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Review
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Advances in Acute Management and Evolving Clinical Practices in Aluminum Phosphide Poisoning: Insights from Recent Case Studies

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Abstract

Aluminum phosphide (AlP) is a pesticide widely used by farmers in certain Asian countries for its high efficacy in protecting crops from pests. However, misuse in both intentional and unintentional poisoning cases has raised major public health concerns. Despite extensive research into treatments for AlP poisoning (AlPP), no specific antidote exists, and management remains largely supportive. This review examined successful treatment cases reported in the literature. A targeted search was conducted using the keywords "AlP", "phosphine", "antidote", "case report", and "treatment" in the scientific databases Scopus, Web of Science, and PubMed. The identified treatments include disinfection of the digestive tract (including gastric disinfection); prevention of phosphine gas release; administration of coconut oil and olive oil; magnesium sulfate; thyroid hormones; extracorporeal membrane oxygenation; continuous renal replacement therapy (including continuous veno-venous hemofiltration); high-dose insulin; red blood cell exchange; dihydroxyacetone; and antioxidant therapy. These therapeutic approaches may serve as supportive therapy by reducing the harmful effects of AlP. This article evaluates medications and chemical substances proposed for the targeted treatment of AlPP and examines their protective mechanisms and the primary consequences of their use.

Keywords: Aluminum phosphide, rice tablet, phosphine, antidote, case report, poisoning

Introduction

Aluminum phosphide (AlP) is among the most common and cost-effective pesticides and is widely used in the grain-preservation industry. It is often encountered as rice tablets containing about 56% AlP (1). Once in contact with moisture, water, or gastric contents, AlP generates phosphine gas (PH_3), a highly poisonous, hazardous entity (2,3). It is a significant public health problem: thousands of people worldwide die every year from pesticide poisoning. AlP poisoning (AlPP) has become one of the most common methods of suicide involving pesticides in several countries. In specialty clinics treating intoxications, AlPP accounted for approximately 76% of cases per year, with a mortality rate of two-thirds among affected individuals (4). This is especially dangerous in developing countries like India, Sri Lanka, and Iran, where the rate of suicide by AlP is increasing (5-7).

As shown in the Figure 1 AlP toxicity results from the release of phosphine gas (3). This gas blocks oxidative phosphorylation by inhibiting mitochondrial cytochrome oxidase, ultimately causing cellular hypoxia and circulatory collapse (8). PH_3 inhibits cellular metabolism, which manifests in symptoms like nausea, diarrhea, colic, hypotension, and life-threatening cardiovascular disorders such as congestive heart failure and arrhythmias (Figure 2).

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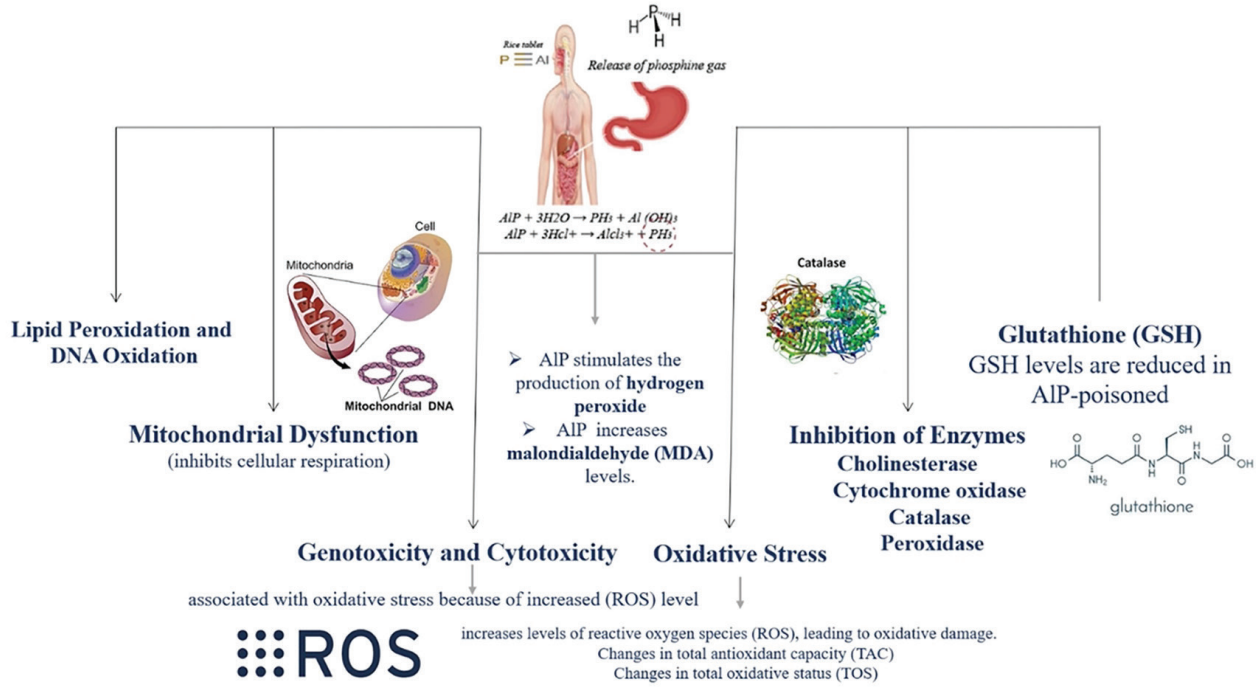

