CHEMICAL AND BIOLOGICAL WARFARE

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The use of chemical[1] and biological weapons in war is prohibited by the Geneva Protocol of 1925 and the Biological weapons convention of 1992.[2]

A) CHEMICAL WARFARE

A chemical used in warfare is called a chemical warfare agent (CWA) and involves using toxic properties of chemical substances to kill, injure or incapacitate an enemy. Chemical warfare agents include gases, liquids and solids.[3] Effects of these ñCWAò include local irritant effects and systemic toxic effects.

Chemical Warfare Agents (CWA) can be classified as persistent or non-persistent. Agents classified as ñnon-persistentò lose their effectiveness after a few minutes or hours. These include chlorine, sarin and other nerve gases. ñPersistent agentsò include those that remain in the environment for several weeks. Medical personnel involved in decontamination and treatment must protect themselves using special suits such as ñHAZMATò suits.

Modern chemical warfare began during World War I and Germany was the first country to employ chemical warfare in the battle field. For many terrorist organizations, chemical warfare might be considered an ideal choice for a mode of attack as they are cheap, has a long shelf life, easy to transport, difficult to detect and effects (death and disability) are immediate. The first successful use of chemical agents by terrorists against a civilian population was on 20th March 1995 where ñAum Shinrikyoô, an apocalyptic group based in Japan released ñSarinò into the Tokyo subway system, killing twelve (12) and injuring over 5000 people. About seventy (70) different chemicals have been used or stockpiled as chemical warfare agents (CWA) during the 20th and 21st century.

01. Mustard Gas[4]

It is chemically referred to as ñDichloroethyl Sulphideò. It is a vesicant or blister forming gas and it is also referred to as ñSulphur Mustardò gas. It is alleged that it was used during World War I.[5,6] During World War II, it was used by the Japanese Imperial Army. It was also used in the war between Iran and Iraq, in 1980 to 1988. It is a volatile liquid contained in ñshellsò which are fired into the enemy territory. Others include ñNitrogen Mustardò which is similar in action.

Clinical Features

i. Skin blisters and vescicles leading to ulceration and infection.

ii. Irritation of the eyes causing conjunctivitis, corneal ulcerations and erosions leading to scarring, impairment of vision and blindness in survivors.

iii. Irritation of the mucosal surfaces of the nose, larynx and upper and lower respiratory passages causing cough and dyspnoea due to chemical bronchitis, bronchiolitis, alveolitis and fatal acute pulmonary oedema. In survivors there can be bacterial broncho-pneumonia which again can be fatal.

iv. Irritation of the larynx often leads to laryngeal oedema and possible death due to asphyxiation.

v. Irritation of the mouth, throat and oesophagus causes nausea, vomiting and epigastric pain. Mustard gas is a persistent warfare agent and a contact hazard.

02. Phosgene

It is chemically referred to as carbonyl chloride. Like chlorine and ammonia it is a very irritant gas and also has a corrosive effect. It is mainly a pulmonary irritant. It is available in ócanistersô. The French modified artillery ammunitions to contain phosgene in response to chlorine canisters used by the Germans.

Clinical features

i. Irritation of the eyes, causing burns and ulceration, leading to scarring, impairment of vision and blindness in survivors.
ii. Irritation of mucosal surfaces of the nose, upper and lower respiratory tracts causing cough and dyspnoea due to chemical bronchitis, bronchiolitis, alveolitis and fatal pulmonary oedema. In survivors there can be lung fibrosis or bacterial broncho-pneumonia which can be fatal.
iii. Exposure to high concentrations may result in death.[7]

03. Sarin Gas

It is a nerve gas falling into the same category was ótabunô, ósomanô, óVXô, óVRô, etc. Sarin, Tabun and Soman were the three ógerman nerve agentsò of the day. Sarin gas is an organic ester of phosphoric acid and is chemically an organophosphate. Sarin gas was released into a Tokyo subway by a terrorist group killing 12 and injuring over 5000 as mentioned earlier. The organophosphates used in chemical warfare are more toxic than those used in other pesticides and capable of causing rapid death.

