Updates in
Emergency Medicine

Review Article

Gastric Decontamination In Aluminum Phosphide Poisoning

Nima Safa[1] , **Samaneh Abiri**[2], **Fatemeh Rahmanian**[2*], **Reza Sahraei**[3]

[1] Department of Emergency Medicine, Faculty of Medicine, Islamic Azad University, Islamic Azad University of Kerman, Kerman, Iran.

[2] Department of Emergency Medicine, Jahrom University of Medical sciences, Jahrom, Iran.

[3] Anesthesiology Department, Jahrom University of Medical Sciences, Jahrom, Fars, Iran.

Corresponding Author: Dr. Fatemeh Rahmanian. Department of Emergency Medicine, Jahrom University of Medical Sciences, Jahrom, Iran. Email: fatemeh.rahmanian1185@gmail.com.

Abstract:

Background: Despite significant progress in toxicology, there is no particular antidote for aluminum phosphide poisoning and the consequences of PH3 gas toxicity. While several researchers have concentrated on the technicalities of supportive intravenous treatment using various medicines such as sodium bicarbonate, Glucose-insulin-potassium protocol, and Digoxin or other methods; new research is attempting to enhance our interventions in the pre-absorption phase of phosphine gas. **Methods:** A narration of literature.

Results: Some researchers are completely opposed to gastric decontamination using water-based solutions, the use of essential oils is proposed to avoid excessive PH3 release. In this study, we reviewed the literature for oil-based gastric decontamination methods. Based on our review, liquid paraffin might improve outcomes of ALP poisoning but it might be associated with adverse events. Evidence about coconut oil is still controversial which might be due to the co-administration of sodium bicarbonate in gastric lavage. Aloe vera, olive oil, and almond oil in gastric lavage have shown impressive benefits, but more evidence is needed.

Conclusion: To conclude, oil-based gastric lavage is associated with less mortality, and water-soluble washing methods and activated charcoal administration should be avoided.

Keywords: Aluminum Phosphide Poisoning, Gastric Lavage, Olive Oil, Coconut Oil

OPEN ACCESS

Citation: Safa, N., & Rahmanian, F. Gastric decontamination in aluminum phosphide poisoning: Narrative review. Updates in Emergency Medicine. Retrieved from https://uiemjournal.com/index.php/main/article/view/40

Received: 29 September , 2022
Reviewed: 9 October, 2022
Accepted: 13 November, 2022
Published: 28 November, 2022

Introduction

Aluminum phosphide is one of the most dangerous pesticides if ingested by a human being *(1,2)*. This pesticide was first introduced as an ideal pesticide in 1973 and is now used in dark gray or the form of yellow crystals under various brands *(2)*. This substance is not absorbed by the skin in humans and the main route of poisoning is oral consumption and respiratory exposure. Also, the main mechanism of poisoning by this substance is the production of phosphine gas (PH3), which is produced by the interaction of aluminum phosphide with water (2-3). It is widely used as a very cheap and effective rodenticide and insecticide to protect cereals during storage and transportation in developing countries *(3)*. The severity of aluminum phosphide poisoning is high in both gastrointestinal and respiratory tract exposure and the produced phosphine gas is easily absorbed from the gastrointestinal tract and lung epithelium *(4)*. From a general point of view, aluminum phosphide poisoning is one of the most

common causes of death in many countries, especially developing countries *(5)*. Causes of aluminum phosphide poisoning most often occur following suicidal ideation, and sometimes accidentally due to occupational exposure and rarely to criminal intent. Most poisonings occur at a young age *(6)*. The compound was first marketed in India, where it causes about 15,000 accidental or intentional poisonings each year, two-thirds of which result in death *(7)*. In Nepal, more than 50% of suicides were due to pesticides, 14% of which were due to the use of aluminum phosphide *(7)*. The use of magnesium sulfate, calcium gluconate, and insulin glucose, known as Glucose-insulin-potassium protocol (GIK) is routinely considered a routine treatment approach in most poisoned along with supportive care in ICU. Here we queried the literature for successful management methods of ALP. While some studies have focused on the details of supportive intravenous therapy by various medications like sodium bicarbonate *(8)*, hemodialysis *(9)*, GIK *(10)*, and Digoxin *(11)*; new studies are trying to improve our interventions in more early phases of phosphine gas pre-absorption.

