OCCUPATIONAL CARBAMATE POISONING IN THAILAND

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Abstract. Carbamate insecticide is a leading cause of poisoning in Thailand. The objective of this study was to characterize the clinical manifestations and modes of occupational exposure in carbamate poisoning cases. We retrospectively studied all the cases of carbamate poisoning due to occupational exposure recorded in the Ramathibodi Poison Center Toxic Exposure Surveillance system during 2005 to 2010. Demographic data, clinical manifestations and severity were analyzed statistically. During the study period, 3,183 cases were identified, of which 170 (5.3%) were deemed to be due to occupational exposure. Ninety-six cases (56.5%) and 35 cases (20.6%) were poisoned by carbofuran and methomyl, respectively. Carbofuran is sold as a 3% grain and applied by sowing; methomyl is sold as a liquid and is applied by spraying. The majority of poisoned patients did not wear personal protective equipment (PPE) while applying the carbamates. The clinical manifestations of occupational carbofuran poisoning recorded were nausea and vomiting (82.3%), headaches (56.3%) and miosis (19.8%). The clinical manifestations of methomyl poisoning were nausea and vomiting (74.3%), headaches (57.1%) and palpitations (11.4%). Most patients in both groups had mild symptoms. Only one case in each group required endotracheal intubation and mechanical ventilation support. There were no deaths and the lengths of hospitalization ranged from 2 hours to 2 days. Occupational carbamate poisoning cases in our series were mostly mild and the patients recovered quickly. There were only rare cases of serious symptoms. Lack of knowledge and inadequate PPE were the major factors contributing to occupational poisoning. Educating agricultural workers about correct precautions and pesticide use could minimize this type of poisoning.

Keywords: carbamate poisoning, occupational exposure, clinical manifestations, PPE, Thailand

INTRODUCTION

Pesticides are used in agriculture in both developing and developed countries. During 2009, 118,152 tons of pesticides was imported into Thailand and 19,709 tons of these were insecticides (Chunyanuwat, 2005). The increasing amount of imported pesticides is increasing the risk of pesticide poisoning (Panuwet *et al*, 2012).

Agricultural workers account for half of the world labor force estimated at 1.3 billion (ILO, 2009). The proportion of the workforce engaged in agriculture is as

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high as 49% in some developing countries (Stellman, 1998). The toxicities of some agricultural chemicals to animals and humans is well-known (Hodgson and Rose, 2005). Millions of agricultural workers are injured in workplace accidents involving agricultural device or poisoned by pesticides and other agricultural chemicals (ILO, 2009).

In Thailand, the number of poisonings from pesticides is increasing (Panuwet *et al*, 2012). Our previous study showed that organophosphate and carbamate insecticides are the leading causes of poisoning in Thailand (Wananukul *et al*, 2007). Most pesticide poisoning is self-induced (Ye *et al*, 2013; Eddleston *et al*, 2015). Pesticide use is a leading choice for self-harm, second only to hanging (Lotrakul, 2006). Occupational poisoning may be more common than attempted self-harm. Among the carbamate insecticides, methomyl and carbofuran are the most common ones in Thailand (Panuwet *et al*, 2012). Methomyl has various formulations, but the primary forms used are 40% soluble powder and 18% v/w soluble concentration; carbofuran is available as 3% granules (FDA Thailand, n.d.).

The objective of this study was to characterize the clinical manifestations and severity of poisonings caused by occupational exposure to carbamate insecticides, especially carbofuran and methomyl, and to determine the modes and outcomes of this exposure.

MATERIALS AND METHODS

We conducted a retrospective study of carbamate insecticide poisoning cases reported to the Ramathibodi Poison Center (RPC) Toxic Exposure Surveillance System from 2005 to 2010. Cases of simultaneous exposure to multiple types of insecticides were excluded from the study. The definition of terms in this study was adapted from the INTOX data management system of the International Program on Chemical Safety (IPCS INTOX) data management system (Laborde, 2004) and the American Poison Control Center Collection system (Bronstein *et al*, 2012). This study was approved by the Ethics Committee on Research involving Human Experimentation, Faculty of Medicine Ramathibodi Hospital, Mahidol University.

