_2.

Post hoc test showed statistical significant difference regarding blood pH, HCO_3 level and serum lactate, between minor and severe, minor and fatal, moderate and fatal groups. While no significant difference was detected between minor and moderate, moderate and severe groups there was significant difference between severe and fatal groups regarding serum lactate level only.

Table 5 showed highly significant difference between the groups regarding duration of stay in ICU; the median was 0.5 day for fatal group, 7days for severe group, 3 days for moderate group and 2 days for minor group.

Post hoc test showed significant difference between all groups except between moderate and severe groups.

Socio-demographic and intoxication data:

Table (1): Distribution and comparative analysis of demographic and intoxication data among studied patients` groups

		Poison severity score				Test value	P-value	Sig.
		Minor	**Moderate**	**Severe**	**Fatal**			
		No.= 11	No.= 3	No.= 3	No.= 13			
Age (years)	Mean ± SD	22 ± 6.69	21 ± 3.61	30 ± 15.87	28.08 ± 8.98	1.523•	0.232	NS
	Range	18 – 40	18 – 25	18 – 48	18 – 43			
Sex	Female	5 (45.5%)	1 (33.3%)	2 (66.7%)	6 (46.2%)	0.704*	0.872	NS
	Male	6 (54.5%)	2 (66.7%)	1 (33.3%)	7 (53.8%)			
Residency	Cairo	2 (18.2%)	1 (33.3%)	1 (33.3%)	6 (46.2%)	23.678*	0.166	NS
	Qalioubia	0 (0%)	1 (33.3%)	0 (0%)	1 (7.7%)			
	Al-Faioum	6 (54.5%)	1 (33.3%)	1 (33.3%)	2 (15.4%)			
	Giza	1 (9.1%)	0 (0%)	0 (0%)	4 (30.8%)			
	Beni-suif	0 (0%)	0 (0%)	1 (33.3%)	0 (0%)			
	Sharquia	1 (9.1%)	0 (0%)	0 (0%)	0 (0%)			
	Daqahlia	1 (9.1%)	0 (0%)	0 (0%)	0 (0%)			
Amount (tablets)	Mean ± SD	0.86 ± 0.23	1.17 ± 0.76	0.83 ± 0.29	1 ± 0.55	0.961•	0.426	NS
	Range	0.5 – 1	0.5 – 2	1 – 1	0.25 – 2			
Delay (hours)	Median (IQR)	4 (2 - 6)	1.5 (1 - 5)	5 (4 - 6)	2 (1 - 4)	5.800≠	0.122	NS
	Range	1 – 6	1 – 5	4 – 6	1 – 6			
Mode	Suicidal	11 (100%)	3 (100%)	3 (100%)	13 (100%)	–	–	–
Route	Ingestion	11 (100%)	3 (100%)	3 (100%)	13 (100%)	–	–	–

P-value > 0.05: Non-significant, *: Chi-square test; •: One Way ANOVA test; ≠: Kruskal-Wallis test

Clinical examination data:

Table (2): One way ANOVA statistical test: Comparison of vital data among the studied patients` groups.

		Poison severity score				Test value	P-value	Sig.
		Minor	**Moderate**	**Severe**	**Fatal**			
		No.= 11	**No.= 3**	**No.= 3**	**No.= 13**			
Mean arterial BP	Mean±SD	80.45± 11.21	68.89±10.18	63.33±3.33	39±22.82	11.742•	0.000	HS
	Range	66.67–100	60–80	60–66.67	13.33–76.67			
Pulse (beats/min)	Mean±SD	100.45±15.69	90.33±26.27	115±10.44	102±15.79	1.159•	0.344	NS
	Range	68–120	70–120	103–122	62–124			
Body temperature	Mean±SD	37.05±0.12	37±0	36.87±0.12	36±0.51	10.875•	0.000	HS
	Range	36.8–37.2	37–37	37–37	35–37			
Respiratory rate	Mean±SD	22.18±5.02	24.33±6.35	20.33±10.79	28±8.96	1.312•	0.292	NS
	Range	16–30	17–28	8–28	8–44			
Post Hoc analysis by LSD and multi-comparison between groups								
Parameters	**Minor Vs Moderate**	**Minor Vs Severe**	**Minor Vs Fatal**	**Moderate Vs Severe**	**Moderate Vs Fatal**	**Severe Vs Fatal**		
Mean arterial BP	0.313	0.140	**0.000**	0.696	**0.012**	0.38		
Temperature	0.814	0.421	**0.000**	0.647	**0.004**	**0.015**		
Temperature groups	1.000	1.000	**0.033**	1.000	0.330	0.330		

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant, *: Chi-square test; •: One Way ANOVA test

Table (3): Chi square test: Comparison between studied groups of patients as regard clinical manifestations.