Figure 1. The mechanisms of acute aluminum phosphide poisoning

AIP: Aluminum phosphide, ROS: Reactive oxygen species

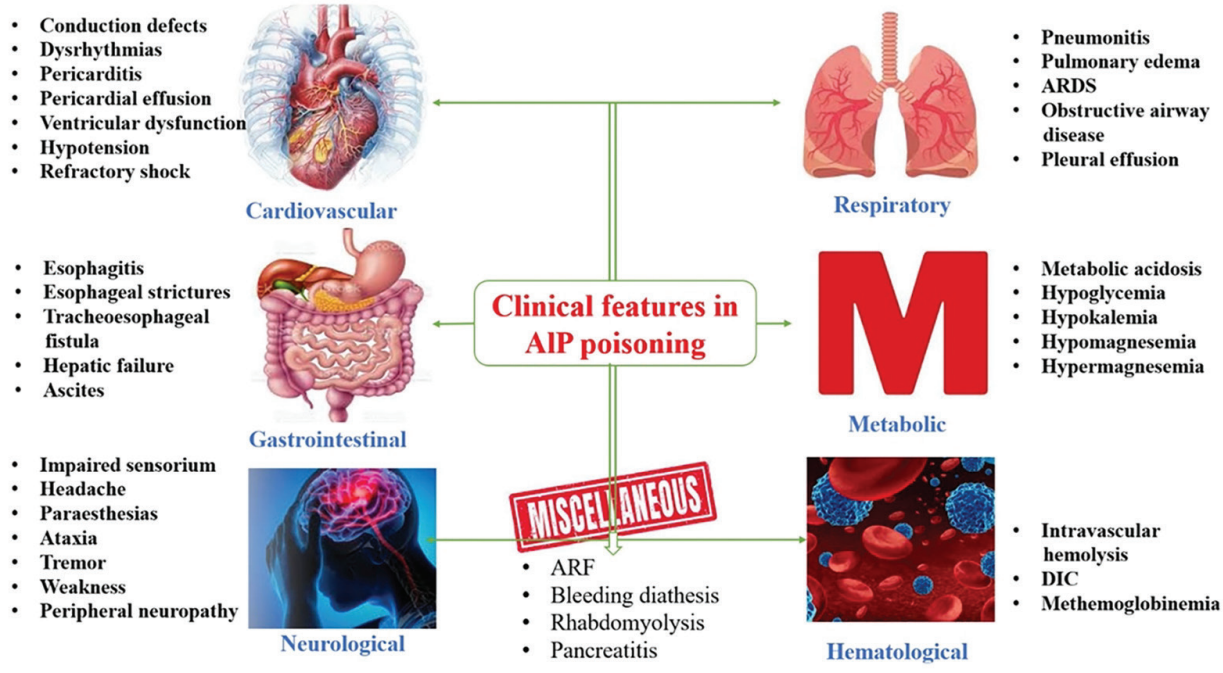

Figure 2. Clinical symptoms of acute aluminum phosphide poisoning

AIP: Aluminum phosphide, ARDS: Acute respiratory distress syndrome, ARF: Acute respiratory failure, DIC: Disseminated intravascular coagulation

Evolving respiratory symptoms can range from dyspnea to acute respiratory distress syndrome (ARDS) and pulmonary edema (9).

