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Case report

Aluminum phosphide poisoning: Successful recovery of multiorgan failure in a pediatric patient

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ABSTRACT

Aluminum phosphide (AlP) is an insecticide and rodenticide that produces phosphine gas when exposed to moisture. Exposure to AIP has been described as through inhalation and ingestion routes and is typically either accidental or a suicidal attempt. The result is potential multiorgan toxicity involving the heart, kidneys, lungs, and liver, with an overall mortality related to exposure reported from 30% to 77%. The initial symptoms are nonspecific and can include epigastric pain, vomiting, diarrhea, dizziness, and dyspnea. Patients rapidly experience multisystem organ failure, cardiovascular collapse, and, finally, death. We report the case of a 3 year old girl with AlP poisoning who developed cardiogenic shock, ventricular arrhythmias, respiratory failure, liver injury, and significant acute kidney injury (AKI). She was successfully supported with veno-arterial extracorporeal membrane oxygenation (ECMO) for 16 days, treated with lidocaine and magnesium sulfate for ventricular arrhythmias, and received continuous renal replacement therapy (CRRT) and hemodialysis for 24 days for metabolic acidosis secondary to AKI. Despite her severe clinical presentation, she had complete normalization of her end-organ dysfunction with no neurological sequelae. This case demonstrates the high index of suspicion required for AlP poisoning given the potential for rapid progression and severe multiorgan toxicity. The authors recommend prompt referral to a tertiary care center with ECMO and CRRT capability in cases of suspected or documented AlP poisoning.

1. Introduction

Aluminum phosphide (AlP) is an insecticide and rodenticide commonly used for agricultural purposes [1,2]. Inhalation or ingestion of aluminum phosphide leads to the production of phosphine gas when exposed to moisture [1,2]. The result is potential multiorgan toxicity involving the heart, kidneys, lungs, and liver [1–3] with an overall mortality related to exposure reported from 30% to 77% [3–6]. Proposed mechanisms of toxicity include inhibition of mitochondrial oxidation with severely decreased mitochondrial membrane potential and inhibition of cytochrome C oxidase, which leads to increased production of reactive oxygen species [7,8]. Patients rapidly experience multisystem organ failure, cardiovascular collapse, and, finally, death.

2. Case report

A previously healthy 3-year-old girl initially presented to an outside emergency room (ER) with a 1 day history of multiple episodes of nonbilious/nonbloody emesis; she was treated for suspected acute gastroenteritis and discharged home after receiving IV fluids and tolerating oral liquids. A few hours later, her 17-year-old brother presented to the same ER with symptoms of abdominal pain, nausea, and vomiting. Further history revealed that their father had used aluminum phosphide pellets around the

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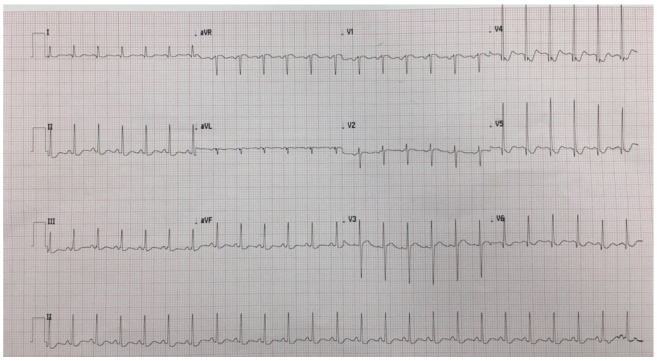

Fig. 1. Initial ECG demonstrated nonspecific ST changes with minimal depression, which was more evident in the inferior and lateral leads.

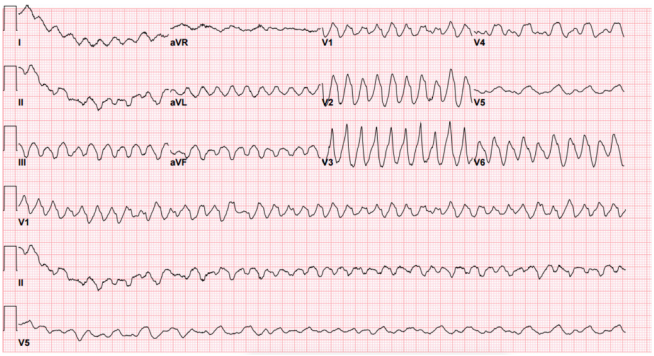

Fig. 2. Torsades de pointes on ECG.