		Poison severity score				Test value	P-value	Sig.
		Minor	**Moderate**	**Severe**	**Fatal**			
		No.= 11	**No.= 3**	**No.= 3**	**No.= 13**			
	Cold	2 (18.2%)	1 (33.3%)	2 (66.7%)	10 (76.9%)	8.890*	0.031	S
	Pallor	1 (9.1%)	2 (66.7%)	3 (100%)	8 (61.5%)	11.306*	0.01	S
	Cyanosed	0 (0%)	0 (0%)	0 (0%)	1 (7.7%)	1.353*	0.717	NS
	Drowsy	1 (9.1%)	0 (0%)	0 (0%)	4 (30.8%)	3.516*	0.319	NS
	Agitation	0 (0%)	0 (0%)	0 (0%)	2 (15.4%)	2.802*	0.423	NS
	Irritability	0 (0%)	0 (0%)	2 (66.7%)	6 (46.2%)	10.070*	0.018	S
	DCL	0 (0%)	0 (0%)	0 (0%)	1 (7.7%)	1.353*	0.717	NS
	Palpitation	5 (45.5%)	1 (33.3%)	3 (100%)	8 (61.5%)	3.648*	0.302	NS
Chest Examination	Bradypnea	0 (0%)	0 (0%)	0 (0%)	1 (7.7%)	1.353*	0.717	NS
	Tachypnea	6 (54.5%)	2 (66.7%)	3 (100%)	11 (84.6%)	3.991*	0.262	NS
Post Hoc analysis by LSD and multi-comparison between groups								
Parameters		**Minor Vs Moderate**	**Minor Vs Severe**	**Minor Vs Fatal**	**Moderate Vs Severe**	**Moderate Vs Fatal**	**Severe Vs Fatal**	
	Cold	0.571	0.099	0.004	0.414	0.142	0.711	
	Pallor	0.031	0.002	0.008	0.273	0.869	0.195	
Neurological assessment	Irritability	1.000	0.003	0.009	0.083	0.136	0.521	

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant, *: Chi-square test; •: One Way ANOVA test, DLC: disturbed conscious level

Table (4): Comparison between patient groups regarding arterial blood gases (ABG) data.

		Poison severity score				Test value	P-value	Sig.
		Minor	Moderate	Severe	Fatal			
		No.= 11	No.= 3	No.= 3	No.= 13			
pH	Mean ± SD	7.38 ± 0.07	7.36 ± 0.03	7.21 ± 0.15	7 ± 0.08	7.530•	0.001	HS
	Range	7.21 – 7.46	7.34 – 7.4	7 – 7.3	7.09 – 7.39			
PCO2	Mean ± SD	32.82 ± 5.98	33 ± 9.17	38.67 ± 12.66	30 ± 6.72	1.134•	0.354	NS
	Range	22 – 41	25 – 43	29 – 53	21 – 48			
HCO3	Mean ± SD	20.06 ± 4.41	17.87 ± 4.8	14.37 ± 2.35	13 ± 3.07	6.848•	0.001	HS
	Range	12 – 28	12.6 – 22	12 – 16.7	7.6 – 18.8			
Lactate	Median (IQR)	1.5 (1 - 8)	2 (1.2 - 2.5)	9.3 (2.6 - 11)	12 (11 - 13)	18.568≠	0.000	HS
	Range	1 – 11	1 – 8	3 – 11	3 – 15			
Post Hoc analysis by LSD and multi-comparison between groups								
Parameters	Minor Vs Moderate	Minor Vs Severe	Minor Vs Fatal	Moderate Vs Severe	Moderate Vs Fatal		Severe Vs Fatal	
pH	0.742	0.004	0.000	0.232	0.029		0.572	
HCO3	0.376	0.028	0.000	0.263	0.070		0.672	
Lactate	1.000	0.042	0.000	0.127	0.026		0.090	

P-value > 0.05: Non-significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant, *: Chi-square test; •: One Way ANOVA test; ≠: Kruskal-Wallis test

Table (5): Chi square test: Comparison between studied groups of patients as regard ICU admission:

		Poison severity score				Test value	P-value	Sig.
		Minor	Moderate	Severe	Fatal			
		No.= 11	No.= 3	No.= 3	No.= 13			
ICU Stay (Days)	Median (IQR)	2 (1 - 2)	3 (2 - 3)	7 (2 - 9)	0.5 (0.5 - 0.5)	17.751≠	0.000	HS
	Range	0.5 – 4	2 – 3	2 – 9	0.5 – 2			
Post Hoc analysis by LSD and multi-comparison between groups								
Parameters	Minor Vs Moderate	Minor Vs Severe	Minor Vs Fatal	Moderate Vs Severe	Moderate Vs Fatal	Severe Vs Fatal
ICU Stay (Days)	0.079	0.037	0.002	0.369	0.004	0.004

P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant, *: Chi-square test; ≠: Kruskal-Wallis test
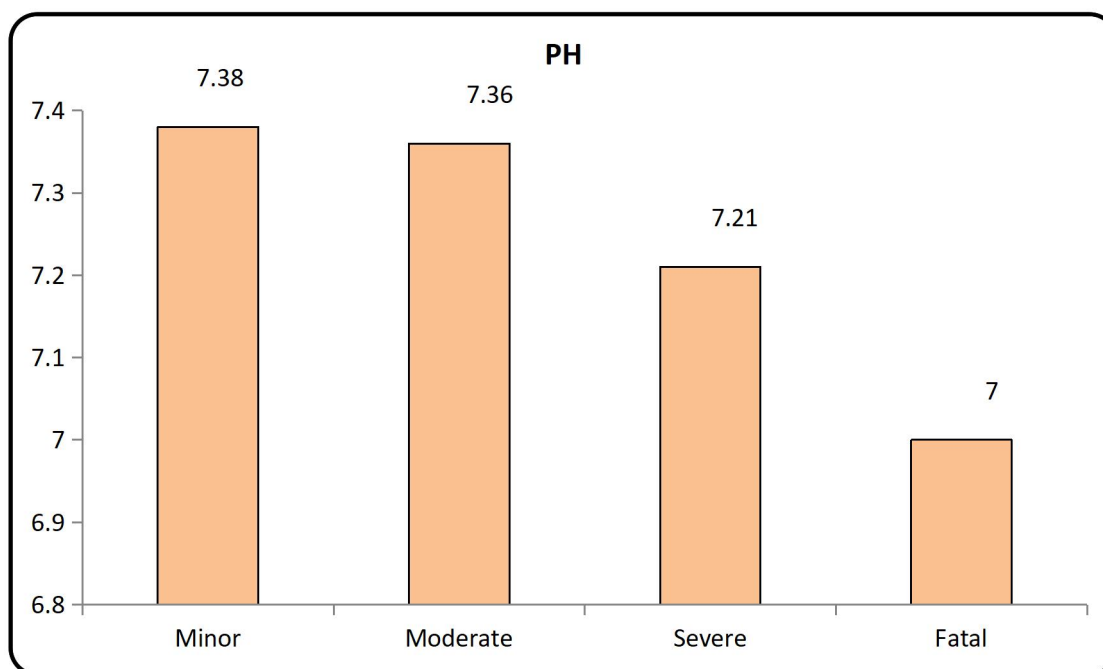