RESULTS

During the study period, 3,183 carbamate poisoning cases were identified. The carbamates involved in these poisoning cases were: methomyl (48.7%), carbofuran (25.2%), and other carbamates (26.1%), such as carbaryl, carbosulfan, fenobucarb and bendiocarb. Of these cases, 170 (5.3%) were determined to be due to occupational exposure. Ninety-six cases (56.5%) were exposed to carbofuran, 35 cases (21.8%) were exposed to methomyl and the remaining 39 (22.9%) were exposed to other carbamates (carbaryl: 9 cases; carbosulfan: 9 cases; fenobucarb: 14 cases; benfuracarb: 2 cases; methylcarbamate: 2 cases; Isoprocarb: 1 case; propoxur: 1 case, and one unknown type). This study focused on occupational poisoning due to carbofuran and methomyl. The formulations of these two carbamates are different: the carbofuran comes as granules and is applied by scattering like sowing, whereas the methomyl comes as a solution, and is applied by spraying.

Table 1 shows the demographic data of the patients poisoned by carbofuran and methomyl. The median ages were not significantly different between the two groups. The ratio of females to males was higher in the carbofuran group than in the

Table 1
Demographic data about methomyl and carbofuran poisoned among studied patients.

	Methomyl (35 cases)	Carbofuran (96 cases)	*p*-value
Gender (m:f)	31 : 4	63 : 33	
Median age in years (range)	42 (19-67)	41.5 (11-71)	0.559
Median time to present to the hospital in hours (range) *	4.0 (0.3-72)	3.5 (0.5-36)	0.772

*5 cases of carbofuran poisoning had no data of time to present to the hospital.

Table 2
Route of exposure and use of personal protective equipment among studied patients.

	Methomyl (35 cases) *n* (%)	Carbofuran (96 cases) *n* (%)
Route		
Dermal only	2 (5.7)	16 (16.7)
Inhalation only	19 (54.3)	28 (29.2)
Combined dermal and inhalation	14 (40.0)	52 (54.2)
Personal protective equipment		
None	29 (82.9)	92 (95.8)
Cotton mask	4 (14.8)	1 (1.0)
Long sleeve shirt		1 (1.0)
Gloves		1 (1.0)
Cotton mask + gloves	2 (5.7)	
Cotton mask, gloves+ shirt		1 (1.0)

methomyl group. The time to presentation to the hospitals was not different between the two groups.

Table 2 shows the major routes of exposure. Inhalation was the most common route of exposure with the methomyl group (54.3%) and the carbofuran group (29.2%). The majority of patients in both groups did not wear personal protective equipment (PPE) when applying the insecticides.

Patients exposed to the insecticides had both cholinergic and some nonspecific symptoms (Table 3). Nausea, vomiting and headaches were the most common symptoms seen in this study. Headaches are nonspecific and not a direct effect of carbamate poisoning. Nausea and vomiting may be muscarinic or nonspecific symptoms. Other muscarinic cholinergic signs and symptoms, such as diarrhea, abdominal pain, hypersecretion, miosis and bradycardia were reported in less than 20% of cases. The cholinergic effects were found more frequently in the carbofuran group. No nicotinic effects ware found.

The symptoms and signs recorded were mostly mild and resolved rapidly without residual problems. They are classified as minor effects according to

Table 3
Signs and symptoms of methomyl and carbofuran poisoned studied patients.

Signs and symptoms	Methomyl (35 cases) *n* (%)	Carbofuran (96 cases) *n* (%)
Cholinergic		
Nausea/vomiting	26 (74.3)	79 (82.3)
Diarrhea	4 (11.4)	13 (13.5)
Abdominal pain	3 (8.6)	7 (7.3)
Sweating	4 (11.4)	19 (19.8)
Salivation	5 (14.3)	16 (16.7)
Bronchorrhea	1 (2.9)	
Miosis	2 (5.7)	19 (19.8)
Alteration of conscious	1 (2.9)	1 (10.4)
Bradycardia	2 (5.7)	10 (10.4)
Nonspecific		
Headache	20 (57.1)	54 (56.3)
Palpitations	6 (17.1)	8 (8.3)

Table 4
Clinical course of methomyl and carbofuran poisoned studied patients.

Clinical course	Methomyl (35 cases)	Carbofuran (96 cases)
Percent of patients with a mild course	97.1	99
Percent of patients with a moderate course	2.9	1
Median length of hospital stay in hours (range)	2 (2 - 72)	24 (2 - 48)

IPCS INTOX definitions. Only one case in each group required intubation and mechanical ventilation, both for less than one day. These two cases were classified as moderate effect according to the IPCS INTOX definition (Table 4). There were no fatalities or major symptoms in either insecticide group.

