SPECIAL CONTRIBUTIONS

The Tokyo Subway Sarin Attack: Disaster Management, Part 1: Community Emergency Response*

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Abstract. The Tokyo subway sarin attack was the second documented incident of nerve gas poisoning in Japan. Prior to the Tokyo subway sarin attack, there had never been such a large-scale disaster caused by nerve gas in peacetime history. This article provides details related to how the community emergency medical services (EMS) system responded from the viewpoint of disaster management, the problems encountered, and how they were addressed. The authors' assessment was that if EMTs, under Japanese law, had been allowed to maintain an airway with an endotracheal tube or use a laryngeal mask airway without physician oversight, more patients might have been saved during this chemical exposure disaster. Given current legal restrictions, advanced airway control at the scene will require that doctors become more actively involved in out-of-hospital treatment. Other recommendations are: 1) that integration and cooperation of concerned organizations be established through disaster drills; 2) that poison information centers act as regional mediators of all toxicologic information; 3) that a real-time, multidirectional communication system be established; 4) that multiple channels of communication be available for disaster care; 5) that public organizations have access to mobile decontamination facilities; and 6) that respiratory protection and chemical-resistant suits with gloves and boots be available for out-of-hospital providers during chemical disasters. **Key words:** sarin; disaster medicine; chemical warfare agents; emergency medical services; EMS; international medicine. ACADEMIC EMERGENCY MEDICINE 1998; 5: 613–617

THE TOKYO subway sarin attack was the second documented incident of nerve gas poisoning in Japan. The first mass public exposure to sarin (methyl phosphonofluoridic acid 1-methylethyl ester) gas occurred in the city of Matsumoto in June 1994.[1] From a worldwide historical perspective, the Tokyo subway sarin attack represents the largest disaster caused by nerve gas in peacetime history. Until these episodes, a terrorist attack with chemical warfare agents in a public setting was incomprehensible. Indeed, the Japanese believed that the Tokyo subway system was the safest transportation system in the world. As a result of this attack, many problems were encountered and the Japanese have been forced to radically alter their approach to disaster management.

We previously published a preliminary report on the Tokyo subway sarin attack.[2] The current article provides further detail related to how the community emergency medical services (EMS) system responded from the viewpoint of disaster management, the problems encountered, and how they were addressed. Companion articles address the hospital response[3] and the national and international responses[4] related to this event.

NATIONAL AND REGIONAL EMS SYSTEM

In Japan, disaster planning is based on the "fundamental law of disaster management." This law

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TABLE 1. Patient Transport to St. Luke's International Hospital in Tokyo, Japan, after Sarin Gas Release

Mode of Arrival	Number of Cases (%)
On foot	174 (34.9%)
Taxi	120 (24.1%)
Car (passing good samaritans)	67 (13.5%)
Car (Tokyo Metro Fire Department) —excluding ambulances	64 (12.9%)
Ambulance	35 (7.0%)
Police patrol car	7 (1.4%)
Others	31
TOTAL	498

basically covers regional disaster planning and its management. In the Tokyo metropolitan area, the Tokyo metropolitan government is responsible for the regional disaster plan and its management. The Tokyo regional disaster plan is intended to provide initial medical rescue and backup support. Under this disaster plan, the Tokyo Metropolitan Fire Department (TMFD) is responsible for: 1) selection of the hospitals in which victims are to be taken; 2) transportation to supporting backup hospitals; and 3) first aid.

This plan also provides for initial rescue teams consisting of staff from metropolitan hospitals, the regional medical association, the Japanese Red Cross, national hospitals, and public health centers. In addition, it includes a wide-area backup system involving surrounding prefectures.

The TMFD is directly responsible for out-of-hospital care in Tokyo. There are a total of 182 emergency medical teams and 1,650 emergency medical technicians (EMTs) in Tokyo to deal with the needs of 10 million people and 5 million households in the 1,750-km^2 Tokyo metropolitan area.[5] Each emergency medical team consists of 3 attending EMTs, one of whom is an authorized EMT called an emergency life-saving technician (ELST). An ELST law in Japan established the ELST position in 1991. ELSTs may provide some advanced medical treatment (e.g., airway management with a Combitube or laryngeal mask airway, IV line placement, and cardioversion). By law, the ELST is prohibited from carrying out these procedures without the permission of a medical doctor. Therefore, the ELST must contact a doctor on 24-hour call at the Tokyo Metropolitan Ambulance Control Center (TMACC) to obtain the doctor's consent for each medical procedure. Endotracheal intubation by an ELST is prohibited by law. In 1995, 6,315 procedures were performed by ELSTs in Tokyo. There is no EMS physician field response system in Tokyo in which a doctor would respond to a disaster site in an emergency vehicle.

