The Surgeon and Acts of Civilian Terrorism: Chemical Agents

William P Schecter, MD, FACS, and Donald E Fry, MD, FACS, the Governors' Committee on Blood Borne Infection and Environmental Risk of the American College of Surgeons

The use of chemical agents for acts of civilian terrorism is as major a concern at the present time as biologic agents. Toxic chemicals offer the terrorist the advantage of easy production and storage, which is not afforded by biologic weapons. Most induce damage by inhalation or surface toxicity.

HISTORY

The first documented use of chemical weapons occurred during the Peloponnesian War (431 to 401 BCE) when Thracian allies of Sparta overcame the defenders of an Athenian Fort at Delium by insufflating fumes of burning coal, sulfur, and pitch through a long tube placed through the wall of the fort.[1] In 98 BCE, the Roman general Sertorius used an ash-like sand in battle to overcome rebel tribesmen in Spain. The sand caused coughing and blindness, forcing surrender within 2 days. Noxious fumes from burning chemicals thought to be a combination of rosia, sulfur, pitch, naphtha, lime, and perhaps saltpeter, were used as a naval weapon by the Byzantine Greeks in 660 CE. The weapon was called "Greek Fire."[2] Some 1,152 years later, Admiral Thomas Cochrane of the Royal Navy suggested sending burning sulfur-laden ships (a forme fruste of Greek fire) into the harbors of Napoleonic France, but his proposal was not accepted by the Admiralty.[3]

Through the centuries, a variety of poisons were used to destroy crops, contaminate water supplies, and assassinate adversaries. Rapid advances in the field of chemistry in the 19th and 20th centuries made available an increasing number of chemicals that could be used for military or terrorist purposes. In 1854, during the Crimean War, a prominent chemist with the unlikely name of Sir Lyon Playfair, suggested the use of cyanide-laden shells against the besieged fort in Sebastopol.[4] The war office rejected the suggestion as inhumane. In 1862, John Doughty of New York suggested the use of chlorine in shells in a letter to the Secretary of War Edwin Stanton. This suggestion was also rejected as inhumane.[5]

Multiple international conferences subsequently prohibited the use of poisons during warfare: St Petersburg in 1868, Brussels in 1874, and The Hague in 1899 and 1907. Despite these declarations, chemical weapons were rapidly introduced during World War I. As early as the summer of 1914, the Germans introduced the flamethrower and on October 27, 1914, the Germans, at the suggestion of the noted chemist Walter Nernst, used dianisidine chlorosulfonate–laden shells, but this weapon was not effective. The German High Command next turned to the Kaiser Wilhelm Institute for Physical and Electrochemistry in Berlin. Professor von Tappan developed a Howitzer shell containing xylyl bromide. The chemical did not vaporize because of the cold temperatures and the weapon was also ineffective. Van Tappan's assistant, the future Nobel Laureate Fritz Haber, then suggested the use of large cylinders containing chlorine as a weapon. On April 22, 1915, the modern age of chemical warfare began when, under Haber's supervision, the Germans released 150 tons of chlorine from 6,000 gas cylinders placed in trenches along the Western Front near Ypres. A gas cloud overwhelmed an Algerian and a French division causing 800 deaths and creating a 4-mile hole in the front. The German High Command, having little faith in the weapon, did not have a "force en réserve" to exploit the rout and the Germans advanced only $4\frac{1}{2}$ miles.[6]

Both sides of the conflict rapidly developed increasingly sophisticated gas masks to deal with the new weapon. By December 1915, phosgene was introduced, but both chlorine and phosgene were relatively ineffective because of the gas masks. In the last year of the war,

Received July 19, 2004; Accepted September 1, 2004.
From the Department of Surgery, University of California, San Francisco, CA (Schecter), and the Department of Surgery, University of New Mexico, Albuquerque, NM (Fry).
Members of the Governors' Committee on Blood Borne Infection and Environmental Risk of the American College of Surgeons are listed in the Appendix.
Correspondence address: William P Schecter, MD, San Francisco General Hospital, 1001 Potrero Ave, Ward 3A, San Francisco, CA 94110.

ISSN 1072-7515/05/$30.00
doi:10.1016/j.jamcollsurg.2004.09.002

mustard agent, a liquid vesicant, was used, effectively immobilizing large numbers of troops.