apartment and in the children's beds to eradicate *Cimex lectularius* (bed bugs). The brother was admitted to receive IV fluids, observed, and discharged with no clinical sequelae of toxicity. The family was from Bangladesh where the pellets can be legally obtained; the pellets were purchased from the Bronx, through their local community. The pellets contained 55% aluminum phosphide. The 3-year-old girl was called back to the ER 11 hours after initial presentation, and on arrival, she was found to be tachycardic (152 beats/min) and hypotensive (66/46 mmHg) and appeared weak and tired. A venous blood gas analysis was performed, and the results demonstrated an anion gap acidosis. Additionally, electrocardiogram (ECG) showed nonspecific ST changes with minimal depression, which was more evident in the inferior and lateral leads (Fig. 1). She was given boluses of normal saline but did not show improvement in blood pressure or heart rate, and she was subsequently started on a dopamine infusion. Clinical examination and rapid deterioration was concerning for cardiogenic shock; therefore, she was transferred to our institution for possible extracorporeal membrane oxygenation (ECMO) support.

Upon arrival, she was found to be tachypneic, tachycardic, and hypotensive with a gallop rhythm on examination and evidence of poor clinical cardiac output. Baseline laboratory values are listed in Table 1. Echocardiogram demonstrated severely depressed left ventricular systolic function with an ejection fraction (EF) of 26% and moderately depressed right ventricular systolic function.

Table 1
Baseline laboratory values.

		Reference
Sodium, mEq/L	139	135–145
Potassium, mEq/L	4.4	3.5–5.0
Chloride, mEq/L	105	98–108
Carbon dioxide, mEq/L	10	22–29
Blood urea nitrogen, mg/dL	25	4–21
Creatinine, mg/dL	0.4	0.40–0.70
Calcium, mg/dL	9.1	8.5–10.5
Anion gap, mEq/L	24	7–16
Alanine Aminotransferase, U/L	16	<= 25
Aspartate Aminotransferase, U/L	31	11–42
White Blood Cell Count, k/uL	9.0	6.0–17.5
Hemoglobin, g/dL	10.5	11.7–13.8
Hematocrit, %	33.0	34.0–40.0
Platelet Count, k/uL	246	150–400
Arterial Blood Gas		
pH	7.335	7.350–7.450
pCO_2, mmHg	21.5	35.0–45.0
pO_2, mmHg	154.0	80–100
HCO_3, mmol/L	11.2	22.0–28.0
Lactic Acid, mmol/L	3.1	0.0–2.2

During the subsequent 6 hours, she developed decompensated cardiogenic shock with worsening acidosis and an increasing lactate level. She required intubation, escalation of dopamine, and addition of an epinephrine infusion. Immediately following intubation, she developed wide complex tachycardia followed by bradycardia and pulseless electrical activity requiring extracorporeal cardiopulmonary resuscitation (ECPR).

She was supported with veno-arterial (VA) ECMO for 16 days. A balloon atrial septoplasty was performed for pulmonary edema while on ECMO on hospital day (HD) 4. She had severely depressed biventricular function and regained pulsatility on HD 15. The next day, she was decannulated with residually depressed left ventricular systolic function (EF 35%) and normal right ventricular systolic function. With regard to her cardiac rhythm, she required aggressive treatment of ventricular tachycardia and torsades de pointes (Fig. 2), with magnesium sulfate ($MgSO_4$) and lidocaine within the first 2 days of admission. The initial dose of $MgSO_4$ was 25 mg/kg followed by a dose of 50 mg/kg. She was given a 1 mg/kg/dose bolus of lidocaine and then started on a continuous infusion of 20 mcg/kg/min that was titrated to 40 mcg/kg/min. Lidocaine was weaned secondary to a change observed in her neurological examination with concerns for seizure activity; however, her EEG showed no evidence of epileptiform activity. Antiarrhythmics were successfully discontinued in the patient on HD 3, and she did not show recurrence of tachycardia. N-acetylcysteine (NAC) was administered as treatment for cardiotoxicity secondary to oxidative stress during the first 3 days of her hospitalization in three doses: a 150 mg/kg/dose as a loading dose, followed by a 50 mg/kg/dose, and finally 100 mg/kg/dose.

Continuous renal replacement therapy (CRRT) was started within 13 hours of admission for severe metabolic acidosis. She was oliguric for the first 7 days of hospitalization followed by 11 days of anuria. A MAG3 scan during hospitalization was consistent with acute tubular necrosis. She continued CRRT for a total of 23 days followed by 1 day of hemodialysis; she was subsequently started on enteral diuretics. Four weeks after admission, her creatinine level normalized. Her aspartate aminotransferase (AST) level peaked on HD 1 at 6874 U/L, and her liver function did not normalize until 16 days later. Fig. 3 shows the trends and normalization of Troponin-T, creatinine, and AST.