AlPP patients may present with manifestations ranging from mild gastrointestinal upset to severe cardiovascular and respiratory failure. Intravascular hemolysis, however, has also been recognized as a rare complication of this poisoning (9). Currently, there is no specific antidote for AlPP; treatment remains largely supportive. Management focuses on correcting metabolic acidosis and addressing severe symptoms resulting from poisoning (Figure 3). Despite the high mortality rates associated with severe cases, ranging from 60% to 85%, there have been instances of successful recovery through prompt medical intervention (10-12).

Accordingly, in this article we review and summarize recent guidelines and findings on the management of acute AlPP.

Materials and Methods

A comprehensive search of the PubMed, Scopus, and Web of Science databases was conducted to identify relevant studies. The search strategy included the keywords: "AlP", "phosphine", "antidote", "case report", and "treatment". Case reports and articles describing successful treatment approaches in human studies for AlPP were reviewed. After the initial retrieval, duplicate records were removed, and the remaining articles were screened for relevance to the study objective. No time limit was applied to the articles, and all case reports describing successful treatments of AlPP were reviewed. Excluded were non-clinical or non-human studies (such as reviews, animal studies, and in vitro research); reports involving phosphide compounds other than AlP; articles with unclear outcomes or fatal cases; and reports lacking sufficient details on the treatment approach or clinical course.

Results

Gastric Decontamination

Since the release of PH_3 begins when AlP interacts with water and stomach acid, researchers have studied various methods to reduce this release.

Potassium Permanganate

There are contradictory reports, with some asserting that gastric washout using potassium permanganate can convert PH_3 into a harmless phosphate through oxidation (13). Furthermore, Sanaei-Zadeh (14) noted that potassium permanganate is a potent oxidizing agent and documented instances of hemolysis and methemoglobinemia following AlPP. Initially, these patients were managed by administering potassium permanganate through gastrointestinal lavage (14,15). Sanaei-Zadeh and Marashi (16)

