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An Unusual Case of Organophosphate Intoxication of a Worker in a Plastic Bottle Recycling Plant: An Important Reminder

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A young man was sent to our emergency unit because he had suffered from vomiting and cold sweating for 2 days. At the time he was admitted, he had no acute abdominal pains or gastrointestinal symptoms, and a physical examination revealed nothing but a faster heart rate and moist, flushing skin. The patient had worked for 6 years at a plastic bottle-recycling factory, but none of his co-workers had the same symptoms. Nevertheless, because the plant also recycled pesticide bottles, we suspected organophosphate pesticide intoxication. The patient's plasma acetylcholinesterase level was checked, revealing 1498.6 $\mu\text{U/L}$ (normal range: 2,000–5,000) on the first day and 1,379 $\mu\text{U/L}$ on the second day. Upon questioning, the patient recalled that one of his shoe soles had been damaged and that his foot had been wet from walking all day in rain collected on the factory floor on the day that his symptoms first occurred. We conducted a study in the change of preshift and postshift acetylcholinesterase levels among six of his co-workers on a rainy day. We used the Wilcoxon signed rank test to compare the preshift and postshift plasma acetylcholinesterase levels; no significant difference was revealed ($p = 0.600$), leaving contamination via the damaged shoe sole suspect. We reviewed the literature on organophosphate intoxication; pesticide bottle-recycling factories were reported to be at a low risk of organophosphate toxicity in the working environment. However, because the potential risk of intoxication is still present, protective equipment such as clothing, gloves, and water-proof shoes should be worn, and employees should be educated on the potential risks. **Key words:** organophosphate, personal hygiene, plastic recycling. *Environ Health Perspect* 108:1103–1105 (2000). [Online 27 October 2000] <http://ehpnet1.niehs.nih.gov/docs/2000/108p1103-1105wang/abstract.html>

The widespread and intensive use of pesticides for agricultural purposes is common in Taiwan, and organophosphate pesticide is one of the most widely used. There are two basic kinds of organophosphate intoxication: suicide and occupational exposure. Occasionally, a suicide attempt involving organophosphate is reported, and the signs and symptoms of this type of intoxication are often severe and/or lethal. Instances of occupational organophosphate pesticide intoxication have rarely been reported, and field studies on this type of poisoning are few. To further complicate the matter, employees are not well educated about the potential toxicity of substances with which they work. As a result, intoxication from occupational pesticide exposure often goes undetected or ignored.

Occupational exposure to pesticide usually occurs through inhalation and dermal absorption among pesticide factory workers and pesticide users, and certainly personal

protection and work hygiene are important among these workers. However, in this paper we report an unusual case of occupational intoxication involving an employee of a factory where plastic bottles, some of which previously contained organophosphate pesticide, were recycled. This case, although diagnosed early, emphasizes the importance of personal protection even in areas considered to be a low risk.

Case Presentation

A 24-year-old male was sent to our emergency unit because he suffered from vomiting, cold sweating, dizziness, and poor appetite, and he had consumed no food or water for 1 day. He was slightly irritated upon arrival. A physical examination revealed a heart rate of approximately 100 beats/min and a respiratory rate of 20/min. His skin was moist and flushed, and his pupils were normal in size. Laboratory data, including

complete blood cell count, liver and renal function tests, and electrolytes, were within normal limits. Based on his history, he was a healthy person with no allergies or systemic diseases, and his family had no remarkable history of specific diseases.

