Rodenticide poisoning in children: A study of clinical profile and electrocardiographic changes

Sheeja Sugunan, Rekha Krishnan, K K Santhosh Kumar, S Geetha

From Department of Paediatrics, Government Medical College, Thiruvananthapuram, Kerala, India

Correspondence to: Dr. Sheeja Sugunan, Department of Paediatrics, Government Medical College, Kedaram Nagar, Thiruvananthapuram - 695 004, Kerala, India. Phone: +91-9446613974. E-mail: sheejavimalk@gmail.com

Received – 05 December 2016 Initial Review – 24 January 2017 Published Online – 04 February 2017

ABSTRACT

Objectives: To study the clinical profile and electrocardiographic (ECG) changes in rodenticide poisoning in children. **Methods:** Patients admitted with a history of ingestion of rat poison between October 2014 and October 2016 were included in the study. Clinical history was taken in detail, and stomach wash samples were sent for toxicological analysis. Continuous ECG monitoring was done in all cases. Investigations to assess organ functions and coagulation profile were done at admission and repeated as indicated. **Results:** There were 17 cases of rodenticide poisoning. Zinc phosphide was the rodenticide identified in 50% of cases, bromodiolone in 30%, and yellow phosphorous in 20% cases. Only 23% presented within 1 h of ingestion and only 12% received stomach wash from referring hospital. Out of the 17 cases, 12 cases (70%) were symptomatic, of which 42% had minor symptoms such as vomiting and abdominal pain and 58% had major symptoms including dysrhythmias, shock, coagulation abnormality, hepatic failure, and seizures. ECG changes were observed in 7 cases (42%), and coagulopathy was seen in 2 (12%) cases of which one had hepatic failure. The mean time of onset of ECG changes was 19.7 h (range 9-36 h). The overall mortality rate was 17.6%. Cardiac arrhythmia was the most common cause of death (66%). **Conclusion:** Zinc phosphide has been detected as the most common chemical being used as domestic rodenticide. Transient rate abnormalities, metabolic acidosis, fever, and leukocytosis are early markers of toxicity and they should be looked for in all cases. General public, medical, and paramedical personnel should be made aware of the toxic nature of rodenticides.

Key words: *Bromodiolone, Children, Electrocardiographic changes, Rodenticide poisoning, Zinc phosphide*

Insecticides and pesticides are increasingly becoming the most common agents of poisoning in children [1]. Rodenticides are among the most toxic substances regularly found in homes. There are no studies on domestic rodenticide poisoning in children. It is imperative to know the different types of rodenticides available, their chemical composition and toxicity symptoms. Mortality rate as high as 77% has been reported [2]. Most of the studies on rodenticide poisoning included mainly adults [2-4]. Poisoning in adults and children are not the same. In adults, ingestions are usually suicidal in intent with ingestion of large quantities compared to children where poisoning is commonly accidental and quantity ingested is also often not known. Very small quantity ingestions can occur which may manifest with only subtle symptoms initially. This study was conducted to study the clinical presentation, risk factors for mortality and early markers of toxicity of rodenticide poisoning in children.

METHODS

This observational, hospital based study was conducted at pediatric intensive care unit of a Government Medical College, Thiruvananthapuram from October 2014 to October 2016. All children <12 years of age, admitted with a history of ingestion of rat poison during the study period, were included in the study after obtaining ethical committee clearance. Clinical history was taken in detail with reference to age, sex, nature of poisoning, the time elapsed between consumption and reporting to the hospital, intent, symptomatology, duration of stay in the hospital and outcome.

All children who presented within 4 h received stomach wash and samples were sent for toxicological analysis. Blood counts, renal function test, liver function test, and coagulation profile were sent at admission in all cases. Continuous electrocardiographic (ECG) monitoring was done in all cases and ECG print taken at 8 h intervals or earlier in the case of presence of any symptom. As most children at admission were either asymptomatic or only had minor symptoms arterial blood gas analysis was performed whenever an ECG abnormality was observed. For continuous variables mean and standard deviation was calculated, and the categorical variables were analyzed by Chi-square test.