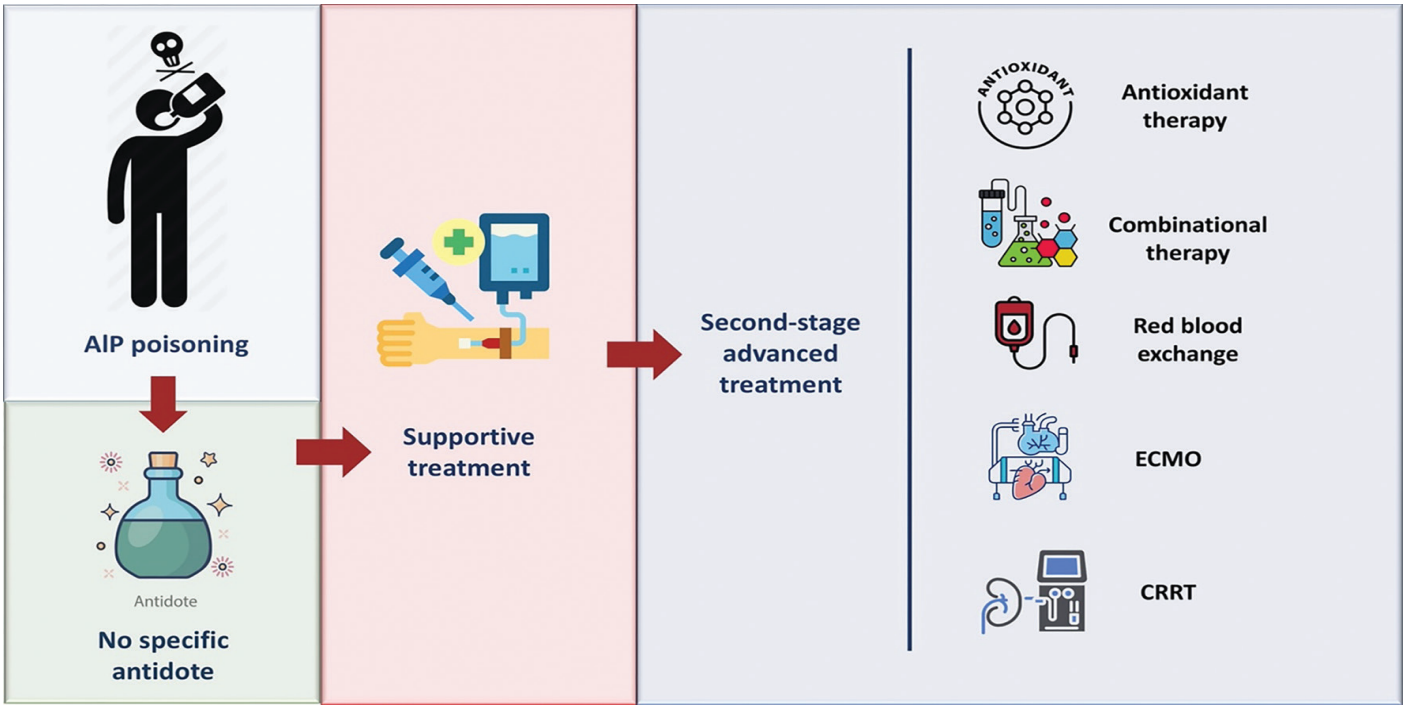

Figure 3. Aluminum phosphide (AlP) poisoning has no specific antidote; initial management is supportive, with escalation to second-stage advanced therapies in nonresponsive cases

CRRT: Continuous renal replacement therapy, ECMO: Extracorporeal membrane oxygenation

state that potassium permanganate is a chemical that easily dissolves in water and can prevent the release of PH_3 gas.

Liquid Paraffin and Castor Oil

Laboratory studies have confirmed that liquid paraffin and vegetable oils can prevent the further release of PH_3 gas (17). Therefore, the use of vegetable oils or liquid paraffin alone for gastric decontamination after acute AlPP is recommended, although gastric lavage with vegetable oils is technically possible. Sanaizadeh and Marashi propose that the management of castor oil effectively prevents the continued release of PH_3 upon interaction with the moist digestive system, accelerates the movement of the digestive system, and facilitates gastrointestinal elimination of the toxic agent (16).

Olive Oil

According to a study (18) gastric lavage with potassium permanganate 1:1000, activated charcoal, and coconut oil can be used as the first step in an emergency to help reduce the rate of PH_3. In another study, it has been suggested that gastric lavage with sodium bicarbonate and coconut oil may represent a feasible supportive approach (19). Another study announced that zinc phosphide poisoning was effectively treated by performing gastric washout using olive oil and providing other supportive therapies (20). Olive oil has been proposed as a potential adjunctive agent that may reduce PH_3 release and improve clinical outcomes.

Coconut Oil

Coconut oil contains a high concentration of saturated fatty acids. It has been reported that coconut oil can prevent the release of PH_3 from AlP (17). In the case of AlPP, a 28-year-old man was administered coconut oil six hours after consuming 12 grams of AlP, showing that coconut oil reduces the expected amount of AlP absorption (21). This study proposed coconut oil as a potentially life-saving and beneficial supplementary treatment for AlPP.

Another investigation involved the treatment of thirty-three patients who had been poisoned with AlP. These patients had thorough gastric lavage, including sodium bicarbonate and coconut oil (22). Based on these findings, the authors reported that coconut oil and other therapeutic interventions may improve survival outcomes.

A dissimilar study on seven patients seriously affected by AlPP found that they were managed with supportive interventions, including permanganate, coconut oil, sodium bicarbonate, and gastric washout with diluted potassium (19). Based on a viability rate of 51.14% among poisoned patients, the authors propose that coconut oil could be recognized as a viable treatment option in conjunction with other therapeutic interventions for managing cases of poisoning.

Magnesium Sulfate

Several studies investigating the effect of magnesium sulfate on AlPP have reported contradictory results regarding its therapeutic efficacy. According to some studies, AlPP does not decrease magnesium levels in these patients, so magnesium sulfate does not improve the patient's condition (22,23). In contrast, other studies exhibited that magnesium levels decrease in AlPP, thus confirming the hypothesis that enhancing magnesium levels can be considered an effective treatment for AlPP (24). In a study of antioxidant effects, magnesium was evaluated in several patients who were poisoned by AlP (25). After demonstrating that oxidative stress induced by AlP during the initial stage of intoxication was responsible for increased lipid peroxidation and decreased glutathione (GSH) levels, the researchers reported meaningful amelioration among patients receiving magnesium. Therefore, magnesium can be considered an adjunctive treatment for reducing oxidative stress caused by AlPP.