The TMFD has a corps of persons who specialize in chemical disasters (i.e., hazmat teams), who have chemical-resistant suits and their own chemical material analyzers, including an infrared gas analyzer and a gas chromatograph–mass spectrometer.

The Metropolitan Police Department also has a laboratory capable of identifying chemical materials with a gas chromatograph–mass spectrometer.

The Japanese Self Defense Forces are controlled by the Defense Agency, which cannot act without the consent of the prime minister (so-called "civilian control"). In a disaster situation, they can enter the disaster area and carry out rescue only after they have received a request from the local government and the consent of the prime minister. They basically cannot act spontaneously.

In Japan, there are only 2 poison information centers in the entire country to deal with inquiries from a population of 100 million. In Japanese university medical schools and medical colleges, the departments of acute medicine, pharmacology, anesthesiology, forensic medicine, public health, and hygiene share responsibility for toxicology cases. The Japanese Association of Clinical Toxicology is a community concerned with poisoning. In Japan, there are no independent departments of clinical toxicology.

Although initially overwhelmed by the sarin attack, the disaster plan and EMS system in Tokyo is considered one of the most sophisticated in the country.

ANALYSIS OF PROBLEMS

Onset of Tokyo Sarin Gas Attack. When the first emergency call came to the TMACC of the TMFD at 8:09 AM, it was reported that there were emergency cases at a subway station. Within an hour emergency calls came separately from 15 affected subway stations, and EMTs were dispatched to their geographically respective stations. At that time the TMACC did not realize that there was one cause for all of these calls.

Out-of-hospital Medical Treatment. Following the sarin attack, 1,364 EMTs and 131 ambulances were sent to the 15 affected subway stations.[6] The TMFD defined the Tokyo subway sarin attack as the largest disaster since World War II. The TMACC was in total confusion because incoming information regarding this disaster exceeded their ability to manage communications. As a result, the EMTs lost radio contact with the doctor at TMACC. No victims were managed with a Combitube or laryngeal mask airway, and only 1 patient received an IV line (in this case a doctor who happened to be present gave the order). All severely ill patients received intubation and adequate ventilation only after admission to hospitals.

Deployment of Concerned Organizations on Site. Within an hour, the police blocked free access around the affected subway stations. At the same time they collected specimens and started to analyze items left behind at the scene.

The TMFD established an emergency rescue quarter at the affected stations, but by then victims who were in the most severe condition, those who required endotracheal intubation, had already been transported to hospitals. In the emergency rescue quarter, "superambulances" (extra-large ambulances equipped with 8 beds) and large tents expandable with compressed air were set up.

Within a few hours, the Japanese Self Defense Forces were dispatched to decontaminate the subway stations and subway trains.

Triage on Site. Triage was done by EMTs at the affected stations. Victims were evacuated from the subway stations to the outside. Among victims whom EMTs had initially categorized as mild cases, however, there were some whose states worsened during transportation.[7]

At the time of the sarin attack, the TMFD had its own triage tags, but these were not used for the majority of the victims, who went to hospitals without the aid of the fire department.

The TMFD asked the regional medical association for aid. A total of 47 doctors, 23 nurses, and 3 clerks were sent to the affected stations in response. St. Luke's Hospital also sent 8 doctors and 3 nurses. However, by the time they reached the affected stations, there were no victims who needed emergency procedures including intubation. Doctors and nurses were mainly engaged in triage of less ill patients at those sites.

Identification of the Cause Material. About 2 hours after the initial chemical exposure, information misidentifying the material causing the victims' illness as acetonitrile was provided by the TMFD. This information later proved to be wrong. Finally, the police identified the material as sarin around 11 AM, because mass spectrum analyzed by a gas chromatograph–mass spectrometer was consistent with sarin in the database of the National Institute of Standard and Technology (USA). The TMFD and police both made efforts to identify the cause material. Although the police at last identified it, this information did not reach hospitals or the TMFD directly. Hospitals and the TMFD received the results of the laboratory from television news after 11 AM.

Decontamination on Site. There was no field decontamination of victims on site. Only decontamination of the affected subway stations and subway trains was done by the Self Defense Forces.