He had been working in a plastic bottle-recycling factory for 6 years, his first and only job. Regarding the work, used bottles were collected and brought to the factory where the workers initially washed them in an automatic washing machine and conveyed them to a grinding machine that crushed them into small pieces. Plastic pesticide bottles were processed every Tuesday, Wednesday, and Thursday. The patient and his six co-workers, who all worked in the same environment, had periodic health examinations that were all normal. The patient's symptoms occurred in the afternoon of a rainy day when he was handling pesticide bottles. He said that he had ignored the symptoms and went directly home after work without seeking medical aid. Unfortunately, the symptoms worsened during the night. Although he was feeling uncomfortable the next morning, he went to work, where his supervisor, who noticed his obvious illness, sent him immediately to the emergency unit at our hospital. When the patient reported that his left shoe sole had been damaged and that his foot had been wet all day from the rainwater on the floor,

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we began to suspect that this water had been contaminated by the residual pesticide from the bottles.

Suspecting organophosphate pesticide intoxication, we determined that the patient's plasma acetylcholinesterase level was 1498.6 $\mu\text{U/L}$ on the first day and 1379.7 $\mu\text{U/L}$ on the second day (normal range: 2,000–5,000 $\mu\text{U/L}$). After receiving conservative treatment, his symptoms disappeared 3 days later. We rechecked the acetylcholinesterase level 5 days after the initial symptoms had occurred and it was in the normal range (2309.8).

Factory Preshift and Postshift Acetylcholinesterase Levels

The recycling factory, located in Kaohsiung County, Taiwan, only processes plastic bottles, which may have been used for milk, disinfectant, oil, or pesticide. The plastic bottles are crushed to produce mainly plastic chips, which are sent to other companies to make plastic utensils. The plastic pesticide bottles were stored without being covered in a corner near the crushing machines. If there were enough pesticide bottles to be recycled, they were processed on Tuesdays, Wednesdays, and Thursdays. Otherwise, they were stored until there were enough to process profitably. The patient worked with six other employees who performed the same tasks that he did.

We visited the factory on a rainy day and observed an open area where the used bottles were stored and also a shed above the machines. The floor was not level, and some rainwater had collected in the lower areas. Water had pooled on the floor around the machines. We then decided to conduct a study of the change in acetylcholinesterase levels before and after the work shift. One Tuesday morning before the shift began, we collected blood samples from six workers to measure acetylcholinesterase. A second test was performed on blood from the workers when they went off duty the following Thursday afternoon. On these days the activities of these workers were unchanged from their regular routine. When we compared the preshift and postshift plasma acetylcholinesterase levels using the Wilcoxon signed rank test, no significant difference was revealed between the two measurements. ($p = 0.600$; Table 1)

Discussion

Pesticides are widely used for agricultural purposes in Taiwan, and recycling of pesticide containers is encouraged to protect the environment and to ensure public safety. There is an island-wide nongovernmental system for recycling containers; thus, plastic bottles are recycled in factories such as the one where the patient worked. Workers in these plants are occasionally exposed to unexpected

substances, including organophosphates. Our case is evidence of this kind of intoxication.

Reviewing the literature on organophosphate intoxication, we discovered that most cases of organophosphate intoxication in Taiwan were caused by drinking organophosphates directly in an effort to commit suicide. Plasma acetylcholinesterase levels in these suicide cases were usually $< 1,000 \mu\text{U/L}$, and patients showed severe clinical conditions, most often miosis and conscious disturbance. The prognosis was usually poor. In our case, the only symptoms were mild muscarinic manifestations and signs such as moist skin, tachycardia, and nausea. His plasma acetylcholinesterase level was slightly decreased (1498.6 and 1379.7 $\mu\text{U/L}$ on 2 consecutive days). By talking with the patient, we ruled out the possibility of oral ingestion of the toxicant. This was an atypical case of organophosphate intoxication not only because of where it was contracted but also because of the patient's nonspecific symptoms and normal pupil size. Without a detailed occupational history, such instances of intoxication could be easily misdiagnosed.

Further examination may be needed after treatment of acute intoxication. Although we found no similar report on acute mild intoxication and its influence, long-term health outcomes of organophosphate exposure, such as neuropsychologic dysfunction, may appear to occur independently of symptoms immediately after acute exposure. According to one report, individuals may experience effects without the benefit of the earlier warning signs of acute toxic exposures (1). For this reason, long-term, sequent examinations are recommended.