Figure (1): showed highly significant difference between the groups regarding blood pH
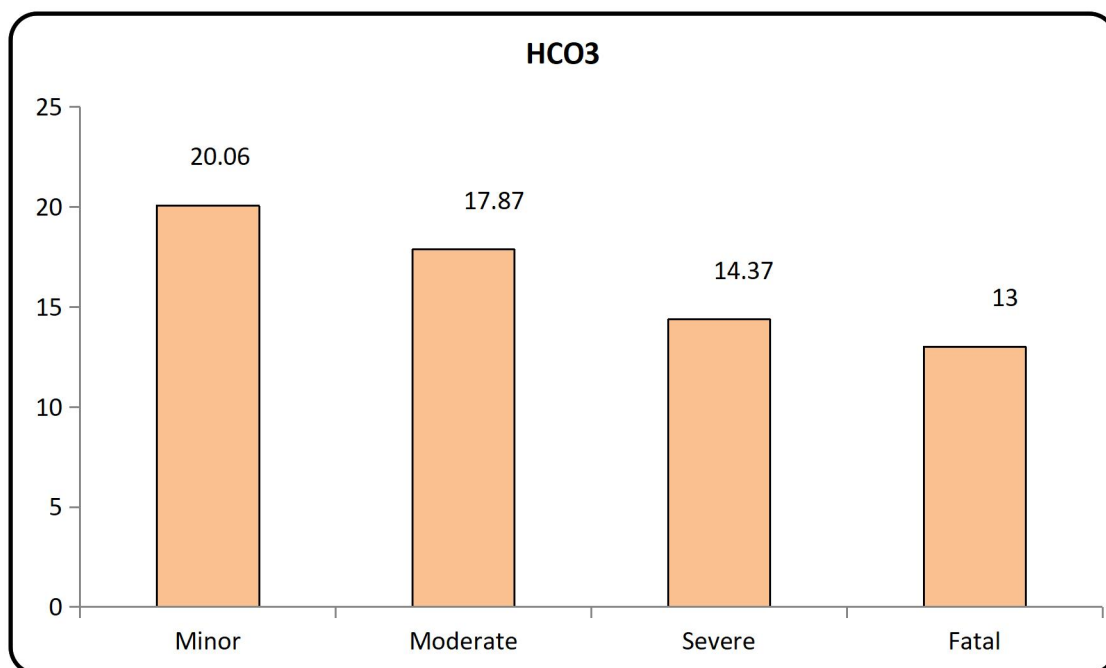
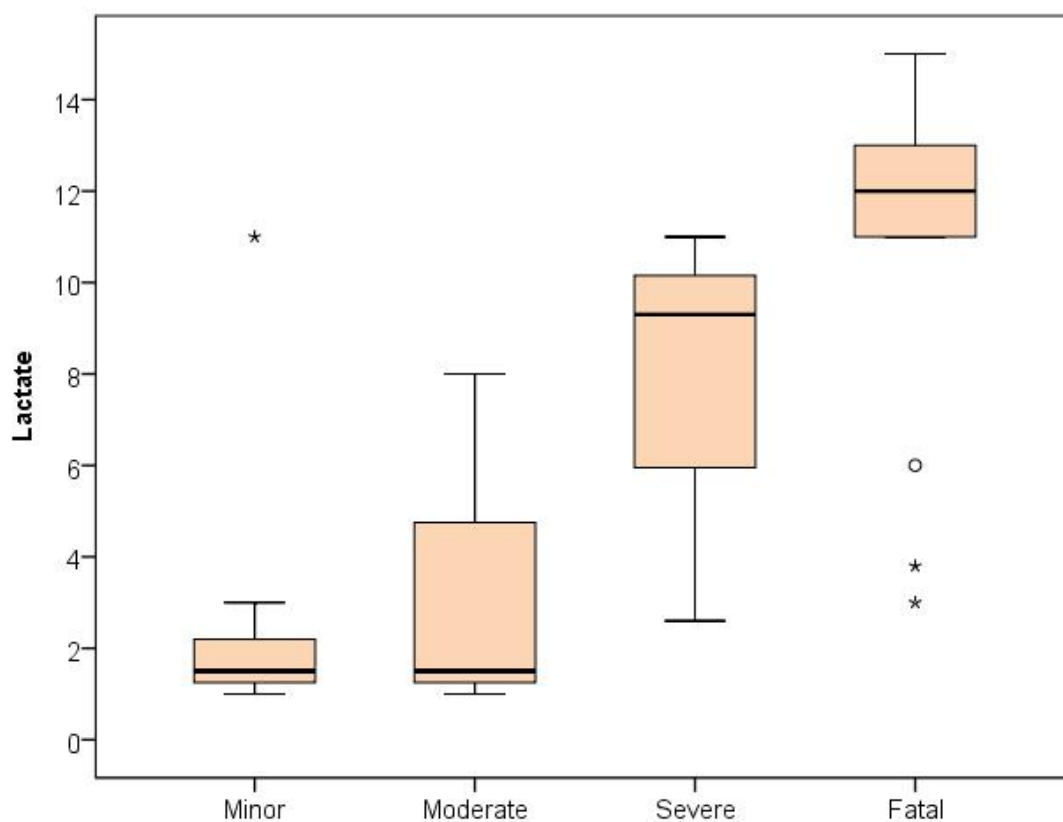**Figure (2): A highly significant difference was detected regarding serum HCO3 level**

Figure (3): There was significant difference between severe and fatal groups regarding serum lactate level only

Discussion

Aluminum phosphide (ALP) poisoning is a major clinical challenge facing toxicologists because of its high incidence of use, complications and fatalities. This study aims to predict value of arterial blood gases in detection of patient's severity; it was conducted on thirty acute ALP poisoned adult patients.

The study revealed no significant difference between groups regarding amount of tablets ingested, time delay and residency so, manifestations were not multifactorial, in addition, no significant difference was found regarding pulse and respiratory rates. These results may be due to the rapid development of manifestations regardless the amount ingested as was

explained by (Navabi et al., 2018) who found that acute AlP poisoning causes rapid development of clinical manifestations after liberation of phosphine gas.

