

Acute aluminium phosphide poisoning: an update

急性磷化鋁中毒：最新資料

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Acute aluminium phosphide poisoning is an extremely lethal poisoning. Ingestion is usually suicidal in intent, uncommonly accidental and rarely homicidal. Unfortunately the absence of a specific antidote results in very high mortality and the key to treatment lies in rapid decontamination and institution of resuscitative measures. This article aims to identify the salient features and mechanism of aluminium phosphide poisoning along with its management strategies and prognostic variables. (*Hong Kong j.emerg.med.* 2008;15:152-155)

急性磷化鋁中毒極為致命。服食之原因通常為蓄意自殺，意外並不普遍，而謀殺更為罕有。不幸地，因沒有特定的解毒劑而引致很高的死亡率。治療的關鍵在於迅速除污及進行復甦措施。本文旨在識別磷化鋁中毒的顯著特徵及機制，連同處理的策略及預後的變數。

Keywords: Aluminum compounds, pesticides, phosphines, shock, suicide

關鍵詞：鋁化合物，殺蟲藥，磷化氫，休克，自殺

Introduction

Aluminium phosphide (AIP) is a solid fumigant which has been in extensive use since the 1940s. It has rapidly become one of the most commonly used grain fumigants because of its properties which are considered to be near ideal; it is toxic to all stages of insects, highly potent, does not affect seed viability, is free from toxic residues and leaves little residue on food grains.¹

Unfortunately, its widespread use has been associated with a galloping rise in the incidence of alphas poisoning. Recent studies have indicated that the number of deaths so far have exceeded the number of fatalities in the Bhopal gas tragedy.² In a study conducted by Siwach and Gupta, aluminium phosphide poisoning was found to be the most common cause of acute poisoning in India.³ It was also found to be the most common cause of suicidal death in north India.⁴ Poisoning shows a distinct male preponderance in the lower socio-economic strata and in rural areas, probably due to the heavy social stress burden in this group.⁵

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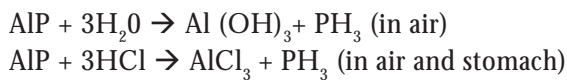
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Physical and chemical properties

Aluminium phosphide is available in the form of 3 gm tablets or 0.6 gm pellets. Tablets are dark brown or grayish in colour and contain two compounds: aluminium phosphide and aluminium carbonate in a ratio of 56:44. Aluminium phosphide is the active component of the mixture whereas aluminium carbonate is added to prevent self-ignition of phosphine

(PH₃) which is liberated when aluminium phosphide comes in contact with moisture:



Each 3 gm tablet releases 1 gm and each 0.6 gm pellet 0.2 gm of phosphine gas on exposure to moisture and leaves behind a non-toxic grayish residue of aluminium hydroxide. Phosphine gas is colourless and odourless. However on exposure to air it gives a foul odour (garlicky or decaying fish) due to the presence of substituted phosphines and diphosphines.

Mechanism of action

After ingestion of aluminium phosphide, phosphine gas is released in the stomach which after absorption into the circulation results in early signs and symptoms. However, some of the aluminium phosphide is absorbed and metabolised in the liver with slow release of phosphine causing delayed onset of toxicity.⁶ Phosphine is excreted through the breath and urine. AIP causes widespread organ damage due to cellular hypoxia as a consequence of non-competitive inhibition of the enzyme cytochrome oxidase of the mitochondria.^{7,8} Chugh et al. has shown that ingestion leads to high superoxide dismutase activity and low catalase levels that result in increased formation of free radicals and accelerated lipid peroxidation.⁹ Lipid peroxidation in turn results in damage to cellular membrane, disruption of ionic barrier, nucleic acid damage and cell death. Focal myocardial necrosis and changes in membrane action potential as a result of altered permeability to sodium, magnesium and calcium manifest as various forms of ECG abnormalities and cardiac arrhythmias.

The various exposure limits for phosphine gas have been defined as:

- Permissible exposure limit (PET): 0.3 ppm over an 8 hr shift
- Short term exposure limit (STEL): 1 ppm
- Immediately dangerous to life and health: 200 ppm
- Lethal in 30 min: 400-600 ppm

Clinical features¹⁰

The presenting symptoms depend on the route of administration. Poisoning by inhalation produces irritation of the mucous membrane, dizziness, easy fatigability, nausea, vomiting, headache and diarrhoea in mild exposure. Ataxia, numbness, paraesthesia, muscle weakness, paralysis, diplopia and jaundice result from moderate degree of exposure. In severe cases of inhalational poisoning, the patient presents with acute respiratory distress syndrome (ARDS), congestive cardiac failure, convulsion and coma.