In the interwar years, use of chemical weapons was again condemned by the Treaty of Washington in 1922 and the Geneva Protocol of 1925. Mustard agent bombs were used by the Spanish and French in Morocco in 1925, the Italians in Ethiopia in 1935, and the Japanese in China in 1937 to 1938.[7]

In the meantime, significant scientific discoveries in the interwar years increased the lethality of the chemical armamentarium. In the 1920s, Fritz Haber, working at the IG Farben laboratories, adsorbed hydrocyanic acid onto a dispersible base, creating a cheap and plentiful supply of cyanide, marketed as the insecticide Zyklon B. In 1933, Haber, a Jew, left Germany in exile and died the next year. A decade later, his discovery would be used to murder 6 million of his own people in Nazi gas chambers.[8]

The search for new insecticides continued at IG Farben. In 1936, Gerhardt Schrader synthesized a cyanide-containing organophosphate that he named Tabun. Two years later, he synthesized a far more potent organophosphate named sarin, an acronym of the initials of the members of the research team. In 1944, another powerful nerve agent, Soman, was synthesized in Germany by Richard Kuhn. These organophosphates were never used as weapons during World War II.

In 1953, a sulfur-containing organophosphate, named VX, was synthesized by Ranajit Ghosh at Imperial Chemical Industries in the United Kingdom. The median lethal dose of this lethal liquid is about the size of a pinhead.[9] The power of VX was accidentally demonstrated during an aircraft spray test near the Dugway Proving Grounds in Utah on March 13, 1968, when 320 gallons of VX were accidentally released and drifted up to 45 miles from the release site, resulting in the death of thousands of sheep.[2]

In the 1980s, Iraq used nitrogen mustard extensively during the Iran–Iraq War, resulting in an estimated 40,000 Iranian casualties. In an action against the domestic Kurdish population, Iraqi forces killed the entire population of the village of Halajba on March 16, 1988.[10] Either a nerve agent or cyanide is believed to be the chemical weapons used.

Chemical weapons have also been used in multiple terrorist events in the closing decades of the 20th century. Several events demonstrate the potential of these weapons to terrorize civilian populations. In November 1978, 914 members of the People's Temple cult, including children, committed mass suicide in Jonestown, Guyana, by drinking Flavor-Aid containing potassium cyanide and a variety of sedatives.[11] In 1984, tampered bottles of Tylenol capsules containing cyanide were sold in various pharmacies and grocery stores in the United States, causing the deaths of seven people.[12] In June 1994, the Aum Shinrikyo terrorist organization released sarin in a residential area of Matsumoto, Japan, causing 8 deaths and 200 injuries.[13] The following spring, on March 15, 1995, the same organization released sarin in the Tokyo subway, resulting in 12 deaths and 1,038 organophosphate poisonings. An additional 4,460 worried but well patients presented to Tokyo hospitals, overwhelming the acute medical care system.[14,15]

CHEMICAL THREATS

There are four major chemical weapons that are available for use in a civilian terrorist event: nerve agents, cyanide, vesicants, and pulmonary agents. Nerve agents are organophosphate compounds that function as cholinesterase inhibitors causing a cholinergic crisis, seizures, apnea, and death. Cyanide interrupts mitochondrial oxidative metabolism causing death. Vesicants are liquid chemicals that cause cutaneous and mucous membrane burns and bone marrow depression. The most commonly known vesicant is mustard agent. Although a large exposure can cause death, most individuals injured by vesicants are incapacitated by cutaneous and mucous membrane burns requiring hospitalization. Pulmonary agents (chlorine, phosgene) are highly lethal chemicals that cause a hypoxic death by direct injury to the pulmonary parenchyma. Other, but generally nonlethal, chemicals are available for use in riot control and as incapacitating agents by the military or police. These chemicals could potentially be used in terrorist events but are likely to be less effective. Finally, there are many toxic industrial chemicals that could be used to poison food and water supplies.

Nerve agents

Nerve agents are organophosphate compounds that were initially synthesized in a search for improved insecticides. These chemicals are cholinesterase inhibitors that cause an excess of the neurotransmitter acetylcholine, resulting in a cholinergic crisis. There are five nerve agents that are available in chemical arsenals. Some chemicals have both a common name and a NATO designation: Tabun (GA), sarin (GB), Soman (GD), GF,