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Editorial

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Toxicology and Terrorism

Recently, a new chapter was started in the handbook of terror involving the application of nerve gas technology to the killing of civilians. On March 19, a terrorist attack in a Tokyo subway resulted in the loss of 10 lives and injury to over 5,000 others. In view of the lethality of the suspected agent, sarin, the fatalities were surprisingly few. Terrorist attacks on civilians are not new, but what was unique about this particular attack was the use of a nerve agent instead of the customary conventional weapons. The possibility that nerve agents can be used against a vulnerable civilian population is alarming. A new era has begun, and we would be remiss if we did not learn from this one attack and take steps to prepare for the next. There is no doubt that those involved in the use of terror will learn from their mistakes and become more effective in their deployment of these horrific weapons.

From a public perspective there are several questions that must be urgently addressed. What can we do to prevent such attacks and how do we respond if such an attack should occur? Can we prevent terrorist organizations from making nerve agents? How do we prevent them from delivering these agents to their targets? Is there anything that we as a society can do to protect ourselves in the event of a gas attack? How do we minimize our vulnerability? How do we respond to an attack? All of these questions are very difficult to answer.

Agents like GB (sarin), GA (tabun), and VX are easily synthesized; however, handling, storage, and delivery of these agents is not quite so simple. Knowledge for performing these tasks is commonplace, and I suspect that any third-year chemistry student could design and build a facility for their production. Clearly, we cannot restrict access to information. *Chemical & Engineering News* responded to the March 19 attack by showing the reader how easy it is to synthesize sarin from dimethylmethylphosphonate (*1*). The information is in the textbooks, and like most technical information, the methodology for the production of nerve gases is not controllable, even if one wanted to.

Nerve gases are highly toxic organophosphate esters chemically similar to the organophosphate pesticides but with substantially higher acute toxicities. For example, the LD_{50} (mg/kg) for rats via dermal exposures is only 0.1 for VX, 2.5 for GB (sarin), but 6.8 for the pesticide parathion, 4,000 for sevin, and 4,400 for malathion (*2*). In comparison, for humans the estimated dermal LD_{50} values for VX, GB, and GA are about 0.09, 24, and 18 mg/kg, respectively (*2*).

Could the raw materials involved in the manufacture of organophosphates be regulated and controlled as a means of preventing terrorist organizations from synthesizing nerve agents? Unfortunately, the starting materials are very common and easily obtained. As pointed out in *Nature* (*3*), legitimate chemical manufacturers are reluctant to disclose their use of raw materials, and the idea that pyrophosphate or phosphoric acid could be taken off the free market is quite unrealistic.

Delivery of weapons onto passenger aircraft has been, to a large degree, prevented by use of scanning equipment. Judging from the reduction in the number of highjackings in recent years, this monitoring program has been highly successful. Perhaps we could establish a similar program for screening all subway passengers or for screening all people who attend large, indoor functions. Imagine the New York subway at rush hour as passengers passed through checkpoints. The sheer number of people involved suggests that a screening program would be extremely difficult to establish. Such security would be needed not only in the underground itself but also in all outlying stations and in the maintenance facilities. It would certainly be an immense, although not impossible, task, and if terrorist attacks on commuter facilities become commonplace there might come a time when such a system has to be instituted. Deployment of nerve gases against civilian populations might be minimized by using appropriate detection devices in conjunction with appropriately trained security forces. Perhaps dogs might be trained to detect nerve gases which to humans seem odorless. The problems are similar to those encountered in preventing the deployment of terrorist bombs.

There are several reasonably effective antidotes to nerve gases. GB, GA, and VX are all organophosphates that, like their less toxic pesticide cousins, inhibit acetylcholinesterase, resulting in the accumulation of acetylcholine at the nerve synapses. Accumulation of acetylcholine results in the overstimulation of parts of the nervous system that control smooth muscle, cardiac muscle, and exocrine glandular function. In general, death results from respiratory failure. Several agents can antagonize the accumulation of acetylcholine. Atropine when used in conjunction with oximes such as pralidoxime, obidoxime, or trimedoxime (*4*) may prevent and reverse, to a degree, the central nervous system effects of the nerve gases. The problem is that atropine and the oximes are themselves highly toxic and they should be administered to a victim of a gas attack only by trained personnel (*4*). It would not be possible for the general population to carry such toxic agents and to self-administer them in the event of a gas attack. In addition, nerve gas exposure could result in mental confusion, dizziness, nausea, and vomiting, and self-administration under such circumstances would be highly risky.

It is unlikely that, in the event of a terrorist attack on a civilian population, emergency personnel could respond with appropriate equipment and antidotes in less than 30 minutes, even if antidotes and other materials were available in the quantities projected. With agents that can kill in seconds, 30 minutes after the gas is in the air is too late. In view of the complexities involved, it seems unlikely that an attack on civilian lives in a crowded public place could be prevented. However, we can act to minimize casualties which are to a degree determined by the nature of our responses and the speed with which they are put in place. Emergency and medical personnel, especially those in cities where large numbers of people congregate at certain times, should be trained to deal with terrorist attacks involving nerve agents. Such personnel should have on hand substances that might limit the toxicity of nerve and/or blistering agents in sufficient quantities to treat thousands of people. Equipment and protective clothing for emergency and medical personnel should also be available.

One approach that might help reduce the number of casualties in the event of gas attacks in crowded public buildings involves the use of sprinkler systems. GB, GA, and VX are all miscible with water (*2*), and washing with weakly alkaline solutions is part of the protocol established by the military for the decontamination of personnel exposed to nerve gases (*4*). Most public buildings in the United States have sprinkler systems installed in the event of fire. Perhaps sprinklers could be deployed almost immediately as a means of confining the released gas and reducing its concentration. In the absence of decontamination kits, washing with copious amounts of water or weak alkaline solutions could remove the nerve agent or at least reduce its concentration in the air.

Suppose that a room containing 1,000 people were exposed to an air concentration of nerve gas sufficiently high to transfer a dose of agent to each of the occupants equal to the LD_{50}, then 500 of those people would die. However, if the concentration of agent in the air could be reduced by 50%, assuming a linear dose response, then fatalities would be reduced to 250, a saving of 250 lives. It is unlikely that a sprinkler system could remove nerve gas from the air with 100% efficiency, but many lives might be saved even with only partial removal of the gas. Experiments could easily be designed to test the hypothesis and with appropriate modifications to sprinkler systems, perhaps involving flow rates and droplet sizes, rendered optimally effective in removing toxic agents from the air. In addition, sprinkler systems could be coupled with nerve gas detectors such as the time-of-flight mass spectrometers currently under development at Johns Hopkins or the surface acoustic wave sensors currently being developed by the U.S. Naval Research Laboratory and thereby reduce the response time possibly to within seconds of the initial gas release.

It seems reasonable to suppose that if nerve gas attacks in crowded, enclosed spaces could be blunted through use of sprinkler systems coupled with specific detection devices, then the presence of such a system might, itself, be a major deterrent. After all, there would be little point in carrying out an attack if its chances of success were substantially reduced.

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References

1. Tokyo subway attack: chemical weapon possible terrorist tool. Chem Eng News 73(13):6-7 (1995).

2. Munro NB, Ambrose KR, Watson AP. Toxicity of the organophosphate chemical warfare agents GA, GB, and VX: implications for public protection. Environ Health Perspect 102:8-38 (1994).

3. Murder on the metro. Nature 374:392 (1995).

4. Munro NB, Watson AP, Ambrose KR, Griffin GD. Treating exposure to chemical warfare agents: implications for health care providers and community emergency planning. Environ Health Perspect 89:205-215 (1990).

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