Nausea, vomiting and abdominal pain are the earliest symptoms that appear after ingestion. Gastrointestinal symptoms which present in moderate to severe poisoning are excessive thirst, abdominal pain and epigastric tenderness while cardiovascular abnormalities seen are profound hypotension, dry pericarditis, myocarditis, acute congestive heart failure and arrhythmias. Involvement of the respiratory system may lead to dyspnoea, which may progress to Type I or II respiratory failure. Nervous system manifestations include headache, dizziness, altered mental status, convulsion, acute hypoxic encephalopathy and coma. Renal and hepatic failures are the other manifestations. Some rare findings in aluminium phosphide poisoning are muscular weakness, wasting, tenderness in proximal lower limb muscles, bleeding diathesis due to capillary damage, acute adrenocortical insufficiency and the pseudoshock syndrome due to impaired fluid distribution which results in micro-circulatory failure.¹¹

Diagnosis¹²

A positive history of ingestion is the basis of diagnosis in most cases. The presence of typical clinical features, garlicky odour from the mouth and highly variable arrhythmias in a young patient with shock and no previous history of cardiac disease points towards aluminium phosphide poisoning. Confirmation can be done by the Silver Nitrate Test.¹³ In this test, 5 ml of gastric aspirate and 15 ml of water are put in a flask and the mouth of the flask is covered by filter paper impregnated with 0.1N silver nitrate. The flask is heated at 50°C for 15 to 20 min. If phosphine is present

the filter paper turns black. For performing the test on exhaled air, the silver nitrate impregnated filter paper is placed on the mouth of the patient and the patient is asked to breath through it for 15-20 minutes, blackening of the paper indicates the presence of phosphine in breath. The sensitivity of the test is 100% and 50% vis-à-vis gastric fluid and exhaled air respectively. However the most specific and sensitive method for detecting the presence of PH_3 in blood/air is gas chromatography.¹⁴ For spot sampling of phosphine in air, detector tubes and bulbs are available commercially.^{15,16}

Laboratory investigations

Laboratory evaluation is mainly done to assess the prognosis. Leucopenia indicates severe toxicity. Increased SGOT or SGPT and metabolic acidosis indicate moderate to severe ingestional poisoning. Electrolyte analysis shows decreased magnesium while potassium may be increased or decreased.¹⁷ Measurement of plasma renin is significant as its level in blood carries a direct relationship with mortality and is raised in direct proportion to the dose of pesticide. The serum level of cortisol is usually found to be decreased in severe poisoning.¹⁸ Chest X-ray may reveal hilar or perihilar congestion if ARDS develops. ECG shows various manifestations of cardiac injury (ST depression or elevation, bundle branch block, ventricular tachycardia, ventricular fibrillation).¹⁹⁻²² Wall motion abnormalities, generalised hypokinesia of the left ventricle, decreased ejection fraction and pericardial effusion can be seen in echocardiography.¹²

Fatal dose

The specified fatal dose is 0.15-0.5 gm. However, most of the patients present with ingestion of three or more tablets which invariably results in death.

Management

The most important factor for success is resuscitation of shock and institution of supportive measures as soon as possible. Intravenous access should be established

and 2-3 litres of normal saline are administered within the first 8-12 hr guided by central venous pressure (CVP) and pulmonary capillary wedge pressure (PCWP). The aim is to keep the CVP at around 12-14 cm of water.²³ Some workers have recommended rapid infusion of saline (3-6 litres) in the initial 3 hr.²⁴ Low dose dopamine (4-6 $\mu\text{g}/\text{kg}/\text{min}$) is given to keep systolic blood pressure >90 mm Hg. Hydrocortisone 200-400 mg every 4-6 hr is given intravenously to combat shock, reduce the dose of dopamine, check capillary leakage in lungs (ARDS) and to potentiate the responsiveness of the body to endogenous and exogenous catecholamines.¹⁰⁻¹² Oxygen is given for hypoxia. ARDS requires intensive care monitoring and mechanical ventilation. To reduce the absorption of phosphine, gastric lavage with potassium permanganate (1:10,000) is done. Permanganate is used as it oxidizes PH_3 to form non-toxic phosphate. This is followed by a slurry of activated charcoal (approximately 100 gm) given through a nasogastric tube. A cathartic (liquid paraffin) is given to accelerate the excretion of aluminium phosphide and phosphine. Antacids and proton pump blockers are added for symptomatic relief.^{6,11,12}

Phosphine excretion can be increased by maintaining adequate hydration and renal perfusion with intravenous fluids and low dose (4-6 $\mu\text{g}/\text{kg}/\text{min}$) dopamine. Diuretics like frusemide can be given if systolic blood pressure is >90 mm Hg to enhance excretion as the main route of elimination of phosphine is renal.¹⁵ All types of ventricular arrhythmias are seen in these patients and the management is the same as for arrhythmias in other situations.¹⁵ Bicarbonate level less than 15 mEq/L requires sodabcarb in a dose of 50-100 mEq intravenously every 8 hour till the bicarbonate level rises to 18-20 mEq/L. Patients may require up to 300-500 ml of sodium bicarbonate.²² Dialysis may be required for severe acidosis and acute renal failure. Magnesium sulphate use (both high and low dose) did not improve survival in controlled clinical trials. Hence its use is not recommended.²⁵

Prognostic markers

Development of refractory shock, ARDS, aspiration

pneumonitis, anaemia, metabolic acidosis, electrolyte imbalance, coma, severe hypoxia, gastrointestinal bleeding, and pericarditis are associated with poor prognosis.

The outcome correlates best with the number of vomiting the patient gets after ingestion and the severity of hypotension the patient develops.²⁶ It does not correlate with the ingested dose.²⁶ The average time interval between intake of poison and death is three hours with a range of 1-48 hours, 95% of the patients die within 24 hours and the commonest cause of death in this group is arrhythmia. Death after 24 hours is due to shock, acidosis, ARDS and arrhythmia. The mortality rate is highly variable, ranging from 37-100% and can reach more than 60% even in experienced and well equipped centres.

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