RESEARCH ARTICLE

Sokoto Journal of Veterinary Sciences

(P-ISSN 1595-093X: E-ISSN 2315-6201)

http://dx.doi.org/10.4314/sokjvs.v19i4.7

Fomnya *et al.*/*Sokoto Journal of Veterinary Sciences*, **19**(4): 198 - 204.

Incidence of organophosphate and carbamate poisoning in dogs within Maiduguri, North-eastern Nigeria

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Publication History:
Received: 20-03-2021
Revised: 13-07-2021
Accepted: 26-08-2021

Abstract

The persistent application of chemicals in pest control and agricultural processes possess a public health concern as their use are often associated with acute or chronic poisoning cases in both humans and animals. In veterinary medicine, pesticides such as organophosphates and carbamates are exclusively used in ectoparasitic control through pour on, tick bath and fumigation. The incidence of organophosphate or carbamate poisoning in dogs within Maiduguri, north-eastern Nigeria was assessed using three government approved and licensed veterinary centres. Data were obtained through the review of three years (2016-2018) retrospective cases of organophosphate/carbamate poisoning and administration of questionnaires to actively practising veterinarians. Investigation revealed that organophosphate/carbamate poisoning in dogs within Maiduguri metropolis constituted 37% of poisoning cases and was on the increase in recent years with 22.96% of the total cases reported in 2016, 34.08% in 2017 and 42.96% in 2018. The case was most prevalent at the peak of the rainy season around July and August. The common clinical signs observed include salivation, vomiting, diarrhoea, muscle spasms, severe weakness and paralysis. Management was usually supportive and symptomatic while antidotal therapy revolved on atropine sulphate only. The effect of ageing in organophosphate poisoning was neglected by most of the clinicians as more than 50% would administer atropine sulphate without considering the duration of the onset of poisoning. It was concluded that the incidence of organophosphate and carbamate poisoning in dogs in Maiduguri constituted 37% of all poisoning cases where 22.96% and 42.96% of it were reported in 2016 and 2018, respectively. Enlightenment programmes for the public and professionals are recommended on the increased cases of poisoning and proper use of antidote in the treatment of chemical toxicosis.

Keywords: Ageing, Carbamates, Dog, Maiduguri, Organophosphates, Poisoning

Introduction

Dogs are usually considered as important domestic animals in terms of security, hunting and companionship (Aiyedun & Olugasa, 2012). The population ratio of man to dog in Borno state, Nigeria was estimated to be 4.1:1 and 3.2:1 in urban and rural areas respectively. The population ratio of male to female dogs are at 1.2:1 and 3.7:1 in urban and rural areas respectively (El-Yuguda *et al.*, 2007).

Pesticides are a heterogeneous combination of chemical substances used in the chemical control of different pests and other harmful microorganisms (Alavanja, 2009). Organophosphates (OPs) and carbamates are a heterogeneous group of chemicals designed for pest and weed control and their appropriate use is considered highly effective and safe (Bolognesi, 2003). The persistent use of pesticides in everyday life has impacted negatively on the ecosystem with high poisoning cases (Moghadamnia & Abdollahi, 2002). Organophosphate and carbamate pesticides exert their toxic action by binding to acetylcholinesterase (AChE) molecules leading to the continuous accumulation of acetylcholine neurotransmitters with the resultant excitation of cholinergic receptors at neuromuscular junctions as well as in the autonomic and central nervous systems resulting in flaccid paralysis (Paudyal, 2008). Spontaneous reactivation of acetylcholinesterase (AChE) precedes the formation of AChE-OP/ carbamate complex and this may occur at a very slow rate, which is usually much slower than the enzyme inhibition requiring hours to days to occur. Adding nucleophilic reagents may increase the spontaneous reactivation of AChE thereby liberating more active enzymes and these agents, therefore, act as antidotes in organophosphate/carbamate poisoning (Eddleston *et al.*, 2002). In the absence of nucleophilic reagents, the AChE-organophosphate complex tends to lose one alkyl group which makes it unable to respond to reactivating agents; this stepwise and progressive time-dependent process is known as ageing. The rate of the ageing process is dependent on various factors like the degree of acidity or alkalinity (pH), degree of hotness or coldness (temperature), and the type of organophosphate compound; dimethyl OPs such as dichlorvos and malathion have an estimated ageing half-life of 3.7 hours whereas diethyl organophosphates such as chlorpyrifos, diazinon, and parathion have an estimated ageing half-life of 33 hours (Worek *et al.*, 1997; Worek *et al.*, 1999). Based on the estimated ageing half-life, it can be deduced that ageing occurs more rapidly with dimethyl organophosphates, therefore oximes are assumed to be useful before 12 hours of poisoning. However, in diethyl OP poisoning oximes may be useful for many days (Worek *et al.*, 1997; Worek *et al.*, 1999). Observable clinical signs in dogs include tremors and hypersalivation, followed by emesis, miosis, bradycardia, seizures, and dyspnea (Verster *et al.*, 2004). Occasionally recorded signs are excessive urination, paresis, and paralysis. Death is caused by respiratory failure, due to bronchospasm, paralysis of the diaphragm and intercostal muscles, and depression of the respiratory centre (Fikes, 1990; Jokanovic, 2009). In cases where atropine sulphate is used as an antidote, it should be noted that atropinisation should be stopped when secretions have dried up (Waseem *et al.*, 2010).