Liothyronine

Thyroid hormones exert short- and long-term effects on mitochondria. The administration of thyroid hormones in the management and therapy of AlPP is primarily attributed to the mitochondrial-safeguarding properties of these substances (26). Following the initial interventions, a dosage of 50 µg of liothyronine was delivered to twelve patients who had been poisoned with AlP (27). Oral administration of liothyronine significantly improved systolic blood pressure, arterial pH, and total thiol molecule concentration. Furthermore, liothyronine reduces lipid peroxidation, increases catalase activity, and preserves total antioxidant capacity. Therefore, liothyronine may be a promising adjunctive therapy for AlP-poisoned patients.

Digoxin

Cardiogenic shock is a major cause of death in AlPP. Digoxin can have a protective role in such cases. For example, an 18-year-old female with acute AlPP and severe cardiac failure was successfully treated with digoxin. The patient received an initial digoxin dose (0.5 mg), followed by 0.5 mg every 6 hours on the first day and 0.25 mg daily thereafter. She fully recovered and was discharged 10 days later. This case suggests that digoxin may be beneficial in managing cardiogenic shock in AlPP (28). Another successful case was a 21-year-old male who consumed a 3-gram tablet of AlP and was successfully treated by administering a combination of antioxidants and digoxin (29).

Intra-aortic Balloon Pump

The intra-aortic balloon pump (IABP) is among the earliest and most prevalent forms of mechanical circulatory support. The device operates through external counterpulsation, employing systolic unloading and diastolic augmentation of aortic pressure to enhance hemodynamics. Despite providing inferior hemodynamic support compared to contemporary mechanical circulatory support devices, IABP may still be the preferred option in suitable circumstances because of its relative ease of insertion and removal, minimal vascular access requirements, and a superior safety profile. IABPs improve myocardial function by optimizing oxygen delivery and reducing oxygen consumption (30). Recently, this method has been used to treat and manage cardiogenic shock due to AlPP alone or in combination with other therapeutic approaches, and promising therapeutic outcomes have been achieved (31).

Three patients with AlPP developed refractory shock despite receiving IV fluids and vasopressors. IABP was attempted, but only one survived (32). Mehrpour et al. (33) reported two cases, a 17-year-old man and a 21-year-old woman, successfully treated with IABP for cardiogenic shock induced by AlPP. Mehrpour et al. (34) also reported a successful case of AlPP treated with IABP. A 24-year-old woman presented with refractory AlP-induced cardiogenic shock and ARDS after ingesting 3 g of AlP. She received gastric lavage, sodium bicarbonate, and intensive care, but her LVEF dropped to <20%. An IABP was inserted, stabilizing her vital signs. By day 20, her LVEF improved to 50%, demonstrating that IABP may be a promising intervention for severe AlPP. Moreover, Siddaiah et al. (35) reported another successful treatment of AlPP using IABP.

Extracorporeal Membrane Oxygenation

Extracorporeal membrane oxygenation (ECMO) is a type of circulatory support used in patients with heart failure, respiratory failure, or both who have failed standard therapies. It provides the body with sufficient time to detoxify and improve organ function (36). A study conducted in India revealed that doctors' use of ECMO resulted in a significant decrease in mortality among poisoned patients. The mortality rate dropped from 88% in untreated cases to 33% when ECMO was employed, highlighting the remarkable effectiveness of this treatment (37).

In another study conducted in Nepal, the patient's hemodynamic status and general condition gradually improved within two days. The patient was transferred to the intensive care unit on the sixth day of ECMO and was discharged from the hospital on the tenth day after ECMO (38).

The authors Mohan et al. (37) The initial study documented the effective treatment of AlPP with refractory cardiogenic shock using ECMO. Hassanian-Moghaddam et al. (39) conducted a study demonstrating a case of AlPP, which was completely cured after four days of treatment with ECMO. Further observational evidence has emphasized the importance of initiating ECMO promptly before profound deterioration in ventricular function. Mohan et al. (40) reported that early veno-arterial ECMO support was associated with improved survival and reversal of myocardial dysfunction in patients with severe AlPP. All of the above studies show that ECMO is a suitable intervention for patients with poor hemodynamic status who have not responded to other conventional treatments.

