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Investigation of Possible Antidotal Effects of Activated Charcoal, Sodium Bicarbonate, Hydrogen Peroxide and Potassium Permanganate in Zinc Phosphide Poisoning

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Zinc phosphide, a commonly used rat poison in Kenya was mixed with maize flour in a concentration of 0.15 % w/w and fed to a group of 60 experimental mice for 3 hours. The mice were then randomly divided into 5 equal groups, A, B, C, D and E. To group A, B, C and D was administered 1 ml of activated charcoal (3 % w/v), sodium bicarbonate (10 % w/v), hydrogen peroxide (0.5 % v/v) and potassium permanganate (1:5000), respectively. Group E was given 1 ml distilled water and used as control. All five groups were observed for symptoms of toxicity, often culminating in death. The observations were continued over a period of 36 hours. Results of the experiment showed that all 4 test substances minimized the lethal effect of zinc phosphide. Although no attempt was made to quantify the antidotal effect of the 4 substances, activated charcoal appeared to have a higher effect than the others, while potassium permanganate had a low rating.

Key words: Z inc phosphide, rat poison, antidote

INTRODUCTION

Zinc phosphide, a dark crystalline powder with a rotten-fish-like odour, is extensively used as a rodenticide under such international brand names as ZP®, ZP tracking powder®, Zinc-Tox®, Gopha-Rid®, Ratol® and Ridall® [1-3]. In Kenya it is available under the trade names Ratkil®, Red Cat®, Rat Rid® and Rat & Rat®. It is usually packed in small plastic packets containing 500 mg of the poison and inserted in grey hard paper envelope together with a leaflet summarizing information on its use and emergency treatment in the event of human poisoning.

Intentional zinc phosphide poisoning is common in Kenya [4]. The Government Chemists Department (Nairobi, Kenya) has investigated several forensic cases involving zinc phosphide rat poison (personal communication). Two such cases are given below.

Case 1
A mother (Mrs. M.C.) gave her 3-year-old son tea poisoned with zinc phosphide on the 23/7/93 at around 6.00 p.m. The child died the following day and the body was discovered in a nearby bush several days later. The mother was arrested on a homicide charge. Chemical analysis of the postmortem material (stomach, liver) confirmed zinc phosphide poisoning.

Case 2
On 17/7/93 at about 5.00 pm the deceased (Miss W.M.) was found dead in bed after the door of her room was forced open. An empty and used packet of Rat & Rat® poison was found on her bedside. Chemical analysis of postmortem material revealed zinc phosphide poisoning.

Metallic (zinc, aluminium, magnesium) phosphides release phosphine gas, once in contact with gastric acid. The toxic effects seen in zinc phosphide poisoning are attributed to the released phosphine [1,2,5]. A literature survey revealed that there is no widely accepted antidote for zinc phosphide poisoning.

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However, some manufacturers recommend the use of sodium bicarbonate even though there is no scientific data to support such treatment. Activated charcoal is an effective adsorbent, while the potassium permanganate and hydrogen peroxide can oxidize the phosphide to phosphate.

In the present work, the authors set out to investigate the effectiveness of activated charcoal, sodium bicarbonate, hydrogen peroxide and potassium permanganate in zinc phosphide poisoning using an animal model.

EXPERIMENTAL

Material and methods

Experimental mice, 6-8 weeks old and weighing 20-25 g were obtained from National Public Health Laboratory (Ministry of Health, Nairobi, Kenya). Maize flour-zinc phosphide mixture was fed to mice before the administration of the 4 substances under investigation. During the preliminary experiments it was necessary to establish a suitable concentration of the poison in the feeding mixture taking into account the lethal dose and the total amount of the maize flour ingested by each animal.

All experiments were carried out in triplicate.

Preparation maize flour-zinc phosphide feeding mixture

Approximation of the lethal dose that would kill 100 % (LD_{100}) of the experimental mice was determined first. Thirty mice were randomly divided into 5 groups of 6 animals each. A freshly prepared aqueous suspension of zinc phosphide powder was administered to the animals in increasing doses using a mouth tube. Mice in the groups I-V received a 1-ml suspension containing 0.5, 1.0, 1.2, 1.5 and 1.8 mg zinc phosphide, respectively, and observed over a period of 36 h.

The LD_{100} of zinc phosphide obtained was 1.2-1.5 mg (about 60-75 mg/kg). In literature the LD_{50} of zinc phosphide in mice is given as 45.7 mg kg [6].

To determine the maize flour consumption of the mice, 60 animals were starved for 24 h prior to the experiment. They were then divided into groups of 12 and provide with 40 g of the flour appropriately placed in petri dishes for feeding. It was observed that after 3 h nearly all mice had stopped feeding. The amount of feed consumed was then calculated by subtracting the amount remaining. The amount ingested per mouse was 1.1 - 1.4 g (mean 1.25 g).

From the above data, a mixture of 1.5 mg zinc phosphide per gram of maize flour (0.15% w/w) was adopted as appropriate feeding mixture. When this mixture was fed to several groups of mice, the fatality was 91.7-100% within 36 h.