Therefore, this study was designed to investigate the incidence, diagnosis, and treatment of reported cases of organophosphate poisoning in dogs within Maiduguri Metropolis using data obtained from three different veterinary centres and practising veterinarians within the metropolis.

Figure 1. Map showing Borno state and its environs

Materials and Methods

Study area

The study was conducted in three veterinary service centres (University of Maiduguri Veterinary Teaching Hospital, Ali Modu Sheriff Veterinary Hospital and Nigeria Police Veterinary Clinic) in Maiduguri, Northeastern

Nigeria. Maiduguri is the capital city of Borno State, Nigeria, West Africa, located on latitude 11.30^0 and 11.45^0 N and longitude 13.50^0 and 13.60^0 E, and the state has a population of 5,860,200 persons and a population density of 5,748 persons per km^2 with a total area of 70,898 km^2. The State occupies the most significant part of the Chad basin and shares international borders with the Republic of Niger to the North, Chad to the North-east and Cameroon to the east. Within the country, its neighbours are Adamawa to the South, Yobe to the West and Gombe to the Southwest (NPC, 2016). The primary occupation of the indigenes includes crop farming, fish farming and cattle rearing (Borno State Diary, 2014). It has an average temperature of 33-38^{o}C with an annual rainfall of 645mm (LCRI, 2007). Figure 1 shows Borno State and its surrounding areas.

Collection of data

The data used in this study were collected in two ways: three years (2016-2018) retrospective cases of organophosphate/carbamate poisoning reported in three major veterinary centres within the metropolis were reviewed and a second questionnaire was given to 30 actively practising veterinarians who shared their experiences on the frequency of cases, types, diagnosis and management of poisoning in dogs.

Selection criteria

A veterinary centre must be government approved and licensed with an established small animal unit manned by a registered veterinary surgeon. Veterinarians must be licensed and actively practising.

Data analysis

The data obtained were analysed using descriptive statistics and were expressed in percentages and represented pictorially using pie charts, bar charts and multiple bar charts.

Results

The result of this investigation revealed that organophosphate/carbamate poisoning in dogs within Maiduguri metropolis has been on the increase in recent years, with 22.96% of the total cases reported in the year 2016, 34.08% in the year 2017 and 42.96% in the year 2018 (Figure 2). The case was most prevalent at the peak of the rainy season around July and August (13.33%) (Figures 3 and 4). Most of

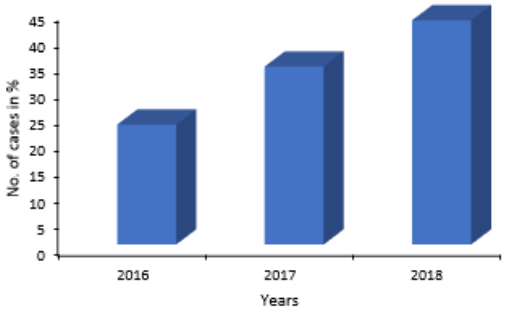

Figure 2: Three years comparative reported OP/carbamate poisoning cases in dogs in Maiduguri from 2016 to 2018