Serial cholinesterase analysis may also be needed in intoxication cases involving unknown baseline cholinesterase data (2). Similar to what Coye et al. (2) found in his study, our case showed a lower cholinesterase level on the second day and an increasing level after 5 days. Urine metabolites of organophosphate have also been used to show evidence of organophosphate exposure. Some organophosphate metabolites that have been reported are alkyl phosphate metabolites and *O,O*-dimethylphosphate, *O,O*-diethylphosphate, *O,O*-diethylthiophosphate, *O,O*-dimethylthiophosphate, *O,O*-diethylthiophosphate, and *O,O*-dimethylthiophosphate (3). These metabolites of pesticides, used as biologic markers of exposure, can also help determine the patient's reentry time into the workforce and evaluate environmental influence on the worker's family and neighbors (4).

We also considered inhalation as a route of intoxication. Because we found no significant difference among cholinesterase levels in the patient's co-workers and because no other

workers showed symptoms of discomfort, we ruled out exposure by inhalation. The occupational health of workers in pesticide factories was examined in Taiwan in a study that focused on absorption by inhalation of organophosphate among pesticide production workers (5). In that study, the authors examined plasma cholinesterase levels of 989 workers and found that the average cholinesterase levels in workers who produced the pesticide and those who packaged it were significantly lower than levels in employees who were not involved in production and packaging (6,442 vs. 7,429 $\mu\text{U/L}$). Wu et al. (5) concluded that inadequate ventilation and poor working practices can increase the potential risk of pesticide poisoning. The mean preexposure cholinesterase level in our study was 6094.3 $\mu\text{U/L}$, and the post-exposure mean was 5901.4 $\mu\text{U/L}$; both figures were lower than the previous study. One reason for the lower levels could simply be our small sample size (6 workers). Other reasons could be that long-term dermal exposure could have influenced the lower cholinesterase levels or that different patterns of work and interpersonal variability affect cholinesterase levels. Further evaluation and assessment is needed to come to any conclusive explanation of the lower levels.

Skin absorption of the pesticide through the broken sole of his shoe may have been how our patient was exposed to the toxicant. Many reports have discussed the role of skin absorption in organophosphate pesticide intoxication, and some considered it the major route. One study of dermal and inhalation exposure revealed that inhalation exposures were insignificant when compared to dermal exposures (6). In that study, 60–90% of the total exposure could be attributed to skin absorption through the hands. Thus, Stewart et al. (6) concluded that the use of protective clothing, particularly gloves, was an important determinant of whether an individual was exposed or not. Even the use of protective clothing cannot completely prevent exposure. Guidotti et al. (7), in a study of pesticide container-handling operations in Canada, reported that the pesticides were found in fabric of 74% of

Table 1. Comparison of the plasma cholinesterase levels in six co-workers.

Worker	Preshift ($\mu\text{U/L}$)	Postshift ($\mu\text{U/L}$)
1	4767.7	5039.3
2	5510.1	4328.6
3	5205.6	4964.3
4	8003.0	7264.8
5	7030.2	5873.2
6	6049.2	7938.4
Mean \pm SD	6094.3 \pm 1217.54	5901.4 \pm 1421.55
Control	4281.1	4299.7

Controls were from random serum samples collected from normal persons per examination.

worker coveralls, 70% of socks, and 55% of T-shirts, and also in 1.6% of the plastic fabric of the gloves. Another study reported that evidence of contamination of pesticides was found on the shoes (93.1%) and the trousers (65%) of pesticide sprayers (8). Therefore, dermal exposure has been reported to be the main route of exposure in some workers, with contaminated shoes and socks playing an important role. Griffin et al. (9) reported that skin absorption for a certain organophosphate, chlorpyrifos, was slower than oral ingestion but was retained longer. The authors found that the half-life of chlorpyrifos absorbed dermally was nearly twice as long as the half-life of the compound after oral exposure, both for the absorption-related phase of the time course and for the elimination phase. Griffin et al. (9) also found that the absorption fraction could be reduced after exposure by washing the skin. In our case, the contaminated water got to the worker's skin through a damaged shoe sole and through his sock, and remained there for at least 1 day. Hence, the relatively longer period of exposure to a mixed organophosphate of a lower concentration may have resulted in our patient's mild to moderate muscarinic symptoms and signs.