RESULTS

Out of 146 poisoning cases, there were 17 cases of alleged rodenticide poisoning. Out of these, 9 were male and 8 were

female. 94% of the cases occurred in children <4 years of age including 2 in infancy. The only case of rodenticide poisoning in an older child occurred in a 7-years-old female child which was homicidal in nature. 4 cases (24%) presented within 1 h of ingestion, 11 cases (65%) presented within 6 h, 1 case presented after 24 h, and 1 after 4 days of ingestion. 12% received stomach wash from the referring hospital. In 10 cases (60%), the chemical ingested was identified as it was either brought by the care taker or detected in toxicological analysis of stomach wash content. 5 (50%) contained zinc phosphide, 3 (30%) bromodiolone, and 2 (20%) yellow phosphorous. Toxicological analysis of stomach wash content revealed the presence of toxin (zinc phosphide) in only 1 case. 12 of the 17 cases were symptomatic, of which 5 (42%) had minor symptoms such as vomiting and abdominal pain and 7 (58%) had major symptoms including dysrhythmias, shock, coagulation abnormality, hepatic failure, and seizures.

About 47% of the children developed fever more than 100.4°C, 12-72 h (mean 33 h) after ingestion that lasted for a maximum of 48 h. 3 of the children had only a single spike of fever. 70% of children with cardiac manifestations had associated fever ($p<0.1$). Blood culture was negative in all cases. Leukocytosis with total count more than 12×109/L with lymphocytic predominance was present in 8 (47%) of patients at admission. 75% of patients with leukocytosis were clinically symptomatic. None of the patients in the asymptomatic group had leukocytosis ($p<0.05$). 5 (71%) patients with ECG changes had leukocytosis. Only 2 children had hypomagnesemia and both these children had ECG changes. Serum sodium, potassium, and calcium were normal in all children. Renal and liver function tests were normal in 16 out of 17 patients. Only one patient had renal and liver function derangement but had history of co-ingestion of paracetamol in toxic dose and presented on day 4 with fulminant hepatic failure.

ECG changes were observed in 7 (42%) cases. The mean time of onset of ECG changes was 19.7 h (range 9 to 36 h). In cases with ECG changes, all had more than 1 abnormal ECG findings. The 1st ECG change observed was transient intermittent bradycardia in 3 cases (42%) and transient sinus tachycardia in 4 cases (58%). All the 7 cases subsequently developed other ECG changes including global T-wave inversion in 5 cases, QT prolongation in 2 cases, wide QRS complex, ST elevation, ventricular tachycardia, and junctional rhythm in 1 case each. ECG changes persisted for an average of 6.5 days (range 3-10 days). Blood gas analysis was performed, in 6 out of 7 cases with ECG changes and decompensated metabolic acidosis (pH<7.35 with HCo3<18) was present at the time of occurrence of ECG changes. Associated respiratory alkalosis was present in 3 cases (50%). Metabolic acidosis persisted for an average of 6.4 days (range 3-10 days).

Coagulation abnormality was found in only 2 cases (11.7%) of which, one had co-ingestion of paracetamol. In the another case, bromodiolone was accidentally ingested by an 11-month-old child who had prolonged prothrombin time (international normalized ratio> 10) and activated partial thromboplastin time (145 s), 6 h after ingestion, which was corrected with vitamin K and fresh frozen plasma. The baby did not have any clinical bleeding and her coagulation profile remained normal at follow-up 2 weeks later. Baby also developed lymphocytic leukocytosis and fever 24 h after admission which subsided 72 h later without antibiotics. She also had intermittent head sweating and global T-wave inversion in ECG which persisted for 2 weeks.

The overall mortality rate was 17.6%. It included 2 cases with cardiac toxicity and 1 case with fulminant hepatic failure. Cardiac causes of death included 1 case of refractory ventricular tachycardia and 1 case of sudden cardiac arrest. Among children with ECG changes, the mortality was 28.5%.

DISCUSSION

Rodenticide poisoning is common in India, and many parts of the world. 80% of single exposures to rodenticides involve children younger than 6 years [5]. In our study, majority of the patients (94%) were below 6 years of age. The cause of poisoning was accidental in 16 cases (94%) and homicidal in 1 case. In the study on Zinc phosphide poisoning by Rahman et al. [6] 83.6% was suicidal and 16.4% accidental in intent. 91% of patients included in that study were more than 10 years of age.