Gastric decontamination by Charcoal:

Activated charcoal is an excellent non-specific chelating agent. Water-insoluble and non-polar organic substances are better absorbed by Charcoal, and branched-chain molecules adhere better to charcoal than straight-chain materials. Alcohol, acids and alkalis, iron, lithium, magnesium, and sodium and potassium salts do not tend to bind to charcoal, unlike aspirin, acetaminophen, barbiturates, TCA, phenytoin, and theophylline, which bind well to charcoal *(12)*. But some case reports have shown evidence of hot charcoal vomitus that might cause thermal burns. Six cases of thermal injury in ALP poisoning were from 2007–2012 as reviewed by Mirakbari *(13)*. The possible mechanism is not well discussed.

Gastric decontamination by water-soluble compounds:

Gastric decontamination with water-based solutions is performed in many cases, as well as gastric lavage by potassium permanganate (KMNO4) and sodium bicarbonate *(14,15)*; while showing successful results in some case reports, it is fully opposed by some researchers. Sanaei-Zadeh et al. showed that water-based products must not be utilized for gastric washing following acute AlP *(16)*. In the study of Agrawal et al., they used gastric lavage with KMnO4 and sodium-bicarbonate in all of their 7 patients while coconut oil was used in 4 patients. all patients with coconut oil use survived; while others died *(14)*.

Gastric decontamination by Sodium-bicarbonate:

Based on the Sanaei-Zadeh et study, Sodium-bicarbonate did not reduce phosphine gas release in-vitro *(16)*; while Shadnia et al. reported that Sodium-bicarbonate primarily neutralizes HCl, reducing the catalytic interaction of phosphide with HCl and therefore limiting phosphine production *(17)*. It may be due to the fact that the reaction of a saturated sodium bicarbonate solution with hydrochloric acid produces carbon dioxide gas *(18)* that may change the reaction in the stomach and for final conclusions about the efficiency or safety of Sodium-bicarbonate gastric decontamination in-vitro studies of gastric juice reaction with Sodium-bicarbonate and Aluminium phosphide is needed.

Gastric decontamination by potassium permanganate (KMNO4):

potassium permanganate is suggested to have the ability to convert phosphine to phosphate *(19,20)*. Potassium permanganate (1:10,000) followed by charcoal gastric lavage was not successful in the study of Mirakbari, in a young case of ALP *(13)*. In the study of Agrawal et al., gastric lavage with

KMnO4 and sodium-bicarbonate was associated with mortality of all intoxicated patients *(14)*.

Gastric decontamination by liquid paraffin:

liquid paraffin is a highly refined distilled fraction of petroleum containing a combination of liquid-saturated hydrocarbons. Sharif et al. *(21)* describe it as a laxative, lubricant, and basis for nasal sprays. Liquid paraffin is not advised for frequent usage because of its adverse effects and the availability of alternative products. It may be obtained without a prescription.

In 60 patients of ALP, gastric decontamination by liquid paraffin with and without Coenzyme Q10 was associated with better outcomes than KMNO4 *(22)*. Also, there is an ongoing clinical trial (NCT04499885) evaluating liquid paraffin versus Sodium-bicarbonate for gastric lavage, registered at ClinicalTrials.gov. ALP and phosphine excretion from the GI tract has been sped up using medicated liquid paraffin. Because of the physiochemical characteristics of ALP and its non-miscibility with fat, in-vitro experimental data show that liquid paraffin inhibits phosphine release from ingested ALP *(23)*. If inhaled, liquid paraffin may induce lipoid pneumonia or pneumonitis. The uptake of fat-soluble vitamins is hampered by liquid paraffin. The anus might exude liquid paraffin, which can irritate the skin *(24)*.