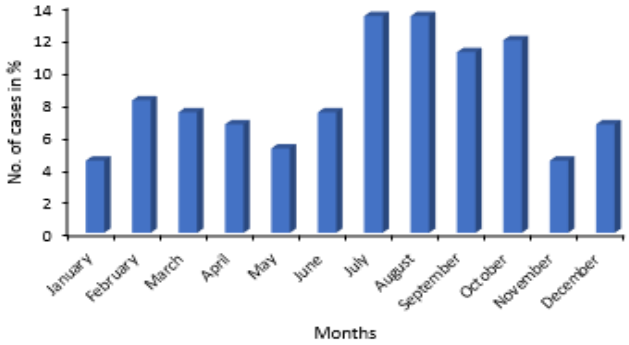

Figure 3: Monthly cumulative reported OP/carbamate poisoning cases in dogs in Maiduguri from 2016 to 2018

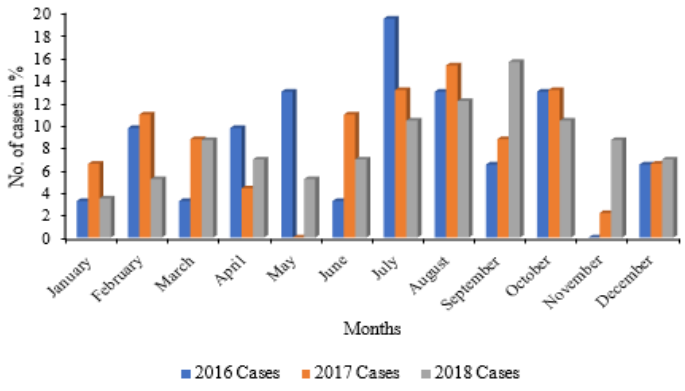

Figure 4. Monthly comparative reported OP/carbamate poisoning cases in dogs in Maiduguri from 2016 to 2018

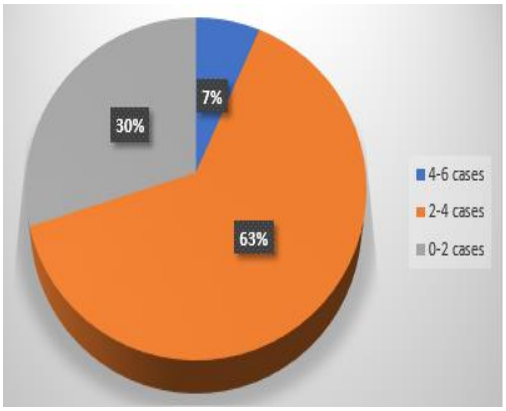

Figure 5. Number of occurrences of OP/Carbamate poisoning cases per month in dogs in Maiduguri

the actively practising veterinarians (63%) usually handle 2-4 cases monthly (Figure 5). The common clinical signs observed include salivation, vomiting, diarrhoea, muscle spasms, severe weakness, and paralysis (Table 1).

The diagnosis was usually tentative which was achieved using history, clinical signs and sometimes laboratory diagnosis (Table 2). Symptomatic and supportive therapy involved the use of fluids, antibiotics, analgesics, antiemetics, demulcents, kaolin, and vitamin supplements (Table 2). Atropine sulphate was the only antidote used for reversing OP/carbamate toxicity (Table 2). The three most prevalent poisoning cases faced by veterinarians practising within Maiduguri metropolis were food poisoning (53%), organophosphate/carbamate poisoning (37%) and lead poisoning (10%) (Figure 6). Concerning ageing, more than 50% of the clinicians administered atropine sulphate without considering the duration of the onset of poisoning (Figure 7).