Continuous Renal Replacement Therapy

Continuous renal replacement therapy (CRRT) is frequently employed to provide renal support for critically sick patients suffering from acute kidney injury, particularly those who are experiencing hemodynamic instability (41). In one study, CRRT was started within two hours of presentation in two poisoned patients after initial reports indicated elevated lactate. CRRT was performed using bicarbonate-based fluids and continued until metabolic acidosis resolved and serum lactate levels normalized; both patients survived. It is thought that CRRT can correct severe metabolic acidosis and stabilize hemodynamic status, helping improve the condition of poisoned patients (42). CRRT is superior to intermittent hemodialysis in these patients and can be used for long-term, hemodynamically unstable patients for whom conventional hemodialysis is relatively contraindicated. In addition, CRRT helped maintain the metabolic environment and resolve the shock state until AlP excretion (43). It is recommended that such extracorporeal treatments be used for patients at high risk of mortality, together with supportive therapies until the hemodynamic condition improves.

Peritoneal Dialysis

Bashardoust et al. (44) reported two severe AlPP cases successfully treated with peritoneal dialysis, highlighting its potential role in correcting metabolic acidosis and improving survival outcomes.

Continuous Veno-venous Hemofiltration

This method treats acid-base and electrolyte disorders in patients with unstable hemodynamics. Several reports describe the successful use of hemofiltration in cases of drug poisoning complicated by hypotension and metabolic acidosis (45). A case report describes a patient who underwent continuous veno-venous hemofiltration for AlPP. Unfortunately, this patient died due to ventricular tachycardia (46). Nasa et al. (42) reported two patients with acute albinism who survived after CRRT. In a separate investigation, hemofiltration was initiated immediately for refractory hypotension and metabolic acidosis; a serum creatinine level of 1.1 mg/dL was measured, so the patient underwent continuous veno-venous hemofiltration for 32 hours. The patient was discharged healthy on the fourth day of hospitalization (47). Notably, hemofiltration should be started before multiorgan

failure occurs (MOF) in our patient, because prolonged periods of metabolic acidosis and hypotension resulting from irreversible cardiac complications and progression of MOF cause high mortality.

High-dose Insulin

In the previous experiences of AlPP, almost all patients poisoned with AlP died of severe hypotension and metabolic acidosis; in this case report study, this patient was successfully managed using glucose-insulin-potassium (GIK) (48). Sedaghattalab (48) reported the successful treatment of a 30-year-old Iranian woman with severe AlPP, presenting with hypotension, shock, and severe metabolic acidosis, using high-dose regular insulin and hypertonic dextrose.

In a study conducted on 88 patients poisoned with AlP, it was shown that 44 of them received insulin infusion, which supports our experience (49). Another experimental study of 60 patients with rice tablet poisoning showed that the durability rate was significantly higher in the GIK group (50). GIK therapy may represent a promising adjunctive strategy in acute AlPP; however, further clinical studies are required before routine incorporation into treatment protocols.

Red Blood Cell Exchange

An animal study showed that infusion of fresh RBCs ameliorated metabolic acidosis and increased survival in mice exposed to AIP. Rahimi et al. (51) stated that hemoglobin has a powerful buffer capacity, enabling red blood cells to show the capacity to preserve blood pH. On the other hand, Zamani et al. (52) stated that an adult patient with AlPP did not respond to traditional treatment and recovered after a complete blood exchange procedure. In addition, some case reports have shown that G6PD deficiency can play a protective role in AlPP, as G6PD insufficiency leads to the breakdown of red blood cells under oxidative stress (52-54). Therefore, it was suggested that removing damaged red blood cells may be helpful in patients exposed to AIP and may be indicated as a potential adjunctive therapeutic option for AlPP.

Hyperbaric Oxygen

Hyperbaric oxygen therapy (HBOT) involves exposure to pure oxygen at elevated atmospheric pressure (55). Several animal studies have investigated the effectiveness of HBOT in rats. The results have shown that this method can be an effective treatment for mild poisoning. This approach may serve as an effective therapeutic option for minor poisonings. This approach may enhance the survival duration of mice exposed to AlPP, although it may not decrease the fatality rate (56). The first reported case of successful treatment of poisoning with HBOT involved a patient who had suffered accidental AlPP. Initially misdiagnosed as carbon monoxide poisoning, the patient received comprehensive treatment, including HBOT, and fully recovered, marking the first reported clinical case of HBOT use in AlP intoxication (57).