Only 23% cases presented within 1 h of ingestion probably signifying the fact that care takers are not really aware of the toxicity of rodenticides. Only 2 children out of 12 referred cases received stomach wash from the referring hospital. Rodenticides containing anticoagulants are the most common rodenticides in use in many parts of the world including the US where it accounts for 78% of rodenticides being used [5], but in our study Zinc phosphide was found to be the most common accounting for 50% of identified rodenticides, while superwarfarins accounted for 30%. The toxin could be identified in toxicological analysis of stomach wash contents in only 1case probably due to late presentation, prior stomach wash from a local hospital or inappropriate analytical methods.

Aluminum and zinc phosphides are highly toxic, low cost rodenticides. Upon ingestion of metal phosphides, phosphine gas (PH3) is released on contact with moisture or hydrochloric acid in the stomach [6]. Toxicity of phosphine is related to oxidant free radicals and associated inhibition of enzymes of metabolism, such as cytochrome c oxidase [7]. There are no specific antidotes for phosphide poisoning. Magnesium had been used for its membrane stabilizing, antiarrhythmic and antioxidant properties. There has been conflicting data on the use of magnesium sulfate. Many studies have shown a decrease in mortality and reversal of ECG changes with early use of magnesium sulfate [8,9], while Siwach et al. [10] in their study on serum and tissue magnesium levels in phosphide poisoning concluded that magnesium therapy did not have any impact on mortality. Metabolic acidosis has been documented in phosphide poisoning and sodium bicarbonate therapy has been found to be useful [10]. In the study by Abdel Rahman et al. [6] metabolic acidosis was present in 20% and respiratory alkalosis in 32% patients with phosphide poisoning. In our study, blood gas analysis was performed only in cases with ECG abnormalities. All cases with ECG abnormalities

had decompensated metabolic acidosis out of which three had associated respiratory alkalosis.

The major targets of PH3 poisoning in the human body are the lungs, heart, brain, gastrointestinal (GI) tract, kidney, and liver [2,10,11,12], In our study (Table 1) cardiac toxicity was the most common (41%), followed by GI symptoms (35%), and coagulopathy (11%). One case had fulminant hepatic failure. Severe hepatic dysfunction has been reported in Zinc phosphide poisoning [3,4,13]. Low incidence of renal involvement and liver involvement (6%) may be due to ingestion of lower quantity of toxin as most ingestions were accidental. GI symptoms (78%) have been reported as the most common symptom followed by respiratory symptoms (29%) in phosphide poisoning [5]. Brief episodes of fever and lymphocytic leukocytosis as symptoms have not been described in other studies. Phosphine produces an atmosphere of hypoxia and free radical stress by binding with cytochrome oxidase and by inhibiting catalase. Fever and leukocytosis may be a reactive response to free radical stress. Whether these symptoms are unique to children is not known as most studies on zinc and aluminum phosphide poisoning have not looked into hematological profile.

About 41% of patients had ECG changes or cardiovascular manifestations in our study (Figure. 1). Chugh et al. [2] also reported conduction disturbances and arrhythmia in 38% of patients with phosphide poisoning. In a study on ECG changes in aluminum phosphide poisoning by Soltaninejad et al. [3], the ECG changes or cardiovascular symptoms appeared between 3 and 5 h after admission probably indicating massive intoxication as all were suicidal in intent. In our study, the average time interval between admission and ECG findings or cardiovascular manifestation was 19.7 h (range 9-36 h). Delayed onset in children may be due to ingestion of small quantity by children or slower effect of phosphine on target organs in children. In all cases with ECG changes there was associated metabolic acidosis which was treated with sodium bicarbonate therapy. Increased incidence of cardiac symptoms in our study probably indicates a higher susceptibility of heart to phosphine in young children.