Gastric decontamination by coconut oil

the application of vegetable oils or castor oil for gastric lavage might prevent increased PH3 release and luminal evacuation stimulation *(16)*. For gastric lavage, Singh Bajwa et al. employed a combination of coconut oil and sodium bicarbonate. They claimed that coconut oil lowers phosphide toxicity by forming a protective barrier over the gastric mucosa, reducing phosphine gas absorption. Furthermore, it aids in the neutralizing of HCl and, as a result, inhibits the release of phosphide from the pellet *(25)*. In another study, Shadnia et al. a 28 years old man with ALP intoxication was treated 6 hours after toxication with seven pellets manifesting severe headaches by coconut oil *(17)*. 42% survival was the benefit of the coconut oil and sodium bicarbonate gastric lavage in another study *(25)*. In another ongoing clinical trial, Paraffin Oil or Coconut Oil is going to be tested in 90 acute aluminum phosphide poisoning cases (NCT04724655). In the study of Dayananda et al., coconut oil administration for gastric lavage for 48 hours, reduced the mortality rate *(27)*. As mentioned, 33 AlP poisoning patients underwent thorough gastrointestinal lavage using a coconut oil and sodium bicarbonate combination that came to a survival rate of 42% *(25)*. Based on the Pajoumand study, gastric lavage with potassium permanganate, charcoal, and coconut oil was successful in one case *(28)*. A coconut oil and sodium bicarbonate mixture was used for gastric washing in 30 patients, and 40% survived *(30)*. In a 19-year-old girl, coconut oil gavage was performed but the patient died due to cardiac toxicity *(31)*. In another study, coconut oil administration was not associated with any improvement in mortality rate *(32)*.

Gastric decontamination by almond oil

Sweet almond oil was also suggested to be used orally, especially after being poisoned with ALP. In a study, a total of 35 adult Wistar rats were given sweet almond oil immediately after ingestion of ALP and again 30 minutes later; the results showed that intragastric sweet almond oil may extend survival time *(26)*. Almond oil-treated rats in the study of Maleki et al., showed significantly reduced mortality in comparison to control groups *(29)*. In vivo study by Rahimi et al. showed that almond oil-treated rats did not develop cardiac toxication *(33)*.

Gastric decontamination by Aloe vera

A unique technique was used to successfully treat rice pill-induced poisoning in a 30-year-old man,

according to Shakeri et al. As a result, they utilized 50 cc sodium bicarbonate and 1-2 L aloe vera syrup, followed by olive oil (150 cc olive oil was given every 2 hours). It was suggested that patients with acute AlP intoxication benefit from the co-administration of insulin-glucose (which increases glucose entry into cells) and that serum corticosteroid and other electrolytes, particularly magnesium and calcium, be closely monitored, as well as their relationship with blood glucose levels. As a result, it is suggested that the role of this pharmacological regimen in the treatment of such poisonings be determined *(34)*. The nephroprotective effect of Aloe vera in aluminum sulfate-exposed rats was studied by Mahor et al. The results of their study showed that creatinine, urea, and uric acid levels were significantly reduced after co-treatment with Al2(So4)3 and Aloe vera extract. their findings show that Aloe vera is beneficial in lowering Al toxicity in the kidney. As a result, Aloe vera and its active ingredient aloin can be utilized as adjuvant therapy for the prevention and control of renal impairment caused by aluminum sulfate *(35)*. The study by Leung et al. was based on the concept that some natural substances might have lead-binding capabilities and might be used as a food supplement to reduce lead accumulation. They conducted that While aloe vera was administered to counteract the 6 weeks of continuous administration of lead, there were no significant changes in the blood, liver, kidney, or bone. high doses of aloe vera resulted in a downward trend in blood lead levels. In the situation of acute severe lead poisoning, high doses of aloe vera and pectin resulted in a downward trend in blood lead levels. this research supported the idea that Aloe vera might be used as a safe supplement to reduce ingested lead buildup *(36)*. The purpose of Jakkala, Laxman K.'s research was to see if Aloe vera plant extract might protect albino rats' livers and kidneys against aluminum-induced degeneration. The results of his study showed that in comparison to the control group, the aluminum-treated group had altered characteristic architecture in liver and kidney sections. Animals who were given aluminum plus aloin demonstrated improvement in liver tissue structure and renal function, which was more pronounced in the long-term treatment group than in the short-term therapy group. aloin's preventive effect against aluminum toxicity was more effective in the 60-day therapy period than in the 30-day treatment period *(37)*.