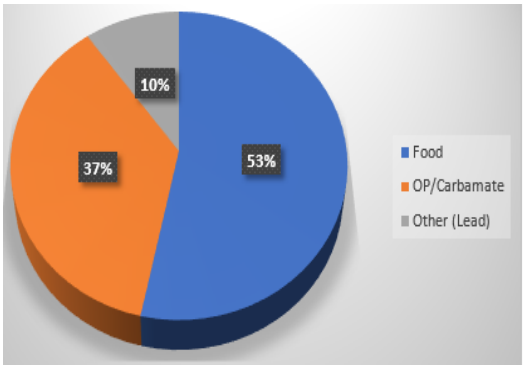

Figure 6: Types of poisoning cases based on occurrence in dogs in Maiduguri

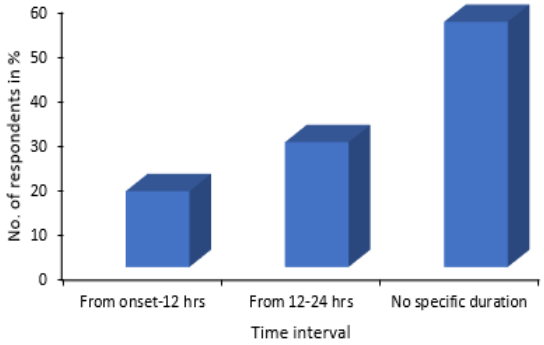

Figure 7: Period of antidote administration in the management of OP/Carbamate poisoning in dogs in Maiduguri

Table 1. Sources and frequently observed clinical signs of poisoning in dogs in Maiduguri

Poisoning	Sources	Clinical signs
Food	Unproperly kept leftover food	Vomiting, diarrhoea, lethargy, anorexia, salivation, shivering.
Organophosphate/ Carbamate	Fumigation, tick bath	Salivation, vomiting, diarrhoea, muscle spasms, severe weakness, paralysis.
Others: Lead	Improperly disposed batteries	Anorexia, vomiting, diarrhoea, constipation, anxiety, salivation, incoordination, opisthotonos.

Table 2. Methods of diagnosis, antidotes, supportive/symptomatic therapy and prognosis of poisoning in dogs in Maiduguri

Poisoning	Method of diagnosis	Antidotes	Supportive/symptomatic therapy	Prognosis
Food	History and clinical signs	Atropine sulphate	Fluids, antibiotics, analgesics, antiemetics, demulcents, kaolin and vitamin supplements	Good
Organophosphate/ carbamate	History, clinical signs and sometimes laboratory findings	Atropine sulphate	Fluids, antibiotics, analgesics, antiemetics, demulcents, kaolin and vitamin supplements	Good-guarded
Others: lead	History, clinical signs and sometimes laboratory findings	Calcium disodium EDTA (Ethylenediamine tetraacetic acid)	Fluids, antibiotics, analgesics, antiemetics, demulcents, kaolin and vitamin supplements	Good-guarded

The source of food poisoning was found to be leftover food, tick bath with OP/carbamate chemicals as well as spraying of dog kennels during fumigation was identified as the source of organophosphate/carbamate poisoning while improperly disposal of batteries was found to be the major source of lead poisoning (Table 1). The prognosis was found to be good if detected and reported on time and guarded to grave when not reported on time (Table 2).

Discussion

The incidence of organophosphate/carbamate poisoning cases (37%) in dogs within Maiduguri metropolis is on the yearly increase with the highest incidence occurring during the peak of raining season (July-August). This observation agrees with related findings from other parts of Nigeria (William *et al.*, 2002; Shima *et al.*, 2015). The high rate of tick infestation during the peak of the rainy season as reported by Konto *et al.* (2014) also explains the high incidence of poisoning in dogs within the Maiduguri metropolis since the major source of organophosphate/carbamate poisoning is chemical bath/fumigation during tick control. The yearly increase in the incidence of organophosphate/carbamate poisoning in dogs within the Maiduguri metropolis poses a threat to the dog population within the metropolis.

The diagnosis is tentative which gives a high possibility of the wrong diagnosis in a situation whereby the history is deficient since some cases of poisoning share common clinical signs. There is little or no publication to compare these specific findings. However, the general management principles of poisoning was found to be convincing as the general and stepwise protocols in the management of poisoning cases were adopted by most of the clinicians which entail removing the animal from the source of the poison, reducing further absorption of the poison through decontamination, administration of specific antidote and supportive and symptomatic therapy (Aki & Alessai, 2019). It was however observed that the effect of 'ageing' associated with the use of atropine sulphate in the management of organophosphate/carbamate poisoning is not always taken into consideration by some clinicians during therapy as atropine sulphate is sometimes being administered irrespective of the time and duration of exposure to the poison. Carbamates such as aldicarb and carbaryl when ingested cause the inactivation of