Many studies in recent years have indicated that potential dermal exposure is not constant over the body surface due to factors of the workplace, personal behavior, and hygiene. In one report on fruit growers' contamination, de Cock et al. (10) noted that within-worker variability of all exposure measurements was larger than between-worker variability. The authors explained that variation in permeability of the skin depends on both physiochemical properties and the location of skin on the body exposure. de Cock et al. (10) also stated that more information is needed about the variability in exposure of the different measured skin locations and factors affecting uptake and metabolism before total dermal uptake can be estimated. Therefore, variability in dermal exposure on the same body location was small relative to variability between different body locations.

In the prevention of intoxication, knowledge, protective clothing, and personal hygiene have been emphasized in many studies. One epidemiologic survey on knowledge, attitude, and practices revealed the importance of worker awareness of the toxicity of pesticides (8). Chen et al. (8) reported that wearing personal protective equipment, such as gloves and masks, and altering the working environment were important. The authors also pointed out that

workers who kept their upper extremities bare or wore only sandals during work had more related symptoms. Chen et al. (8) also stated that teaching workers proper working hygiene may help prevent secondary skin exposure from sweat or other sources of contamination. Gomes et al. (11) also emphasized the use of protective clothing to provide substantial protection against skin exposure. Just as indoor residual pesticide presents a potential risk for human exposure, particularly in small children, residual pesticide in the environment may also become a potential risk for employees (12). Thus, good personal hygiene and regular training can reduce potential exposure of pesticides to acceptable low levels.

Finally, individual susceptibility may also play a role. In our study, postshift acetylcholinesterase levels in three workers were higher than their preshift levels. However, the other three workers had lower postshift acetylcholinesterase levels, although there was no significant difference according to Wilcoxon signed rank analysis. We also observed that personal work practices and hygiene were similar among workers. Thus, personal intrinsic factors, such as polymorphism of biotransformation of xenophobics, may also explain the variability of acetylcholinesterase activity among these workers, although further study is needed.

Follow-up Protective Measures

After this incident and our field observations, the employer paid more attention to the protection of workers and the prevention of poisoning. We suggested that the employer require workers to wear personal protective equipment such as gloves and waterproof shoes. Furthermore, workers were educated about the occupational hazards associated with their work. The employer instituted training programs on pesticide toxicity and intoxication symptoms, personal protection, first aid for exposure, and personal work site hygiene (e.g., washing hands before eating and smoking, removing boots and socks in an area away from the work site, and being careful to step onto a clean floor). Finally, we recommended that the employer provide periodic health examinations that include a check of serum acetylcholinesterase level.

Conclusion

Although the pesticide bottle recycling factories seem to have relatively low toxicity working environments, the potential risk of intoxication still exists and should not be neglected. We have reported a case in which

an employee in such a factory was exposed to organophosphate through contaminated water that was absorbed into his feet through a break in his shoe sole. This led to intoxication and illness. In a working environment with hazardous organophosphate, protective respiratory equipment and work clothes in good condition, particularly gloves and shoes, are very important. Although recycling factories have fewer workers than pesticide production factories, intoxication remains a danger. We believe that it is important for employers and employees to recognize the hazards and for employers to provide training programs on proper work hygiene and clothing and to enforce appropriate protective measures at the work site. We hope that the results of this study will encourage regulatory agencies and employers to more carefully consider the potential risks of similar work and make a more concerted effort to promote the health and safety of these employees.

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