Gastric decontamination by other oils

In a more recent study, vitamin E, N-acetyl cysteine, and olive oil administration came into the successful treatment of acute aluminum phosphide poisoning in a 33-year-old man *(38)*. Corn oil application is also being studied in new registered clinical trial (IRCT20191030045275N2). Glycerone or Dihydroxyacetone was also used in some limited series of cases, with clinical success *(39)* and is supported by an animal study *(40)*.

Conclusion

According to our findings, liquid paraffin may improve the outcomes of ALP poisoning, but it may also be associated with side effects. Evidence on coconut oil is still inconclusive, which might be attributable to the use of sodium bicarbonate in gastric lavage. Gastric lavage using aloe vera, olive oil, and almond oil has shown promising results, but further research is needed. To summarize, oil-based gastric lavage is related to lower mortality, while water-soluble cleaning techniques and the administration of activated charcoal should be avoided.

Declarations:

Acknowledgment:

We would like to thank the Clinical Research Development Unit of Peymanieh Educational and Research and Therapeutic Center of Jahrom University of Medical Sciences for providing facilities for this work.

Authors Contributions:

NS: Contributed to the review by conducting a comprehensive literature search and identifying relevant studies for inclusion.

SA: Provided expertise in the topic area and helped conceptualize the review's framework and scope. Contributed to the critical evaluation of the studies included and helped draft the manuscript.

FR: Conducted a thorough review of the literature and extracted data from the studies included in the review. Also contributed to the analysis and interpretation of the results, and helped revise the manuscript.

RS: Provided insight into the clinical implications of the review's findings, as well as practical recommendations for healthcare providers. Contributed to the final editing and formatting of the manuscript.

Conflict of interest:

There are no conflicts of interest in this study.

Research funding: None.

Data availability: No data are available for this review study.

REFERENCES

1. Hosseini SF, Forouzesh M, Maleknia M, Valiyari S, Maniati M, Samimi A. The molecular mechanism of aluminum phosphide poisoning in cardiovascular disease: Pathophysiology and diagnostic approach. Cardiovascular Toxicology. 2020 Oct;20*(5)*:454-61.

2. Jaiswal S, Verma RK, Tewari N. Aluminum phosphide poisoning: Effect of correction of severe metabolic acidosis on patient outcome. Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2009 Jan;13*(1)*:21.

3. Karimani A, Mohammadpour AH, Zirak MR, Rezaee R, Megarbane B, Tsatsakis A, Karimi G. Antidotes for aluminum phosphide poisoning–an update. Toxicology reports. 2018 Jan 1;5:1053-9.

4. Katira R, Elhence GP, Mehrotra ML, Srivastava SS, Mitra A, Agarwala R, Ram A. A study of aluminum phosphide (AlP) poisoning with special reference to electrocardiographic changes. The Journal of the Association of Physicians of India. 1990 Jul 1;38*(7)*:471-3.

5. Sheta AA, El-Banna AS, Abd Elmeguid R, Mohamed HE, Gad NH. A study of the predictive factors of mortality in acute poisoning with aluminum phosphide with special reference to echocardiography and SOFA score. Environmental Science and Pollution Research. 2019 Nov;26*(32)*:33135-45.

6. Lu MF, Nie SN. Progress in treatment of acute aluminum phosphide poisoning. Zhonghua lao dong wei sheng zhi ye bing za zhi= Zhonghua laodong weisheng zhiyebing zazhi= Chinese journal of industrial hygiene and occupational diseases. 2019 Nov 1;37*(11)*:877-80.

7. Ghimire R, Utyasheva L, Pokhrel M, Rai N, Chaudhary B, Prasad PN, Bajracharya SR, Basnet B, Das KD, Pathak NK, Baral MP. Intentional pesticide poisoning and pesticide suicides in Nepal. Clinical toxicology. 2021 Jun 11:1-7.

8. Ramadan N. Aluminum phosphide poisoning; a case of survival. Asia Pacific Journal of Medical Toxicology. 2019 Mar 1;8*(1)*:28-9.

9. Bashardoust B, Farzaneh E, Habibzadeh A, Sadeghi MS. Successful treatment of severe metabolic acidosis due to acute aluminum phosphide poisoning with peritoneal dialysis: a report of 2 cases. Iranian journal of kidney diseases. 2017 Mar 1;11*(2)*:165.