Eight point six percent of methomyl and 12.5% of carbofuran poisoned cases needed atropine therapy. The doses of atropine prescribed were modest, ranging from 0.6-1.2 mg; some cases were treated symptomatically with antiemetics or antivertigo medications (Table 5).

The lengths of hospitalization ranged from a few hours to a few days and all the patients recovered completely without complications.

DISCUSSION

Farmers want to protect their crops from pests in order to have maximum yields. Pesticides are commonly used for this purpose. Exposure to pesticides is a public health concern. Pesticide poisoning is a major type of poisoning in several

Table 5
Treatment of methomyl and carbofuran poisoned studied patients

Treatment	Methomyl (35 cases)	Carbofuran (96 cases)
Endotracheal intubation (%)	2.9	1.0
Atropine (%)	8.6	12.5
Metoclopramide/ domperidone (%)	11.4	7.3
Dimenhydrinate (%)	11.4	14.6

developing countries including Thailand (Yang *et al*, 1996; Wananukul *et al*, 2007). Our previous study found that insecticides accounted for 50% of all pesticide poisoning cases (Wananukul *et al*, 2007). Of insecticide poisonings, carbamates, organophosphate and pyrethroids are the common causes of poisoning. There is a 10% of mortality rate among those poisoned by carbamate in a previous study (Wananukul *et al*, 2007); however, that study did not differentiate the types of exposure. In this study occupational exposure accounted for only 5.3% of all carbamate poisoning.

Although there are more than 10 different types of carbamates available in Thailand (FDA Thailand, n.d.), methomyl (35 cases) and carbofuran (96 cases) were responsible for most of the occupational carbamate poisoning cases in our study. Methomyl poisoning is usually more common than carbofuran poisoning (Wananukul *et al*, 2007); but in our current study carbofuran poisoning was more common than methomyl poisoning. This is because the commercial methomyl available in Thailand is an emulsifiable, soluble concentrate; whereas carbofuran is mainly available as granules. However, some workers do not recognize the potential toxicity of carbofuran as evidenced by our finding that the percentage of patients not wearing PPE was higher in the carbofuran group.

The mortality rates for carbamate poisoning have been reported to be 5.7%, 11.5% and 17.6% in Taiwan, Thailand and South Korea, respectively (Yang *et al*, 1996; Wanaukul *et al*, 2007; Lee *et al*, 2011). Carbofuran and methomyl are classified as Class IB (highly hazardous) according to the WHO hazard classification of pesticides (WHO and IPCS, 2010). Carbofuran and methomyl can cause severe poisoning and even mortality (Wananukul *et al*, 2007). However, severe cases are rarely found in occupational exposure (Singh *et al*, 2007). Our current study revealed only a small percentage of patients with occupational carbamate exposure developed cholinergic signs and symptoms. Most cases were mild and there were no mortalities. Most severe cases are from intentional ingestion (Wananukul *et al*, 2007). When evaluating the number of times atropine had to be administered, the number of patients needing endotracheal intubation and the length of hospital stays, we can see most cases were mild. The nonspecific symptoms seen in these patients suggest the symptoms were not due to carbamate poisoning. There were no significant differences in clinical manifestations between the methomyl and carbofuran poisoned patient groups.

The majority of patients in our study did not use PPE while working with insecticides. This suggests most did not recognize the risks due to exposure in their work. Fewer patients use PPE in the carbofuran poisoned group. This implies they were not aware of the risk of dermal exposure. Therefore, workers need to be educated about the risks of exposure. PPE has some negative points. Thailand is hot and humid, making wearing PPE in the field bothersome. New PPE is needed to reduce this discomfort and protect the wearer. This may help the risk of occupational pesticide exposure.

Our study had some limitations. This was a retrospective study. Some data was incomplete. Case and substance identification were only based on history, since laboratory identification of pesticides is not available in most hospitals in Thailand. Only a few cases had their blood analyzed for cholinesterase activity. However, substance identification, clinical course and diagnosis were verified by follow-up phone calls from the poison center. Some symptoms, especially non-specific ones, might have been caused by other etiologies not diagnosed during the admission.

Carbamate poisoning due to occupational exposure was mostly mild. The clinical features and outcomes of patients exposed to carbofuran and methomyl were similar. Lack of education about carbamate toxicity and prevention by using PPE contributed to the occupational exposure.

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