Clinical features

Poisoning occurs from inhalation and skin absorption.

i. Nicotinic actions at neuro-muscular junctions
ii. Muscarinic actions (DUMBELS)
iii. Direct effect on the central nervous system

Death usually occurs from respiratory failure. Of the nerve gases ñVXô is a persistent chemical warfare agent (CWA) and a contact hazard.

04. Arsine[8]

There are organic compounds of Arsine and fired in artillery shells. They include :-

i. Diphenyl chlorascine
ii. Diphenyl amyl chlorascine
iii. Diphenyl cynarascine

Inhaled arsine is extremely toxic. It has a powerful effect of destroying red blood cells (intra-vascular haemolysis) leading to haemoglobin uria, acute tubular necrosis and renal failure.

05. Chlorine

Germans used chlorine in World War I. They simply opened canisters of chlorine upwind of the opposing side and let the prevailing winds do the dissemination. In early 2007, multiple terrorist bombings have been reported in Iraq using chlorine gas. As mentioned earlier it is mainly an irritant to the skin and eyes. But the main irritant effects are observed in the respiratory system causing severe breathing problems and also death similar to óMustard gasô, phosgeneô etc.

06. Hydrogen cyanide

This group also includes cyanogen chloride. They are cytotoxic agents and causes death by óhistotoxic anoxiaô. German dictator and ómass murdererô, Adolph Hitler used cyanide gas in his famous gas chambers to exterminate millions of Jews. (Refer chapter 8 on ócyanide poisoningô).

07. Sensory irritants[9]

They are also referred to as óLachrymatorsô. They are fired in artillery shells or canisters. They are commonly used by law enforcement authorities mainly in riot control or to disperse people voicing protests against the government in power.

7.1 Chloracetaphenone ï CN[10]
It is referred to as ótear gasô. It causes irritation of the eyes causing lachrymation, blurring of vision and temporary blindness. It also irritates the skin, nasal mucosa and respiratory tract mucosa causing bronchospasm. Deaths have been reported.[10]

7.2 Chlorobenzylidene malonitrite ï CS
It is more irritant but less toxic than chloracetaphenone.[11] However it causes skin and eye irritation, irritation of the nasal and respiratory mucosa with lachrymation, rhinorrhoea and difficulty in breathing.

7.3 Dibenzoxazipine ï CR
It is more potent and less toxic than CN or CS.[12]

08. Agent 15 (B2)

It is an incapacitating poison and extremely persistent in soil and water. Actions are similar to atropine. Erratic behaviour, confusion, hallucinations, incoordination and blurring of vision due to mydriasis are the common clinical manifestation. These will be helpful to defeat enemy forces.

09. Fentanyl Derivatives

On 26th October 2002, Russian Special Forces used a chemical agent (Presumably KOLOKOL-1) an aerosolized fentanyl derivative as a precursor to an assault on Chechen terrorists ending the Moscow theatre hostage crisis.

10. Herbicides

It is recorded that between 1961 to 1967, the US Air-force sprayed 12 million US gallons of concentrated herbicides, mainly ñAgent Orangeò (containing dioxin as an impurity in the manufacturing process) to destroy vegetation in South Vietnam. This caused about half a million (500,000) children to be born with dioxin related deformities.

11. Lewisite

It is a blister agent like sulphur mustard etc. It was used by the imperialist Japanese army during World War II. But unlike sulphur mustard which take a few hours, the actions of the Lewisite are immediate. Its actions are persistent and also a contact hazard. Clinical features are similar to those of ósulphur mustardô and óphosgeneô

12. Other gases

12.1 Carbon monoxide
12.2 Hydrogen sulphide
12.3 Hydrogen chloride
12.4 Oxides of nitrogen

13. Toxins

13.1 Botulinum toxin
13.2 Ricin
13.3 Saxitoxin
13.4 Abrin
13.5 Mycotoxins

B) BIOLOGICAL WARFARE

Offensive use of infective living organisms against enemies and civilians around them during a war is considered to be biological warfare. Even bacterial exo-toxins propagated through food, water and air which could incapacitate enemies and civilians are also considered to be weapons of biological warfare.