10. Pannu AK, Bhalla A, Gantala J, Sharma N, Kumar S, Dhibar DP. Glucose-insulin-potassium infusion for the treatment of acute aluminum phosphide poisoning: an open-label pilot study. Clinical Toxicology. 2020 Oct 2;58*(10)*:1004-9.

11. Oghabian Z, Mehrpour O. Treatment of aluminium phosphide poisoning with a combination of intravenous glucagon, digoxin and antioxidant agents. Sultan Qaboos University Medical Journal. 2016 Aug;16*(3)*:e352.

12. Neuvonen PJ, Olkkola KT. Oral activated charcoal in the treatment of intoxications. Medical toxicology and adverse drug experience. 1988 Feb;3*(1)*:33-58.

13. Mirakbari SM. Hot charcoal vomitus in aluminum phosphide poisoning-A case report of internal thermal reaction in aluminum phosphide poisoning and review of literature. Indian journal of anaesthesia. 2015 Jul;59*(7)*:433.

14. Agrawal VK, Bansal A, Singh RK, Kumawat BL, Mahajan P. Aluminum phosphide poisoning: Possible role of supportive measures in the absence of specific antidote. Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2015 Feb;19*(2)*:109.

15. Hashemi-Domeneh B, Zamani N, Hassanian-Moghaddam H, Rahimi M, Shadnia S, Erfantalab P, et al. A review of aluminium phosphide poisoning and a flowchart to treat it. Arh Hig Rada Toksikol 2016;67:183-93. doi: 10.1515/aiht2016-67-2784

16. Sanaei-Zadeh H, Mahdi Marashi S. Gastric decontamination in aluminium phosphide poisoning: a case against the use of water-based solutions. Arhiv za higijenu rada i toksikologiju. 2016 Dec 14;67*(4)*:364-5.

17. Shadnia S, Rahimi M, Pajoumand A, Rasouli MH, Abdollahi M. Successful treatment of acute aluminium phosphide poisoning: Possible benefit of coconut oil. Hum Exp Toxicol. 2005;24:215–8.

18. Harned HS, Davis Jr R. The ionization constant of carbonic acid in water and the solubility of carbon dioxide in water and aqueous salt solutions from 0 to 50. Journal of the American Chemical Society. 1943 Oct;65*(10)*:2030-7.

19. Perry HE. Rodenticides. In: Shannon MW, Borron SW, Burns MJ, eds. Haddad and Winchester's clinical management of poisoning and drug overdose. Philadelphia, PA: Saunders – Elsevier; 2007: 1218, 1225–6.

20. Borron SW, Burns MJ. Haddad and Winchester's clinical management of poisoning and drug overdose. Saunders/Elsevier,; 2007. Mirakbari SM. Hot charcoal vomitus in aluminum phosphide poisoning-A case report of internal thermal reaction in aluminum phosphide poisoning and review of literature. Indian journal of anaesthesia. 2015 Jul;59*(7)*:433.

21. Sharif F, Crushell E, O'driscoll K, Bourke B. Liquid paraffin: a reappraisal of its role in the treatment of constipation. Archives of disease in childhood. 2001 Aug 1;85*(2)*:121-4.

22. Darwish RT, Sobh ZK, Hamouda EH, Saleh EM. The efficacy of Coenzyme Q10 and liquid paraffin oil in the management of acute aluminum phosphide poisoning. Toxicology Research. 2020 Jul;9*(4)*:444-53.

23. Goswami M, Bindal M, Sen P, Gupta SK, Avasthi R, Ram BK. Fat and oil inhibit phosphine release from aluminium phosphide--its clinical implication. Indian journal of experimental biology. 1994 Sep 1;32*(9)*:647-9.

24. J.K. Aronson. Paraffins. Meyler's Side Effects of Drugs: The International Encyclopedia of Adverse Drug Reactions and Interactions (Fifteenth Edition),Elsevier, 2006,Pages 2693-2697, ISBN 9780444510051, https://doi.org/10.1016/B0-44-451005-2/01478-9.