Varying mortality rates have been reported ranging from 25% [4] to 77% [2] in various metal phosphide poisoning studies. Lower mortality (17.6%) in our study may be due to a small quantity of accidental ingestion, early identification of minor ECG changes and supportive treatment with $NaHCO_3$, intravenous magnesium sulfate, inj hydrocortisone, and inj carnitine in cases with ECG changes. Steroids have been recommended in Zinc phosphide poisoning due to its possible role in decreasing pulmonary injury and hypotension [14,15]. Chugh et al. [16] in their study on aluminum phosphide poisoning had also reported adrenocortical insufficiency. All children were given stomach wash with 2% $NaHCO_3$ (to reduce gastric acid and production of phosphine) and 1:10,000 potassium permanganate (to oxidize phosphine to less absorbable phosphide). In the 2 cases in which death occurred due to cardiac toxicity, one presented with transient bradycardia at 3 h and developed resistant ventricular tachycardia unresponsive to amiodarone and shock and died at 10 h. The second case developed transient intermittent bradycardia at 12 h and sudden onset of respiratory distress and tachycardia at 30 h post ingestion due to pulmonary edema which responded to nasal continuous positive airway pressure. He went on to develop transient sinus tachycardia at 48 h with shock requiring inotropic support for 48 h and QRS widening with ST elevation was observed at 72 h. He developed sudden onset refractory bradycardia leading to cardiac arrest on day 10 after admission. This child also had three episodes of seizure on day 5 of hospital stay. Transient, intermittent bradycardia as the initial rhythm abnormality was associated with increased risk of mortality ($p<0.05$). In both the cases of death since zinc phosphide was not identified in stomach wash, they did not receive steroids, sodium bicarbonate, and carnitine or IV magnesium. All other children with ECG changes received the supportive treatment for zinc phosphide poisoning.

The child with a history of accidental ingestion of bromodiolone had abnormal coagulation profile at 6 h post ingestion. The early appearance of coagulation abnormality probably signifies greater sensitivity of young infants to bromodiolone. Occurrence of ECG changes in the child with bromodiolone ingestion probably indicates undisclosed combination of rodenticides for better efficacy by manufactures or shopkeepers. Time to stomach wash did not have any impact on outcome, probably it is the quantity ingested which is more important as has been shown in other studies [13,17]. The better outcome in patients who presented early [18] and received GI decontamination with sodium bicarbonate has also been described [2]. The small sample size is a limitation of this study. Blood gas analysis was performed

Table 1: Analysis of symptoms

Symptoms	n (%)
Vomiting	6 (35)
ECG changes	7 (41)
Coagulopathy	2 (12)
Liver failure	1 (6)
Seizure	1 (6)
Fever	8 (47)
Head sweating	2 (12)
Pulmonary edema	1 (6)
Shock	1 (6)
Leukocytosis	8 (47)

ECG: Electrocardiographic

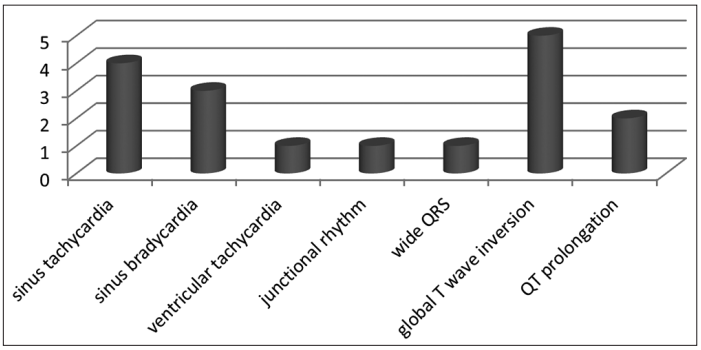

Figure 1: Electrocardiographic changes observed in rodenticide poisoning

only on observing an ECG change, whether metabolic acidosis was present at admission itself in these children is not known. Further studies with larger sample size will help us elucidate the toxidrome of rodenticide poisoning in children more clearly.

CONCLUSION

Zinc phosphide has become the most common chemical being used as domestic rodenticide. Transient heart rate abnormalities, fever, leukocytosis, and metabolic acidosis are early markers of toxicity, and they should looked for in all cases. All children with rodenticide poisoning should be observed with continuous ECG monitoring for 1st 48 h. Initial manifestations in children are more subtle compared to adults probably due to ingestion of lower quantities. Cardiac arrhythmia was the most common cause of death. General public, medical, and paramedical personnel should be made aware of the toxic nature of rodenticides.