Dihydroxyacetone

Dihydroxyacetone is synthesized as dihydroxyacetone phosphate during glycolysis within the cell, and it plays a crucial role in the production of adenosine triphosphate (ATP). PH_3 toxicity primarily occurs through inhibition of ATP generation in cells. However, the entry of DHA into the glycolysis pathway can avert an energy crisis (ATP depletion) in cells and prevent cell death. This is crucial for organs particularly vulnerable to ATP depletion, such as the heart and brain. A recent animal study demonstrated that DHA substantially reduced mortality (58).

A case report showed that in addition to the usual management of AlPP, patients received DHA. Administering DHA via gavage at a dose of 7 g in 50 ml of sodium bicarbonate, twice at 1-hour intervals, improved clinical symptoms. This is the first case report to emphasize the effective treatment of AlPP with DHA (59). However, it was found that administration of DHA in poisoned patients significantly improved severe acidosis and AlP-induced PaO_2 (60).

Antioxidant Therapy

After exposure to AlP, a decrease in GSH plasma concentration has been observed and reported (25). N-acetylcysteine (NAC) can increase GSH reserves. Regarding the efficacy of NAC in AlPP, there are conflicting reports, and only one documented case has been reported in which NAC delivery, as part of treatment, failed to save the patient (61).

Nevertheless, Azad et al. (62) reported that NAC injection can substantially increase survival in a mouse model. Consequently, the administration of NAC can be considered a therapeutic agent in addition to a multi-therapeutic strategy.

Marashi et al. (63) recommended that the use of coenzyme Q10 (CoQ10) as an antioxidant could be regarded as an alternative therapy approach. According to their assertion, relying on prior research conducted on patients with heart failure with a similar condition to AlPP, CoQ10 can also increase the systolic function of the heart and help save the poisoned person (64-66).

Recently, vitamin E has been recognized as an effective treatment for managing people with AlPP. A 21-year-old male who consumed a 3-gram tablet of AlP was successfully treated with a combination of antioxidants. This treatment included a slow intravenous infusion of 1000 mg of vitamin C every 12 hours, an intramuscular injection of 400 units of vitamin E, and an oral NAC. The NAC dosage was 70 mg/kg every 4 hours after an initial loading dose of 140 mg/kg for a maximum of 17 doses (29).

When combined with additional supportive treatments, vitamin E, 400 mg BD intramuscularly, dramatically reduced mortality in subjects exposed to AlP (67).

Table 1 summarizes the key therapeutic interventions and clinical outcomes from the reviewed case studies.

Table 1. Therapeutic interventions and clinical outcomes in cases of aluminum phosphide poisoning: a review of case studies

Treatment/intervention	Study model, year, country	Gender, age, and amount of AlP	Outcome, reference
CRRT	Case report 2013 India	Female 30 half tablet (1.5 gm) Man 24 one tablet	Early initiation of CRRT, in addition to other supportive treatments, resulted in the survival of both poisoned patients (42).
Continuous veno-venous hemofiltration	Case report 2016 Türkiye	Female 24 two tablets	The patient's hemodynamic condition improved during hemofiltration, which increased blood pressure and gas levels for up to 32 hours. She was discharged from the hospital on the fourth day of her stay (47).
ECMO	Case report 2018 Nepal	Female 67 two tablets	The patient who had been poisoned was released from the intensive care unit on the sixth day following ECMO. She was discharged from the hospital on the tenth day after ECMO (38).
IABP	case report 2019 Iran	Two cases of poisoning	This case study confirmed the successful treatment of cardiogenic shock due to AlP poisoning in a 17-year-old man and a 21-year-old woman using the IABP procedure (33).
DHA (7 gr in 50 mL sodium bicarbonate, gavage)	Case report 2020 Iran	Two cases of poisoning	The clinical symptoms were relieved, and the patients were discharged after administering DHA (7 g in 50 mL of sodium bicarbonate via gavage) (59).
Magnesium sulfate, trimetazidine IABP, and ECMO	Case report 2021 Nepal	Female 17 two tablets	She was shifted to the general division on the 11th day of her admission (68).
ECMO and CRRT	Case report 2021 China	Female 15 one tablet (3.2 g)	The poisoned patient was successfully treated with ECMO along with CRRT (69).
Sodium bicarbonate (50 ccs), aloe vera syrup (1-2 L), and olive oil (150 cc)	Case report 2021 Iran	Man 33 three tablets	Combination therapy was a successful experience in treating acute AlPP (70).
Red blood cell exchange	Case report 2021 Türkiye	Female 15 500 mg	Despite the lack of improvement in the patient's hemodynamic condition with supportive treatment, she achieved successful treatment by automated red blood cell exchange (71).
Olive oil	Case report 2021 Iran	Man 33 three tablets	Research from this study suggests that using olive oil as a gastric lavage may be beneficial (72).
High-dose insulin	Case report 2022 Iran	Female 33 unclear	Treatment with these drugs was successful, and this patient was saved with glucose-insulin-potassium (48).
VA-ECMO and IABP	Case report 2023 Russia	Man 20 unclear	The patient was discharged after 34 days of treatment (31).
HBOT	Case report 2024 Czech Republic	Male 40 accidental	The patient was treated entirely with HBOT and discharged (57).