The antidotal effect of the test substances

Sixty experimental mice weighing 20-25 g were deprived of food for 24 h prior to the experiment. They were then fed on zinc phosphide-maize flour mixture (0.15 % w/w) for 3 hours. The mice were then randomly divided into groups of twelve. Each animal in the 5 groups was treated with 1 ml of the test substances as shown in Table 1:

Table 1: Antidotal test substances administered to the mice

Group	Substance
A	Activated charcoal (3 % w/v)
B	Sodium bicarbonate (10 % w/v)
C	Hydrogen peroxide (0.5 % v/v)
D	Potassium permanganate (1:5000)
E	Distilled water

Drinking water in suitable containers was provided throughout the experimental period. The five groups of mice were observed continuously over a period of 36 h. Mice were removed from the cages immediately after death to preclude the others from cannibalizing on them, a common phenomenon in mice.

RESULTS

Results of the experiment are summarized in Figure 1. The results shown represent the mean percentage survival of three experiments. As expected in biological experiments, it was difficult to replicate the results but there was consistency of trend in all 3 experiments. Activated charcoal had better antidotal effect while potassium permanganate appeared to be less effective than the others. No attempt was made to vary the concentration of each of the test substances. Therefore, the results must be interpreted cautiously. Indeed, varying the concentration of the four substances would be expected to give comparatively different results.

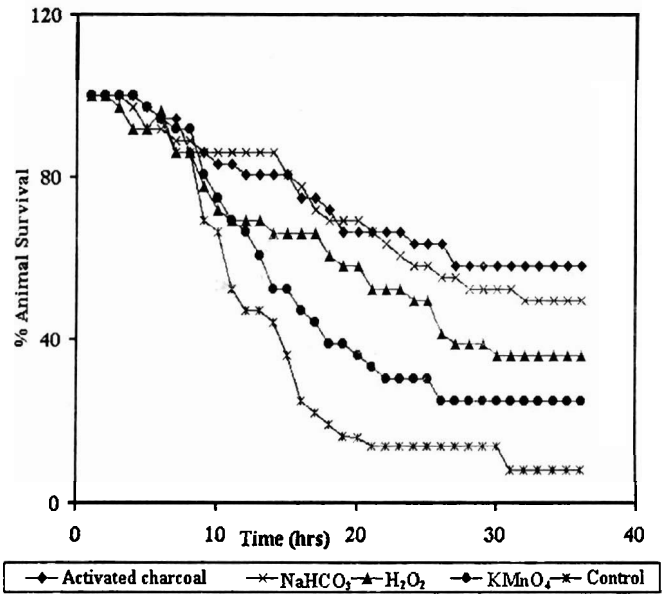

Figure 1: The antidotal effect of the test substances on zinc phosphide poisoning

DISCUSSION

Zinc phosphide is currently the most widely used rat poison in Kenya and possibly other East and Central African countries. It is cheap, readily available and reputed to be very effective. During a retrospective study of poisoning cases in Kenyan hospitals covering the period 1991-1993, eighty five cases of poisoning with rat poison were recorded [4]. In the case histories of patients, the poisoning agent was positively identified by the trade name or simply referred to as "rat poison powder". A quick survey of the Kenyan market shows that it is the only rat poison sold in powder form, the others being presented as liquids or impregnated pellets.

Figure 1 represents a biphasic response. In the first phase lasting up to 8 hours, mice were dying at approximately the same rate regardless of the intervention measures. In the second phase, the antidotal effect of the test substances is evident. Few deaths were recorded 24 hours after administration of the test substances. In explaining these observations, one needs to take into account the fact that mice were fed on zinc phosphide for three hours prior to administration of test antidotal substances. Within that time a significant amount of poison must have been absorbed from the gastrointestinal tract, which could not be neutralized by the test substances.

This situation closely approximates to what happens in human poisoning. Usually, by the time a poisoned patient is brought to the hospital, significant amount of the poison would have been absorbed. Thus the final outcome will be determined by how soon treatment is initiated. This clearly means that emergency measures, such as induced vomiting must be given at the earliest possible time.

In the case histories of zinc phosphide poisoned patients, gastrointestinal disturbance (nausea, vomiting) is a common feature. This is consistent with published literature on zinc phosphide poisoning [5,7]. The management of the 85 cases of poisoning cited above varied considerably and generally did not involve administration of antidotes.

Results reported in this paper suggest that all 4 substances could be of value in treatment of zinc phosphide poisoning in humans. It was however, not the intention of the authors to work out optimum doses of each of the 4 substances but to show that they have a role in management of zinc phosphide poisoning. Indeed considering that they would be used during gastric lavage or stomach washout, it is

not possible to simulate their use in humans using an animal model. This is due to repeated use of each chemical during such procedures. In which case activated charcoal and sodium bicarbonate would be left in the stomach after gastric lavage while potassium permanganate and hydrogen peroxide would not. Thus the total amount of substance used in gastric lavage and stomach washout would be many times more than is implied by this paper. In the conscious patient, the substance should be administered in small amounts while encouraging the patient to vomit after 5-10 minutes.

Zinc phosphide is a cellular poison, causing non-competitive inhibition of cytochrome oxidase. Thus a multiplicity of symptoms is observed, the most prominent ones being cardiovascular. A common feature of zinc phosphide poisoning is the delayed toxicity, often manifested as cardiovascular edema. For most common poisons, the acute phase of poisoning ends within 24 hours, and the patient either recovers or succumbs to the effect of the poison.

In the present work, mice were still dying 36 hours after administration of the poison. It is recommended that patients poisoned with zinc phosphide should be kept under observations for at least 3 days even if symptoms of poisoning are absent.

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