Secondary Exposure of EMTs. Of 1,364 EMTs, 135 (9.9%) showed acute symptoms and received medical treatment at hospitals,[8] which interfered with the rescue work. They wore standard work clothing without respiratory protection. Most of them started to have symptoms during transportation, and it is suspected that they were exposed in ambulances to the vaporized sarin from the victims' clothes. The ventilation in ambulances and minivans at first was poor, because the windows were shut. After the EMTs' secondary exposure appeared, an order was transmitted to completely open the windows of ambulances and to improve the ventilation of the emergency rescue vehicles.

Transportation of Victims from the Scene to Hospitals. EMTs transported 688 victims to hospitals by ambulances (452 victims) and minivans.[7] The rest of them, >4,000 victims, reached hospitals on foot or via taxis or private vehicles of good samaritans. During the period immediately after the sarin attack, radio-controlled taxis played a remarkable role in the transportation of patients. The means of transportation from the scene to St. Luke's International Hospital is provided in Table 1. Approximately 25% of the victims were transported by taxi.[9] Furthermore, 2 of 3 cardiopulmonary arrest victims were transported to our hospital via private vehicles passing a station. Appropriate guidance to private vehicles picking up the victims was not given by the authorities. This, in part, concentrated victims at St. Luke's Hospital.

Because of the chaotic state in the control center, EMTs were unable to get hospital availability information. As a result, some of them had to search for available hospitals on their own by using public phones. It took until midnight for the TMFD to determine how many patients were admitted and in which hospitals.

We also studied the number of victims received by St. Luke's Hospital from each station (Fig. 1). Tsukiji Station is the nearest station to St. Luke's Hospital (0.5 km), and the largest number of victims arose from that station. However, St. Luke's Hospital received its largest number of victims (>2.5 times that from the nearest station, Tsukiji) from Kodenma-cho Station, which is 3.0 km from St. Luke's. This clustering of cases likely occurred because of insufficient information about where and how many victims there were, and where and how many victims were being cared for at different hospitals.

Interhospital Transportation. The emergency capacity at St. Luke's Hospital was almost reached. If the number of victims at St. Luke's had been larger, transfer of victims to another hospital

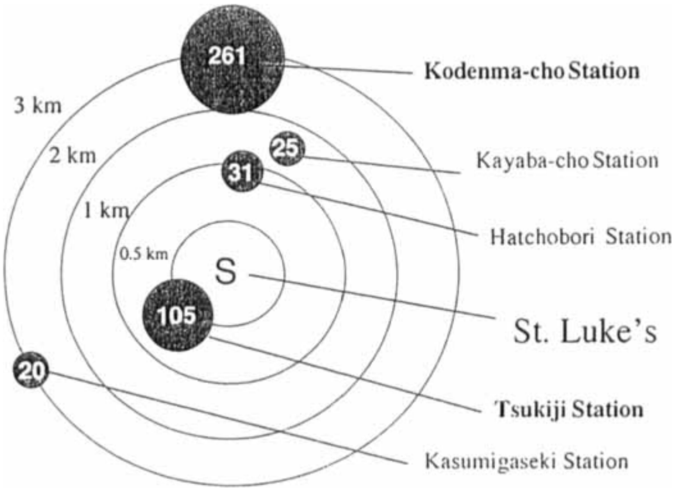

Figure 1. Victims received at St. Luke's International Hospital in Tokyo, Japan, after sarin gas release.

would have been necessary. We reviewed what would have been possible in such a circumstance. The TMFD, which should have provided interhospital transportation, could not do so because of a shortage of ambulances. A supporting backup system also was not available.

DISCUSSION

In the community EMS response, 3 major problems were exposed. The first problem was the limited out-of-hospital care imposed by EMT practice restrictions, the second was a lack of cooperation and communication among the organizations concerned, and the third was a general lack of preparedness for a chemical disaster, including the absence of decontamination at the scene and rescuer protection.

The ELSTs had the technical ability to optimize patient ventilation, but they could not use their advanced airway skills because of the legal restriction requiring prior physician contact. In a situation in which the control center cannot be contacted, it seems advisable for an ELST to use the concept of good samaritan actions (or independent practice) and practice to the fullest extent of his or her skills. However, the cultural climate of Japan does not allow such an approach. EMTs are highly hierarchically bound.

If ELSTs, under the law, had been allowed to maintain an airway with an endotracheal tube, more patients might have been saved. However, from the viewpoint of safety, when intubation is performed by poorly prepared personnel or under inappropriate circumstances, the procedure can be dangerous.