Throughout hospitalization, she suffered no significant neurological sequelae and had a normal result in neurological examination on discharge. On HD 36, she was discharged to an acute care rehabilitation center on furosemide and carvedilol for heart failure. Six weeks later, during an outpatient cardiology follow-up visit, she returned to school with no focal neurological deficits. She had normal biventricular systolic function on echocardiogram, normal

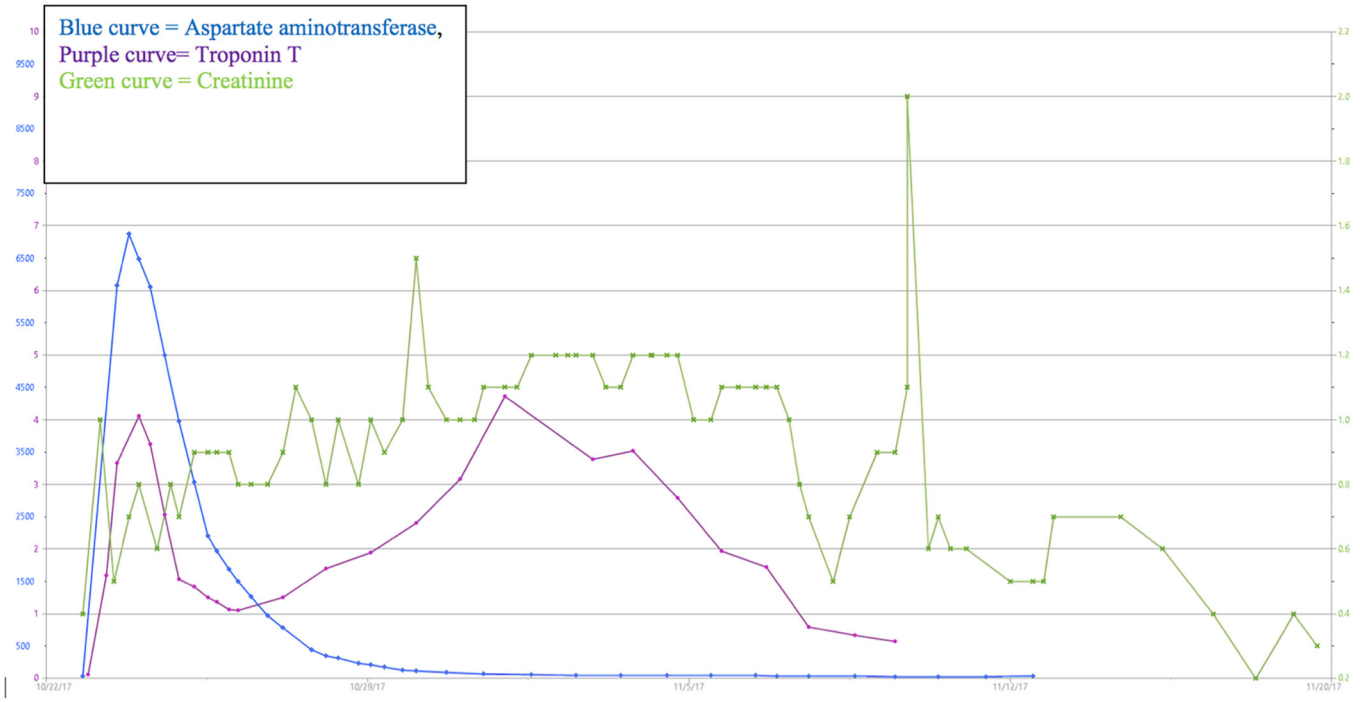

Fig. 3. Selected laboratory trends from admission through 4 weeks of hospitalization.

electrolyte levels, and renal function on basic metabolic panel, and her only medication was carvedilol, which was continued for cardiac remodeling.

3. Discussion

AlP poisoning can have a varied presentation and clinical course. The initial symptoms can be nonspecific and include epigastric pain, vomiting, diarrhea, dizziness, and dyspnea [1,4]. Emesis has been reported to have a garlic odor, which may increase suspicion for AlP poisoning [5]. Exposure has been described as through inhalation and ingestion routes and is typically either accidental or a suicidal ingestion [3,6–8]. In our case, the mechanism of exposure was accidental inhalation of phosphine gas from an insecticide related to placement of pellets for attempted bed bug eradication.