Biological weapons takes three major forms.

a. Deliberate poisoning of food and water with infectious material.
b. Use of micro-organisms, toxins or animals, living or dead, in a weapon system.
c. Use of biologically inoculated fabrics.

A successful biological attack will have a devastating impact and could result in millions or even billions of deaths and cause severe disruption to societies and economies. Ideal characteristics of biological weapons are high infectivity, high potency, non-availability of vaccines and delivering as an aerosol.

Diseases considered for weaponization or known to have been weaponized include Anthrax, Plague, Ebola, Tularaemia, Cholera, Marburg virus, Brucellosis, Q fever, Machupo, coccidiodes mycosis, Glanders, Melioidosis, Shigella, Rocky mountain spotted fever, Psittacosis, Yellow fever, Japanese B encephalitis, Rift valley fever and small pox. (A minimum of 20 diseases).

As mentioned earlier naturally occurring toxins like Ricin, Abrin, Botulinum toxin, saxitoxin and mycotoxins can also be used in Biological warfare.

Biological warfare can also specifically target plants to destroy crops or defoliate vegetation. Attacking animals is another area of biological warfare intended to eliminate animal resources for transportation and food. It is important to note that all of the classical and modern biological warfare are diseases of animals, the only exception being small-pox. Therefore it is most likely that such animals will become ill earlier than humans.

Today, at least 17 nations are believed to have offensive biological weapons programs.[13]

1. Plague

The earliest documented incident of the intention to use biological weapons is recorded in the Hittite texts of 1500-1200 BC, in which victims of plague were driven into enemy lands. During the middle ages victims of bubonic plague were used for biological attacks. This was either by flinging corpses (dead bodies) or the excrement of victims using catapults over walls into castles. In the Second World War, Imperial Japanese Airforce bombed Ningbo with ceramic bombs full of fleas carrying bubonic plague.[14] Plague is caused by Yersinia pestis a gram negative bacillus. The vector is the rat flea Xenopsyllacheopis. The fleas

bite humans causing plague. Clinical features are attributed to an endo-toxin.[15]

2. Anthrax

During the First World War, Germany pursued an ambitious biological warfare programme and Anthrax was used. Field testing carried out in the United Kingdom during World War II left Gruinard Island in Scotland contaminated with anthrax for the next 48 years. Anthrax is produced by Bacillus anthracis. It produces a toxin which is very virulent. Spores are used in warfare as they can withstand extremes of temperature and humidity. The spores are further perfect for disposal by aerosols. Inhalation of such spores results in dyspnoea, marked cyanosis and death (wool sorters disease). Fatality rate is 90% or higher.

In the largest biological weapon accident known, the accidental aerosolized release of antrax spores caused the anthrax outbreak in Sverdlovsk in the Soviet Union in 1979, resulted in 68 deaths and sheep became ill as far as 200 km from the release point of the organism from a military facility. This area is still out of bounds for visitors.[16] An anthrax aerosol is odorless.

On September 18, 2001, and a few days after, several letters were received by members of the U.S. Congress and media outlets containing anthrax spores. The attack killed five persons.[17] In the case of Anthrax, it is likely that by 24-36 hours after an attack those with compromised immune system or those who have received a large dose of the organism due to proximity to the release point will become ill with classical signs and symptoms. When diagnosed early, about 80% can be treated, with antibiotics. If not detected óearlyô, the mortality rate is moderately high. A 993 report by the US congressional Office of Technology Assessment estimated that between 130,000 and 3 million deaths could follow the aerosolized release of 100kg of Anthrax spores upwind of the Washington, DC, area ï lethally matching or exceeding that of a hydrogen bomb.[18]

Iraq has acknowledged producing and weaponizing Anthrax.[19] During a 1945 outbreak in Iran, 1 million sheep died. The terrorist group Aum Shinrikyo (responsible for releasing sarin gas in a Tokyo, Japan subway station in 1995) also dispersed aerosols of anthrax and botulism throughout Tokyo on at least 8 occasions. For unclear reasons attacks failed to produce illness.[20]