25. Singh Bajwa SJ, Bajwa Kaur SK, Kaur J, Singh K, Panda A. Management of celphos poisoning with a novel intervention: A ray of hope in the darkest of clouds. Anesth Essays Res. 2010;4:20–4.

26. Saidi H, Shojaie S. Effect of sweet almond oil on survival rate and plasma cholinesterase activity of aluminum phosphide-intoxicated rats. Human & experimental toxicology. 2012 May;31*(5)*:518-22.

27. Dayananda VP, Satish Kumar MN, Rakesh Kumar B. Coconut oil as an adjuvant to magnesium sulphate therapy in acute aluminum phosphide consumption. Int J Anesth Res. 2018 Feb 27;6*(2)*:509-14.

28. Pajoumand A, Jalali N, Abdollah M, Shadnia S. Survival following severe aluminium phosphide poisoning. Journal of Pharmacy Practice and Research. 2002 Dec;32*(4)*:297-9.

29. Maleki A, Hosseini MJ, Rahimi N, Abdollahi A, Akbarfakhrabadi A, Javadian N, Amiri S, Behnoush B, Dehpour AR. Adjuvant potential of selegiline in treating acute toxicity of aluminium phosphide in rats. Basic & clinical pharmacology & toxicology. 2019 Jul;125*(1)*:62-74.

30. Devi KJ, Soreingam K, Singh VK. Role of coconut oil and soda bicarbonate in gastric lavage in the management of celphos poisoning. Journal of Health Research and Reviews. 2016 Jan 1;3*(1)*:31.

31. Ghosh S, Biswajit M, Chatterjee PK, Saurabh S, Sudeep KN, Shukla P, Sharmistha C. Aluminum Phosphide Poisoning Presenting like Acute Myocardial Infarction in a Young Girl. The Journal

of the Association of Physicians of India. 2018 Oct 1;66*(10)*:92-3.

32. Vaidyanathan R, Hg A, Noor A, Adarsh S. Comparative study of management of aluminium phosphide poisoning-our experience. J Evid Based Med Healthcare. 2020;7:2349-562.

33. Rahimi N, Abdolghaffari AH, Partoazar A, Javadian N, Dehpour T, Mani AR, Dehpour AR. Fresh red blood cells transfusion protects against aluminum phosphide-induced metabolic acidosis and mortality in rats. PloS one. 2018 Mar 28;13*(3)*:e0193991.

34. Shakeri M, Soroosh D, Shakeri H, Kalani N, Hatami N, Foroughian M. Successful Treatment of Acute Aluminum Phosphide Poisoning by Aloe Vera Syrup: A Case Report. International Journal of Medical Toxicology and Forensic Medicine. 2021;11*(2)*:33016-.

35. Mahor G, Ali SA, Parveen N. Aloin from Aloe Vera leaves: A potential natural aluminium detoxificant. Biosci Biotech Res Comm. 2019;12*(2)*:531-8.

36. Leung PC, Siu WS, Erik CH. A Food Supplement with Lead Chelating Effects: A Preliminary Study. J Heavy Met Toxicity Dis. 2017;2:1.

37. Jakkala, Laxman K. "Aloe vera protects the aluminium induced degenerative changes in liver and kidney of albino rats , Rattus norvegicus.", Journal of Global Biosciences. Vol. 4(8), 2015 pp. 3158-3164.

38. Mohammad Hossien Kamaloddini, Parvin Zohoorian, Mahdi Foroughian , Sara Hemmati Awli, Ali Teimouri. Successful Treatment of Acute Aluminum Phosphide Poisoning: Possible Benefit of Olive Oil-A Case Report. Updates in Emergency Medicine, 2021; 1*(1)*.

39. Oghabian Z, Ahmadi J, Pakravan S, Dabaghzadeh F, Heidari MR, Tajaddini S, Karami-Mohajeri S. Successful treatment of aluminium phosphide poisoning by dihydroxyacetone: A two-case report study. Journal of clinical pharmacy and therapeutics. 2020 Oct;45*(5)*:1194-8.

40. Ahmadi J, Joukar S, Anani H, Karami-Mohajeri S. Dihydroxyacetone as a definitive treatment for aluminium phosphide poisoning in rats. Arhiv za higijenu rada i toksikologiju. 2018 Jun 27;69*(2)*:169-76.