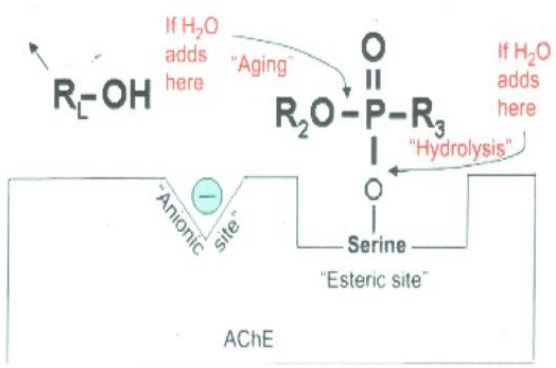

Figure 8. The ageing process in organophosphate poisoning
Source: Krieger (2010)

acetylcholinesterase (AChE) activities by carbamylation of the serine hydroxyl group located at the active site of the AChE, the carbamylation process is temporary and reversible which makes the AChE activities to be restored when spontaneous hydrolysis of carbamylated enzymes occur resulting in AChE release (Jokanovic, 2009). On the other hand, organophosphate chemicals cause the phosphorylation of the same active site of AChE, but in this case, a stable and irreversible bond is formed after 24-48 hours; this process is known as 'ageing' (Garcia *et al.*, 2006; Li *et al.*, 2007; Jokanovic, 2009).

Ageing as illustrated in Figure 8, is a time-bound process that is a result of dealkylation of organophosphorus inhibited acetylcholinesterase (AChE) which results in the loss of an alkyl group after the formation of organophosphate-AChE complex (aged enzyme) with the concomitant production of an oxyanion on the phosphoryl group of the OPs (Curtil & Masson, 1993; Mercey *et al.*, 2012).

AChE is an enzyme that belongs to the serine hydrolase class mainly found in the brain, synapses, neuromuscular junctions, and erythrocytes. Its major function is to block nerve impulses through selective hydrolysation of acetylcholine neurotransmitters into choline and acetic acid. Continuous inhibition of AChE results in the continuous firing of nerve impulses, which in turn causes increased parasympathetic activities and voluntary muscle twitches which may lead to death due to seizures and respiratory failure. The mechanism of action of organophosphates is through covalent bonding of the organophosphate compound to the catalytic serine site of the AChE and blocking the active site in the process (Mercey *et al.*, 2012).

Conversely, carbamates occupy both anionic and esteratic sites of AChE and the inhibition in carbamates is due to a reaction between the carbamoyl moiety and the active site serine hydroxyl group of AChE to form carbamoylated enzyme rather than phosphorylated enzyme as with the organophosphates (Vale & Lotti, 2015).

Antidotal therapy in OP poisoning entails the use of anticholinergic agents (e.g., atropine sulphate) and oximes (e.g., pralidoxime or 2-PAM, diacetylmonoxime or DAM, obidoxime) to prevent, minimise or reverse the toxic effects. Atropine sulphate antagonises acetylcholine receptors, while oximes are agents that nucleophilically substitute and move the phosphorylated serine into the active site of the acetylcholinesterase enzyme to reactivate the OP-inhibited AChE (Paudyal, 2008; Mercey *et al.*, 2012). In the ageing process, already aged AChE will not be reactivated by the administration of anticholinergic agents alone e.g atropine sulphate. Therefore, reversing the ageing process can only be effective using AChE effectors and the administration of the AChE effectors should be before AChE is completely aged. Post ageing management can be achieved through realkylation reaction of the aged AChE by oximes which may eventually pave way for atropine sulphate treatment which neutralises the oxyanion at the active site of aged AChE (Mercey *et al.*, 2012).

The incidence (37%) of organophosphate/carbamate poisoning in dogs within the Maiduguri metropolis may be associated with the use of chemicals especially by non-professionals in fumigation and tick bath. Even though poisoning cases associated with organophosphate and carbamate chemicals are being adequately managed, the ageing process associated with poison exposure was however not given adequate consideration when administering atropine sulphate. Administration of oximes in addition to atropine sulphate and symptomatic treatment is recommended to improve the outcome of treatment of organophosphate toxicity in dogs within the Maiduguri metropolis. Enlightenment programmes for the public and professionals are advocated on the increased cases of poisoning.

Acknowledgements

The Veterinary hospital/clinics and the actively practising veterinarians within the Maiduguri metropolis who provided all the data used in this study are appreciated.

Conflict of Interest

The authors declare that there is no conflict of interest.

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