Given the restrictions of the ELST law in Japan, doctors should be more actively involved in out-of-hospital treatment requiring advanced airway care. The presence of a physician on scene might permit guidance of EMTs during intubation, whether via endotracheal tube or another technique.

During this disaster, the concerned organizations acted independently, and there was too little communication among them. The adverse effects of a vertically-structured EMS system were previously noted following the Hanshin great earthquake in January 1995, but the lesson was not learned.[10-12] Regional disaster plans emphasized the importance of mutual communication among concerned organizations, but a practical communication system was not established. Disaster drills exist in Japan, and each of the concerned organizations in Tokyo performs these drills. However, while disaster drills are held regularly by each concerned organization, there are no integrated drills including all of the concerned organizations. Integration and cooperation of the concerned organizations should be established through disaster drills.

Triage in chemical disasters, including nerve agents, is not easy, since there is delayed symptomatology that can be consequential. EMTs must be educated about the toxicologic aspects of chemical disasters. In particular, they should be repeatedly given the knowledge of chemical monitoring devices. Toxicologic education and investigation is one of the most important roles of the university medical schools and medical colleges, through the Association of Clinical Toxicology. These educational institutions along with hospitals, laboratories, hazmat teams, and Japanese Self Defense Forces personnel should share such information and opinions.

With this incident, the importance of the Japanese poison information centers and their current limitations became apparent. In a chemical disaster, poison information centers should be regional mediators of all toxicologic information. Specific information regarding cause material, counteraction, and decontamination should be gathered in poison information centers along with medical therapeutic information. The poison information centers should be able to rapidly distribute that information to hospitals, fire departments, the police, the public, and the mass media. At present, such a communication system, although needed, has not been established in Japan.[13]

Patient transportation is also based on exchange of information: How many victims? How severely ill or injured are the victims? Where are the victims located? How many victims need to be taken to a hospital and are likely to be admitted? Following the sarin attack, it took too long to answer these questions. A real-time and multidirectional communication system should be established. There should be multiple channels of communication, so that if one channel breaks down, another channel may survive. Satellite-mediated portable phones, wireless communication, and an Internet network are good candidates. The number of the victims found was far beyond the transport ability of the TMFD. In such a situation, nongovernmental vehicles should be used. Furthermore, these vehicles should be guided systematically to hospitals that can accommodate victims, avoiding concentration at one hospital. Following the sarin attack, backup transportation did not exist. If there had been more victims or a larger number of severe victims, this would have become an enormous problem. During the period immediately after the sarin attack, radio-controlled taxis played a remarkable role in the transportation of patients, and their ability to collect information also cannot be minimized.

Following this attack, a new disaster report taxi system was initiated. Through this system, authorized taxis should report where and how disasters have arisen to a taxi control center via radio as soon as possible. However, poisoning of drivers in a chemical disaster has not been considered. This system is an information collection system rather than a rescue system. In any case, establishment of improved measures for communication during disasters will be essential.

Decontamination on site is essential for chemical disasters. Respiratory protection and chemical-resistant suits with gloves and boots are necessary for out-of-hospital treatment including decontamination. A public organization, such as the armed forces (in Japan, the Self Defense Forces) or a fire department, must prepare sufficient mobile facilities where victims can shower and change clothes. These facilities could be used not only for dealing with nerve agents but also for other chemical disasters and nuclear disasters. Such a mobile decontamination system has already come on the market in Germany.

Secondary exposure of EMTs occurred due to absent field decontamination and protection. Fortunately, the source chemical was a diluted form of sarin. If the source material had been sarin in its pure form, the resulting situation would have been more catastrophic.

CONCLUSION

We investigated the community emergency response to the Tokyo subway sarin attack from the viewpoint of disaster management. If ELSTs could, under the law, be allowed to maintain an airway with an endotracheal tube or use a laryngeal mask airway without physician oversight, more patients might be saved in similar chemical disasters. Under the restrictions of the ELST law in Japan, advanced airway control at the scene will require that doctors become more actively involved in out-of-hospital treatment. Integration and cooperation of concerned organizations should be established through disaster drills. In chemical disasters, poison information centers should act as regional mediators of all toxicologic information. A real, multidirectional communication system should be established. Multiple channels of communication should be available. Public organizations must have available some mobile decontamination facilities. Respiratory protection and chemical-resistant suits with gloves and boots are also necessary for out-of-hospital care during chemical disasters.

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