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Prehospital management of sarin nerve gas terrorism in urban settings: 10 years of progress after the Tokyo subway sarin attack☆

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Summary Chemical agents have been used previously in wartime on numerous occasions, from World War I to the Gulf War. In 1994 and1995, sarin nerve gas was used first in peacetime as a weapon of terrorism in Japan. The Tokyo subway sarin attack was the first large-scale disaster caused by nerve gas. A religious cult released sarin gas into subway commuter trains during morning rush hour. Twelve passengers died and about 5500 people were harmed. Sarin is a highly toxic nerve agent that can be fatal within minutes to hours. It causes the clinical syndrome of cholinergic hyperstimulation by inhibition of the crucial enzyme acetylcholinesterase. Therapy of nerve agent toxicity is divided into three categories, decontamination, respiratory support, and antidotes. All of these therapies may be given simultaneously. This article reviews toxicology and management of this acute chemical emergency. To help minimize the possible catastrophic impact on the public, we make several recommendations based on analysis of the Tokyo subway sarin attack and systematically review the current scientific literature.

Introduction

Of so-called weapons of mass destruction, chemical weapons have been used in previous wars.[1] Diseases and injuries produced by the offensive chemical weapons used against civilians have been lethal or extremely disabling.[2] Furthermore, certain types

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of nerve gas such as sarin could be available to small groups and even to individuals. The potential impact of nerve gas chemical terrorism in urban setting was well illustrated by a 1995 Tokyo subway sarin poisoning of Aum Shinrikyo religious cult.[3–6] Twelve people died and more than 5500 people were injured in that attack.

If used as offensive weapons under certain meteorological conditions, nerve gas agents could cause large-scale mass casualties.[4] Victims may present in enormous numbers and overwhelm local medical resources.[5] Therefore, the hostile use of nerve gas agents would cause significant impacts on emergency medical system on an unprecedented scale.[6]

We reviewed the literatures on toxicology and disaster epidemiology regarding nerve gases as well as analysis of Matsumoto City, Japan and the Tokyo subway sarin poisoning. We made recommendations specifically to emergency medical services to address effective mass casualty management strategies when facing the potential catastrophe.

Methods

We sought to identify published investigations designed to analyze data for toxicology and actual incidents of nerve gas chemical terrorism. We also performed focused analysis of sarin poisoning in the Tokyo subway system in 1995 because this event represented an actual attack of nerve gas terrorism in a typical urban setting. Finally, we briefly summarized recommendations for a mass casualty management strategy based on current scientific evidence.

Regarding literature sources and search strategies, we searched three sources for relevant reports; Medline databases of peer-reviewed articles, government and military reports, and web sites of relevant government, academic, military, and commercial entities. We developed our Medline search strategies including MeSH terms such as Chemical Warfare, Chemical Warfare Agents, Gas Poisoning, and Sarin. The literature written in Japanese language was searched using appropriate medical database (Ichushi, Tokyo, Japan). We also consulted the medical staff of St. Luke Hospital, Tokyo, Japan, to collect hospital information about the Tokyo subway attack. Finally, we identified additional articles from the personal bibliographies, electronic resources, media reports, and conference proceedings.

To identify potentially relevant articles, we reviewed titles, abstracts, and full-length articles if available. Given the large volume of web sites screened, one of authors (YT) collected data from each Web-based report. We reviewed information about mass casualty management strategies from each reference. We did not restrict year of publication for any reports but focused mainly on more recent years of publication mostly after 1995, the year of Tokyo subway sarin attack since we report on the progress after this tragedy.

Toxicology

Nerve agents

Nerve agents are the most toxic of known chemical warfare agents. They are chemically similar to organophosphate pesticides and exert their biological effects by inhibiting acetylcholinesterase enzyme.[7] Accumulating acetylcholine at receptor site creates acute cholinergic crisis. Death ensues because of respiratory depression and can occur within seconds to minutes.[1]

The ''classic'' nerve agents include tabun (also designated as GA), sarin (designated as GB), soman (designated as GD), cyclosarin (designated as GF), and VX (Table 1). G-type agents are clear, colourless, and tasteless liquids that are miscible in water and most organic solvents.[7] They evaporate approximately at the same rate as water, within 24 h after deposition on the ground. An exception is cyclosarin which is oily. Their high volatility makes a spill of any amount a serious vapour hazard.[1] Sarin is odourless and the most volatile nerve agent. Tabun has a slightly fruity odour, and soman has a slight camphor-like odour. VX is the exception since it is

Table 1 Selected physical features of nerve agents[7]

	Tabun	Sarin	Soman	VX
Colour	Colourless	Colorless	Colorless	Amber
Taste	Tasteless	Tasteless	Tasteless	Tasteless
Odour	Fruity	Odourless	Camphor	Odourless
Specific gravity[a]	1.073	1.089	1.022	1.008
Molecular weight (Da)	162.3	140.1	182.2	267.4

[a] Specific gravity of water = 1.0.