Case Study

Three Occupationally Exposed Cases of Severe Methyl Bromide Poisoning: Accident Caused by a Gas Leak during the Fumigation of a Folklore Museum

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Methyl bromide (CH$_3$Br) is widely used as a plant quarantine fumigant and as a soil fumigant$^1$), but in 1992 it was designated by the Montreal Protocol on Substances that Deplete the Ozone Layer. According to the Montreal Protocol, its use is to be fully phased out by 2005 in developed countries and by 2015 in developing countries$^2$). However, its use is still currently being allowed after abolishment for such purposes as quarantine processing, shipping pretreatment, some essential uses, and emergency processing since an alternative substitute that is as easy to use as methyl bromide, has an equivalent effect, and is effective against a variety of pests, does not exist$^3$). For this reason, it continues to be used in Japan. It is still frequently used, and poisoning accidents caused by its use are still common$^4$–$^7$).

We herein report three cases of severe methyl bromide poisoning thought to have been caused by the presence of the victims in an adjoining room during the fumigation of a folklore museum.

Case Presentation

Onset and clinical course of poisoning

An accident involving three men who appeared to have suffered methyl bromide poisoning during the fumigation of a folklore museum occurred in Fukuoka Prefecture on December 29, 2002.

Case 1 (31 yr old), Case 2 (29 yr old), and Case 3 (46 yr old) were employees working for the same exterminator. They began sealing off the storage area within the museum in the morning of December 27, two days before the poisoning occurred. They began spraying the agent at around 6:00 p.m. on the same day. The agent used was a fumigant comprised of 86% methyl bromide and 14% ethylene oxide. The amount used was 80 g/m$^3$ in an area with an inner volume of 1,166 m$^3$ (Figs. 1 and 2). There was a slight gas leak from a hose immediately after the start of spraying, but it was repaired, and the spray operation lasted about one hour. The employees then ate and rested in the museum’s reception room after 7:00 p.m. and later slept in the same room. At around 3:00 a.m. on December 28, Case 1 moved to a car parked outside to continue sleeping after feeling sick. He did not take part in any of the subsequent fumigation work because he continued to feel sick. Cases 2 and 3 continued to sleep in the museum, and they periodically checked the methyl bromide gas concentration in the storage area. During this time, they re-injected fumigant whenever they confirmed that the concentration had fallen. They began venting the gas at around 1:00 a.m. on the 29th, after about 30 h of fumigation. They removed the sheet used to seal off the fumigated area around 7:00 a.m. The physical condition of Cases 2 and 3 also deteriorated at around 2:00 p.m. on the same day. They called their employer for a ride back when they could no longer continue working and their condition had deteriorated to the point of not being able to drive. They waited in the car where Case 1 was resting. Cases 2 and 3 experienced convulsive seizures at around 4:00 p.m., at which time all three were rushed to hospital and admitted.

Case report

Case 1: A 31-yr-old male fumigator.

The patient was rushed to the hospital along with Cases 2 and 3 at 5:00 p.m. on December 29 because he felt sick. No convulsions were noted at the time of admission, but mild impaired consciousness was seen. He was diagnosed as having methyl bromide poisoning in light of his work history and the symptoms of his colleagues. His serum and urinary bromide levels were both high on December 30: 87.4 µg/ml and 122.4 µg/mg · CRE, respectively. The patient was followed up without use of any particular medication. Subsequently, mild desensitization was seen in the left forearm, but severe neurological symptoms such as convulsions were not noted. He was discharged on January 20, 2003, and he returned to work in January.

Case 2: A 29-yr-old male fumigator.