Cardiovascular complications including dysrhythmias (bradycardia and ventricular arrhythmias such as ventricular tachycardia (VT)) and systolic heart failure ranging from decreased cardiac function to complete cardiovascular collapse are common in AlP poisoning [8–11]. The initial ECG for our patient showed diffuse ST depression similar to acute presentations of myocarditis. She developed VT and torsades de pointes 2 days after ECMO cannulation (Fig. 2); it was controlled with the combination of lidocaine and $MgSO_4$, and after 2.5 days, lidocaine was successfully weaned without further recurrence of ventricular arrhythmias. Lidocaine, $MgSO_4$, and amiodarone have been used to convert VT to sinus rhythm in patients with AlP toxicity [9,12], but there is also description of treatment failure with both of these medications as well as electrical cardioversion [13]. Interestingly, ours is the first case described in a pediatric patient with successful termination of VT and torsades de pointes with lidocaine and $MgSO_4$ while supported with ECMO.

ECMO has been well described for reversible cardiogenic shock in patients with AlP poisoning [8,14–17]. Our patient required ECMO for 16 days, which is slightly longer than the typical course of cardiogenic shock (7–14 days) in patients with AlP poisoning [8,11]. Prompt referral to an ECMO center and initiation of support for patients with severe metabolic acidosis, refractory shock, and severe left ventricular dysfunction have been associated with improved survival [14,15]. The EF of our patient was 26% at presentation, improved to 35% at the time of decannulation from ECMO and further improved to 40% before discharge (31 days after initiation of ECMO). At follow-up 3 months later, she had normal biventricular function with a left ventricular EF of 59%; her right ventricular systolic function had normalized at the time of decannulation. Her Troponin-T on ECMO day 2 was elevated to 4.06 ng/mL, peaked on ECMO day 10 at 4.37ng/mL, decreased to 1.72 ng/mL, and continued to trend down thereafter. She was maintained on carvedilol for chronic heart failure and cardiac remodeling. NAC, which was administered to our patient, has been described as treatment for cardiotoxicity secondary to oxidative stress in AlP poisoning, and its use has been associated with a decreased hospital length of stay [18].

Intermittent hemodialysis, CRRT, and peritoneal dialysis have all been described as treatment for acute renal failure and metabolic acidosis in AlP poisoning [19–21]. Bayazit et al. reported a case of a 12-year-old girl who had normalization of renal function in 10 days [19], but they did not report the length of hemodialysis requirement. Nasa et al. report CRRT support for 3 days in two adults [20] with AlP poisoning but did not describe when their renal function recovered. An additional report described the use of peritoneal dialysis for 3 days in one patient and for 4 days in another patient, but the authors did not comment on renal function [21]. Our patient was supported with CRRT for 23 days, with one additional day of intermittent hemodialysis. Her MAG3 scan during hospitalization was consistent with acute tubular necrosis, which has been reported in another case [22], and her creatinine level normalized within 4 weeks. Two months post discharge, she had normal renal function and urine output and had been able to maintain normal electrolytes and acid–base balance.

We presented a rare case of pediatric AlP poisoning that was associated with cardiogenic shock, ventricular arrhythmias, liver

involvement, and significant acute kidney injury. Despite her severe clinical presentation, she had complete normalization of her end-organ dysfunction, although long-term sequelae will likely not be known for some time. A high index of suspicion for AlP poisoning is necessary given the potential for rapid progression of multisystem organ failure, cardiovascular collapse, and death [4,16,23]. Factors that have been associated with decreased survival include ECG changes (ST segment depression and sinus tachycardia) and metabolic acidosis on arterial blood gas analysis at presentation [1]. Given the multisystem organ failure and high risk of morbidity and mortality, we would recommend prompt referral to a tertiary care center that can provide ECMO and CRRT or hemodialysis in cases of suspected or documented AlP poisoning. Furthermore, our case highlights the potential for slow clinical improvement of end-organ injury, especially with regard to cardiac function. While she has had full resolution of symptoms and end-organ damage, close follow-up is necessary given the long-term potential for morbidity and lack of long-term follow-up data for cases of AlP poisoning.

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Conflict of interest

The authors declare that they have no potential conflicts of interest to disclose.

Abbreviations

AlP	Aluminum phosphide
AST	aspartate aminotransferase
CRRT	continuous renal replacement therapy
ECG	electrocardiogram
ECMO	extracorporeal membrane oxygenation
ECPR	extracorporeal cardiopulmonary resuscitation
EF	ejection fraction
ER	emergency room
HD	hospital day
NAC	N-acetylcysteine
$MgSO_4$	magnesium sulfate
VA	veno-arterial
VT	ventricular tachycardia

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