Furthermore, there was a highly significant difference between the groups regarding mean arterial blood pressure and body temperature ,also a significant difference between groups was found regarding pallor, peripheral cyanosis, cold extremities, irritability .This is mainly due to affection of organs with high oxygen requirements like brain and heart which are more susceptible to damage resulting from cytochrome oxidase inhibition and hypoxia caused by phosphine gas (Masoud and Barghash, 2013).

Arterial blood gases measurements showed high significant difference between the groups regarding pH; the mean values revealed decreasing pattern as passing from moderate, severe to fatal groups.

Serum bicarbonate level revealed high significant difference between the groups, showing mild decrease in moderate cases, low value in severe cases and very low in fatal cases.

Serum lactate level showed also high significant difference between the groups, being normal in moderate cases, high in severe cases and very high in fatal cases.

Ghoneem et al., (2020) found that arterial blood gases showed significantly lower pH and serum bicarbonate in fatal cases than moderate and severe cases; this was in accordance with (Farzaneh et al., 2018). Metabolic acidosis could be attributed to lactic acid accumulation due to oxidative phosphorylation inhibition and poor tissue perfusion (Gurjar et al., 2011).

Rehab and Samia, (2013) concluded that power of hydrogen (pH) <7.27 and bicarbonate (HCO3) <13.3 were the best cut-off points for predicting mortality in poisoned patients. Shadnia et al., (2010) discovered a statistically significant difference in blood pH and HCO3 between people who died from acute AlP poisoning and those who survived.

This study revealed that fatal cases stayed for half a day in the ICU. Aluminum phosphide is one of the most dangerous poisons as it causes high rapid mortality rates among poisoned cases. This is due to the rapid release of phosphine gas and rapid distribution to all body cells causing organ failure (Bansal et al., 2017).

Conclusion

Arterial blood gases parameters namely serum bicarbonate, lactate and blood pH have predictive value in ALP acutely poisoned cases.

Recommendations

Serum bicarbonate, serum lactate and blood pH should be used in all acute ALP cases even with minor manifestations, also, cases with normal values of the recommended parameters could be placed in inpatient unit with ABG monitoring to decrease hospital stay cost. More studies are needed on larger number of cases studying other body systems.

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القيمة التنبؤية لغازات الدم في مرضى التسمم الحاد بعوسفيد الالومنيوم الذين ادخلوا لمركز علاج التسمم بمستشفيات جامعة عين شمس

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الملخص العربي

الخلفية العلمية: يسبب التسمم بفوسفيد الالومنيوم مضاعفات خطيرة ومميتة وذلك لانها تؤثر على وظائف اعضاء حيوية والتي من الممكن معرفتها يتحليل غازات الدم الشريانية .

الهدف من الدراسة: هو استقصاء دورغازات الدم الشريانية في التنبوء بشدة التسمم الحاد بفوسفيد الالومنيوم .

طريقة البحث: معلومات هذه الدراسة تم جمعها من سجلات الدخول بالمستشفى لثلاثين بالغ مصاب بالتسمم الحاد بفوسفيد الالومنيوم بمركز علاج التسمم مستشفيات جامعة عين شمس .قسمت الحالات الى بسيطة ,متوسطة ,شديدة ومميتة على حسب بي اس اس (مقياس شدة التسمم) .

نتائج البحث: وجد اختلاف كبير بين المجموعات في حموضة الدم , مستوى البيكربونات , اللكتات بالدم و ضغط الدم الشرياني المتوسط و درجة حرارة الجسم.كما وجد اختلاف بينهم في برودة الاطراف ,الشحوب ,الزرقة الطرفية و الهيجان.كما اظهر اختبار بوست هوك اختلافا بين المجموعة البسيطة و الشديدة والمجموعة البسيطة و المميتة و المجموعة المتوسطة و المميتة وذلك بحموضة الدم و مستوى البيكربونات و اللكتات بالدم وبين المجموعة الشديدة والمميتة بمستوى اللكتات بالدم.

الخلاصة: تفيد هذه الدراسة ان لغازات الدم الشريانية و هي مستوى البيكربونات واللكتات وحموضة الدم قيمة تنبؤية في حالات التسمم الحادة بفوسفيد الالومنيوم و توصي هذه الدراسة بعمل دراسات اخرى على عدد اكبر من الحالات لدراسة عوامل خطورة اخرى.

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1.   قسم الطب الشرعي والسموم، كلية الطب، جامعة عين شمس، القاهرة، مصر