The patient was rushed to the hospital at 5:00 p.m. on December 29 after experiencing generalized tonic-clonic seizures with impaired consciousness. He suffered from status epilepticus on admission and underwent endotracheal intubation and phenobarbital i.m. shortly after arrival. Intravenous infusion (1A) of phenytoin (Aleviatin) did not control the convulsions. Continuous thiamylal sodium (Isozol) infusion alleviated the
convulsions. He was diagnosed as having methyl bromide poisoning based on his work history. Beginning the following day, he underwent four dialysis treatments, with each treatment consisting of direct hemoperfusion followed by 24-h continuous hemodiafiltration. As a result, his serum bromide level, which was 164.9 µg/ml on December 30, decreased to 6.6 µg/ml on January 3. He opened his eyes when spoken to on January 20, but action myoclonus of both upper extremities, the cervix, and the face was noted. These symptoms were controlled by the oral administration of phenytoin (Aleviatin), diazepam (Cercine), zonisamide (Excegran), and clonazepam (Landsen). Despite a medical history that included a gastrostomy, aspiration pneumonia, and a tumor at the gastrostomy site, he was transferred to another hospital for rehabilitation and myoclonus treatment on July 22, 2003. He was discharged on May 31, 2004, and he is currently recuperating at home with a physician making house calls. He can now walk with the aid of a walker, but he requires assistance to eat because of lingering action myoclonus. He can speak, but his speech is unclear when he is tense, and he suffers from a cognitive deficit.

Case 3: A 46-yr-old male fumigator.

The patient was rushed to the hospital at 5:00 p.m. on
December 29 after experiencing generalized tonic-clonic seizures. On arrival at the hospital, he was barely conscious with a Japan Coma Scale score of 20, but he immediately suffered from status epilepticus and his respiratory state began to deteriorate. Therefore, he underwent endotracheal intubation and the same procedures performed in Case 2. His serum bromide level, which was 157.3 μg/ml on December 30, decreased to 10.7 μg/ml on January 3. In addition, he developed pulmonary edema on January 5. His severe convulsions were brought under control by the same medications as those used in Case 2, but walking and oral ingestion on his own were impossible. He also had difficulty speaking. He was transferred to another hospital for rehabilitation treatment on June 6, 2003. He was subsequently discharged on December 25, 2003, with little change seen in his symptoms. He is currently recuperating at home with a physician making house calls. He currently suffers from constant action myoclonus, and he experiences a major convulsive seizure about once every several months. For meals, a combination of gastrostomy feeding and oral ingestion is used. In terms of daily living activities, he requires total assistance and suffers from a cognitive deficit.

Discussion

In the past, cases of methyl bromide poisoning in Japan frequently occurred mainly among employees of methyl bromide manufacturers and quarantine fumigation workers, such as those engaged in harbor loading and unloading and the importing of grains. In recent years, the number of cases of acute poisoning in these occupations has decreased as a result of the rationalization of operations, improvements in the work environment, and more thorough education. However, there are still sporadic cases of fumigation-related poisoning among farmers who fumigate the soil and pest exterminators, where guidance and supervision regarding the handling of fumigants are sometimes lacking.

The three cases presented here worked for a pest extermination company that mainly fumigates museums and similar facilities.

Fumigators usually must obtain a license from the state after taking a course on the safe handling of fumigants sponsored by a Plant Protection Station. Moreover, the license has to be renewed every three years, at which time the fumigators are required to take a course. The number of cases of accidental poisoning has decreased considerably since the implementation of this system, but pest exterminators like the patients presented here are not subject to this requirement.

Case 3 was supposedly licensed as a chief safety specialist for specified chemical substances, but it is not clear just how much he knew about the toxicity of methyl bromide and how to handle it during fumigation. Little was learned from Cases 2 and 3 in interviews conducted after the accident because their memory was not clear, but Case 1 was not wearing protective equipment such as a mask and gloves during fumigation. In addition, the company where they worked did not give them any instructions regarding where to wait after spraying the chemical. This fumigation company has a work force of about 100, but it does not give its employees a biannual checkup as required by the Ordinance on Prevention of Hazards due to Specified Chemical Substances, suggesting the existence of problems with its management system.