CRRT: Continuous renal replacement therapy, ECMO: Extracorporeal membrane oxygenation, IABP: Intra-aortic balloon pump, VA-ECMO: Veno-arterial membrane oxygenation, HBOT: Hyperbaric oxygen therapy

Conclusion

AlPP poses a significant global health challenge because of its high mortality rate and the lack of a definitive antidote. Managing it is complex because exposure to moisture rapidly releases phosphine gas, which can cause severe systemic toxicity.

Among poisoned individuals, critical factors influencing mortality and survival include exposure to AlP (amount of aluminum consumed, tablet freshness) and the individual's personal characteristics; these should be considered essential parameters. The approach to managing AlPP should be based on a thorough understanding of its toxicological effects and associated clinical manifestations. Given that there is currently no specific antidote for AlP, treatment remains supportive and focuses on several key strategies. First, early gastrointestinal decontamination is crucial. Second, continuous hemodynamic monitoring is essential to manage cardiovascular instability, a common complication in severe cases. Ultimately, a holistic treatment approach that includes multidisciplinary collaboration among intensivists, cardiologists, and toxicologists can significantly improve patient outcomes and reduce mortality rates associated with AlPP. This review highlights various therapeutic strategies that have been explored to mitigate the effects of acute AlPP.

Gastric decontamination with vegetable oils, including coconut and olive oil, has shown promise in inhibiting the release of phosphine gas by forming a barrier that prevents further absorption of the toxin. Adjunctive therapies, such as magnesium sulfate and liothyronine, have been investigated for potential benefit. Magnesium sulfate may help correct hypomagnesemia and reduce arrhythmias, while liothyronine, a synthetic thyroid hormone, may protect mitochondrial function and enhance cellular metabolism. Advanced supportive treatments, including ECMO and CRRT, have emerged as critical interventions for patients with severe cardiopulmonary compromise. These modalities support organ function and provide a window for recovery by stabilizing hemodynamic parameters and correcting severe metabolic disturbances. High-dose insulin therapy has been associated with improved cardiac output and systemic perfusion, possibly due to its inotropic and vasodilatory effects. Red blood cell exchange has been considered in cases of significant hemolysis caused by oxidative stress, with the aim of removing damaged cells and replacing them with healthy cells.

Novel approaches, such as DHA administration, aim to bypass impaired cellular respiration by providing alternative substrates for ATP production, thereby sustaining vital cellular functions. Antioxidant therapies using agents such as NAC, coenzyme Q10, and vitamin E aim to mitigate phosphine-induced oxidative damage and potentially improve survival rates. Despite these varied interventions, AlPP management remains predominantly supportive. The effectiveness of many treatments is based on limited case reports and small studies, underscoring the need for more extensive, controlled clinical trials to establish standardized protocols. Early recognition and prompt initiation of combined therapeutic strategies are key to improving patient outcomes.

While significant progress has been made in exploring potential treatments for AlPP, there remains a crucial need for ongoing research to develop evidence-based guidelines. Multidisciplinary collaboration and increased awareness can enhance the management of this life-threatening condition and reduce its global impact.

Ethics

Acknowledgment

This study is the result of an in-house investigation and does not receive external financial support. The authors confirm that they have no conflicts of interest.

Footnotes

Authorship Contributions

Surgical and Medical Practices: S-A.B., A.B., H.H-A., M.B., S.H., A.J., O.M., M.A., Concept: A.B., O.M., M.A., Analysis or Interpretation: H.H-A., M.B., O.M., Writing: S-A.B., S.H., A.J.

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