REFERENCES

1. Sharma J, Kaushal RK. Profile of poisoning in children. Pediatr Oncall. 2014;11(2):40-2.
2. Chugh SN, Dushyant, Ram S, Arora B, Malhotra KC. Incidence & outcome of aluminium phosphide poisoning in a hospital study. Indian J Med Res. 1991;94:232-5.
3. Chugh SN, Aggarwal HK, Mahajan SK. Zinc phosphide intoxication symptoms: Analysis of 20 cases. Int J Clin Pharmacol Ther. 1998;36(7):406-7.
4. Soltaninejad K, Beyranvand MR, Momenzadeh SA, Shadnia S. Electrocardiographic findings and cardiac manifestations in acute aluminum phosphide poisoning. J Forensic Leg Med. 2012;19(5):291-3.
5. Mowry JB, Spyker DA, Brooks DE, McMillan N, Schauben JL. 2014 Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 32nd Annual Report. Clin Toxicol (Phila). 2015;53(10):962-1147.
6. Rahman MA, Naggar EL, Nashwa M, Mahdy EL. Zinc phosphide toxicity with a trial of tranexamic acid in its management. J Adv Res. 2011;2(2):149-56.
7. Proudfoot AT. Aluminium and zinc phosphide poisoning. Clin Toxicol (Phila). 2009;47(2):89-100.
8. Chugh SN, Kumar P, Aggarwal HK, Sharma A, Mahajan SK, Malhotra KC. Efficacy of magnesium sulphate in aluminium phosphide poisoning - Comparison of two different dose schedules. J Assoc Physicians India. 1994;42(5):373-5.
9. Kumar S, Elhence GP, Mital HS, Mehrotra VS, Khanna PN. Intravenous magnesium sulphate therapy in aluminium phosphide poisoning. JAPI. 1990;38(1):32.
10. Siwach SB, Singh P, Ahlawat S, Dua A, Sharma D. Serum and tissue magnesium content in patients of acute aluminium phosphide poisoning and critical evaluation of high dose magnesium sulphate therapy in reducing mortality. J Assoc Physicians India. 1994;42(2):107-10.
11. Sudakin DL. Occupational exposure to aluminium phosphide and phosphine gas? A suspected case report and review of the literature. Hum Exp Toxicol. 2005;24(1):27-33.
12. Hsu C, Han B, Liu M, Yeh C, Casida JE. Phosphine-induced oxidative damage in rats: Attenuation by melatonin. Free Radic Biol Med. 2000;28(4):636-42.
13. Saleki S, Ardalan FA, Javidan-Nejad A. Liver histopathology of fatal phosphine poisoning. Forensic Sci Int. 2007;166(2-3):190-3.
14. World Health Organization. International Programme on Chemical Safety: Phosphine and Metal Phosphides. Health and Safety Guide No. 28. Geneva: World Health Organization; 1989.
15. Nin N, Peñuelas O, de Paula M, Lorente JA, Fernández-Segoviano P, Esteban A. Ventilation-induced lung injury in rats is associated with organ injury and systemic inflammation that is attenuated by dexamethasone. Crit Care Med. 2006;34(4):1093-8.
16. Chugh SN, Ram S, Sharma A, Arora BB, Saini AS, Malhotra KC. Adrenocortical involvement in aluminium phosphide poisoning. Indian J Med Res. 1989;90:289-94.
17. Singh S, Singh D, Wig N, Jit I, Sharma BK. Aluminum phosphide ingestion - A clinico-pathologic study. J Toxicol Clin Toxicol. 1996;34(6):703-6.
18. Singh UK, Chakraborty B, Prasad R. Aluminium phosphide poisoning: A growing concern in pediatric population. Indian Pediatr. 1997;34:650-1.

Funding: None; Conflict of Interest: None Stated.

How to cite this article: Sugunan S, Krishnan R, Kumar KKS, Geetha S. Rodenticide poisoning in children: A study of clinical profile and electrocardiographic changes. Indian J Child Health. 2017; 4(2):136-139.