First, an examination of the fumigation process revealed that the fumigation of the storage area of the folklore museum (Fig. 1) involved the use of 80 g/m³ (about 17,725 ppm of methyl bromide) in an area with an inner volume of 1,166 m³. Normally, the recommended amount for this kind of fumigation job is about 20–40 g/m³ over a 24-h period, even when the temperature is low during the winter. Thus, the concentration used was quite high. According to the fumigation company that did the work, it is normal for gas to leak during the fumigation of a sealed space within a facility; for this reason, the company usually uses a generous amount of gas to begin with and then repeatedly checks the concentration during fumigation. When the gas concentration is low, the manual states that more chemical should be injected, as was the case in this accident. In other words, the purpose of checking for leaks appears to be to keep the concentration of the chemical above a certain level to ensure insecticidal efficacy, rather than to confirm the safety of the operation.

Given these facts, one would think it would be inconceivable to sleep in the same facility adjacent to the area being fumigated. Actually, the gas concentration by the detector tube method in some room of the museum was checked after the poisoning accident occurred (Fig. 1). The methyl bromide concentration in the training room at around 9:00 p.m. on December 29, the day of the accident, was 16–17 ppm. On the following morning, December 30, a concentration of 15 ppm was detected in the entrance hall, which was some distance from the storage area. The concentration in the reception room where the fumigators slept was not measured, but a concentration of 17 ppm was detected in the office next to it at around 9:00 p.m. on December 29, the day of the accident. According to the measures related to fumigation work with methyl bromide found in the Ordinance on Prevention of Hazards due to Specified Chemical Substances, fumigators are not supposed to enter an area with a concentration of 15 ppm or higher. Moreover, the permissible concentration recommended by the Japan Association of Industrial Health is 1 ppm. Given the fact that a concentration of 10–17 ppm was detected the day after the sheet was removed, it is clear that gas had
In fact, analysis of serum bromide concentrations for HS-GC\(^{17}\) (Fig. 2) showed that the concentrations detected in the patients were considerably high: 164.9 µg/mL in Case 2 and 157.3 µg/mL in Case 3 on December 30, the day after onset (normal value: 3.7 ± 1.5 µg/mL\(^{17}\)). Urinary bromide concentrations were also high: 75.3 µg/mg CRE and 98.7 µg/mg CRE, respectively (normal value: 11.1 ± 3.7 µg/mg CRE\(^{17}\)). Even the serum bromide concentration of Case 1, who went outside the museum about 9 hours after the fumigation started because he felt sick, was 87.4 µg/mL, and the urinary bromide concentration of this patient was 122.4 µg/mL. Clearly, this patient had also been exposed to a high concentration of methyl bromide.

In severe cases of methyl bromide poisoning, neurological symptoms such as intention tremors and action myoclonus are seen\(^{4–7, 10, 18}\), but the first symptoms are often nonspecific, like headache, nausea, vomiting, and dizziness\(^{8, 9, 18, 20}\). After exposure, there is often a latent period before symptoms appear\(^{4, 8, 20}\). We have experienced cases in which the symptoms first appeared 1–3 d after exposure\(^{9}\). Case 1 complained of feeling sick after working for about 9 h, and his condition deteriorated about a day and a half later. It appears that Cases 2 and 3 felt a little sick, but onset in these patients occurred in the form of tonic-clonic seizures with impaired consciousness on about the second day of fumigation work. On December 30, the day after onset and the day on which we first received news of the accident, we were convinced that the patients had methyl bromide poisoning based on their work history and telltale symptoms like status epilepticus, without waiting for a definitive diagnosis\(^{17}\). We immediately gave instructions to initiate dialysis the day after onset. Case 1, who went outside the museum about 9 hours after the fumigation started because he felt sick, was 87.4 µg/mL, and the urinary bromide concentration of this patient was 122.4 µg/mL. Clearly, this patient had also been exposed to a high concentration of methyl bromide.

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References


11) H Ichikawa, T Sakai, Y Horibe, E Kaga and M Kawamura: A case of methyl bromide intoxication showing symmetrical lesion in the basal ganglia stem on magnetic resonance imaging. Clinica Neurol 41, 423–427 (2001)