3. Clostridium botulinum

The bacterium produces neurotoxins A, B and E causing marked neuromuscular blockage. It is a form of food poisoning. Botulinum toxin is also used in biological warfare. After the 1991 Persian Gulf War, Iraq admitted to the United Nations inspection team of having produced 19,000 litres of concentrated botulium toxin, of which 10,000 litres were loaded into military weapons. These 19,000 litres have never been fully accounted for. This is approximately three (3) times the amount needed to kill the entire current human population by inhalation.[21]

4. Tularaemia

This is due to infection by Franciscella tularensis a gram negative organism. Vectors are ticks and blood sucking flies whose bites cause infection in humans. It can devastate and incapacitate families, communities, civilians and combatants in times of civil war.

5. Cholera

It is caused by a gram negative bacillus called Vibrio cholerae. The infection results in severe diarrhoea leading to dehydration, hypovolaemia, electrolyte imbalance, hypotension, circulatory collapse and death. Like Tularaemia it can devastate and incapacitate families, communities, civilians and combatants in times of civil war.

REFRENCES

1. Lockwood AH, Nerve Gases (1991), The physicians for social responsibility quarterly; 2:69 76

2. Mason JK and Purdue BN (200), Pathology of Trauma, 3rd edition, Arnold. ch 7:p97

3. Lockwood AH, Nerve Gases (1991), The physicians for social responsibility quarterly; 2:69 76

4. Mason JK and Purdue BN (200), Pathology of Trauma, 3rd edition, Arnold. ch 7:p97

5. Reddy KSN (1995), The Essentials of Forensic Medicine and Toxicology. 9th edition, ch:37; p485

6. Williams JL (1993), Pathological and clinical aspect of mustard gas intoxications, Intensive and Critical Care Digest, 12:1-2

7. Eeisenmenger *et al* (1991), Clinical and Morphological findings in mustard gas intoxications.

8. Dacre JC and Goldaman M (1966), Toxicological and Pharmacology of chemical warfare agent óSulphur mustardô, Pharmacological review, 48:228-326

9. Fernando R., Management of Poisoning (2007), Natural Poison Information centre, National Hospital, Colombo. 3rd edition, p93.

10. Smith Sydney and Fiddes FS (1949), Forensic Medicine, 9th edition, London Churchill: p466.

11. Mason JK and Purdue BN (2000), Pathology of trauma, 3rd edition, Arnold. Ch;6:p76.

12. Stein AA and Kirwan WE (1964), Chloracetaphenone poisoning, A clinical pathological report, J. Forensic Science, 9:374-382.

13. Himsworth H, 1969 and 1971, Report of Inquiring into the medical and toxicological aspects of C.S, Parts 1 and 2, London HMSO.

14. Ballantyne B and Swanston DN (1974), The irritant effect of dilute solutions of Dibenzoxapine on eyes and tongue, Acta Pharmacological Toxicologica, 35:412-413.

15. Cole LA. The spectre of biological weapons. Sci Am. December 1996:60-65

16. Daniel Barenblatt (2004), A plague upon humanity, p32.

17. Kumar and Clark, Clinical Medicine, 4th edition, WB Saunders, ch 1: p36.

18. Meselson *et al* (1994), The Sverdlovsk Anthrax outbreak in 1979, Science 266:1202-1208.

19. Gray, Collin (2007), Another bloody century: Future welfare, P 265-269, Phoenix ISBN 0304367346.

20. Office of Technology Assessment, US Congress, 1993

21. Zilinkas RA. Iraqôs biological weapons: the past as future? JAMA. 1997;278:418-424

22. WUDUnnS, Miller J, Broad W. How Japan germ terror alerted world. New York Times, May 26, 1998:1-6

23. Rheinhart, Courtney Elizabeth, ñClostridium botulinum toxin development in refrigerated reduced oxygen packaged Atlantic croaker.