

Nuclear, Biological and Chemical Warfare/ Terrorism - Medical Preparedness for Effective Planning

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Abstract

The threat of nuclear, biological and chemical (NBC) warfare, as a full-fledged warfare or as a localized terrorist attack, is a distinct possibility in the current international political and military scenario. Dissemination of information and training of all concerned i.e. army, general public, fire brigade, police and other organizations must be carried out before a NBC disaster occurs. Comprehensive planning is required for the protection and management of the resulting casualties and the complex nature of the injuries sustained.

Key words: nuclear warfare, chemical warfare, biological warfare, nuclear medicine, bioterrorism.

Introduction

In the current international, political and military scenario Nuclear, Biological and Chemical (NBC) warfare/

threat has assumed a realistic dimension. The effects of NBC warfare will be far reaching. It is pertinent to note that a NBC warfare may not occur

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only as a full fledged warfare. It may take shape of a localized terrorist attack.

Salient Features in Medical Treatment of NBC Casualties

The following are the salient features: (1)

- The magnitude of casualties will generally far outstrip the medical and other resources.
- Specialized ambulances will be required for casualty evacuation.
- Health care facilities including equipment and health care workers may themselves suffer significant damage.
- The responders may require Personal Protective Equipment (PPE).
- Triage protocol to be followed in a NBC scenario needs to be different from that followed during other disasters.
- Casualty evacuation has to be done separately for contaminated and non contaminated cases.
- Significant number of casualties would be burn casualties.
- An integrated multidisciplinary program on capacity development through education, training and critical infrastructure development is required
- There will be significant psychological stress disorder cases including those of Acute Stress Disorder and Post Traumatic Stress Disorder.
- Community should have the knowledge of the effects of NBC agents with basic emergency precautions and preventive measures.
- The medical preparedness for Chemical, Biological, Radiological and Nuclear (CBRN) management necessitates development of SOPs for CBRN management at the incident site for triage, personal protection decontamination, resuscitation, casualty evacuation followed by treatment of exposed victims at the hospital level. The critical infrastructure for medical management includes CBRN casualty treatment centers /wards and training facilities for specialist response to deal with covert CBRN attacks.

Status in India

Government of India in recognition of the importance of disaster management as a national policy had set up a High Powered Committee (HPC) in August 1999 and a National Committee on Disaster Management (DM) after the Gujarat Earthquake for

making recommendations on the preparation of DM plans and for suggesting effective mitigation mechanism. Recommendations of the HPC laid the foundation for DM framework in India. Indian Ocean Tsunami acted as the catalyst and the Government of India took a defining step in the legislative history of the country by enacting DM Act 2005. Of the eight Battalions of National Disaster Relief Force four are specially trained to manage NBC disasters. (2)

Effects of Nuclear Explosion

Blast, thermal and ionizing radiation are the different mechanisms which are responsible for nuclear casualties. Immediately after a nuclear explosion temperature may go upto 106 degree centigrade and pressure upto 105 atmospheres. The energy of nuclear explosion is released in the form of blast (fifty percent) heat (thirty five percent) and nuclear radiation (fifteen percent). The flash of light of a nuclear burst is followed by a ball of fire. Gamma rays and neutrons are emitted from the ball of fire. This is followed by pressure wave called the shock wave which travels at supersonic speed. This wave after striking the earth is reflected back. The reflected and the incident waves fuse together to form the Mach Wave. There is an initial and residual ionizing radiation on after detonation of nuclear

weapon. The initial radiation is released within the first minute after detonation whereas the delayed radiation includes the local fall out due to debris which reaches the ground within few days and global fallout which enters the atmospheric circulation and falls on the earth surface after months or even years. The various types of ionizing radiations released are neutrons, alpha and beta particles, gamma and X-rays.

Protective measures

The various protective measures which should be known to all are as follows:

- Not to look at the flash of a nuclear explosion. To prevent retinal burns and flash blindness, eyes should be closed.
- If outdoors, protection from the blast should be taken by lying down immediately on the ground.
- Protection from heat should be taken in underground shelters with overhead cover.
- Avoidance of entry into contaminated areas.
- Not consume suspected food, water, fruit, milk and vegetables.
- Personal cleanliness.
- Decontamination of personnel and equipment at decontamination centres.

- Periodic medical review of personnel who have been exposed to small doses of radiation.

Essentials for effectivity

Organizational Set-up

To deal effectively with NBC warfare casualties, planning for an appropriate organizational set up is an essential requisite. Special centers capable of providing protection from the NBC effects must be catered for, at district, state and national levels. VIPs key personnel, equipment including communication set up, should have provision for taking protective shelter in the event of a NBC strike.

Burn Centers

A large number of victims of a NBC warfare will be burn casualties. Burns may be caused by 'flash', fire or beta particles after a nuclear fallout. Specialized burn centers should be functional to cater for the management of these casualties.

Decontamination Centers

As an operative guideline all casualties of a nuclear warfare must be regarded as radiation victims unless otherwise proved. Monitoring and decontamination of the residual radioactive contamination should be done. The injured must pass through a decontaminated center into protected

area and be screened at a reception area. Washing bathing and laundry facilities should be provided at decontamination centers.

Additional Support

Augmented support both in terms of medical and administrative will be required for management of NBC casualties. Planning must be done for air lifting of manpower and other resources.

Training

Training in NBC warfare related events must be done for maximum number of civil and military personnel. Use of dosimeters, general precautions and measures in case of a NBC attack should be known.

Triage Protocol

Nuclear explosion casualties require a triage protocol which is different than that for other casualties. The most seriously injured with multiple injuries and those with irradiation dosage significant should get the last priority. The first priority should be given to casualties who have a reasonable chance of survival, if treated.

Radiological and Nuclear Emergencies

Nuclear Medicine is a branch of medicine and medical imaging that uses

radioisotopes in diagnostic and therapeutic measures. Nuclear energy has numerous widespread applications in the field of industry, medicine, agriculture and research. Because of these widespread applications, the availability of radioactive sources has become easy. While their radioactive strength is in itself a deterrent to pilferage, they do have the potential of being stolen and used in a Radiological Dispersal Device (RDD) or Improvised Nuclear Device (IND) (2).

CBRN Stores

Specified hospitals for CBRN treatment should stock all the drugs, decorporation agents and other specialized items for treatment of CBRN casualties (2). They will include:

- Growth factors, colony stimulating factors, and other radiation recovery agents are very useful for restitution of the immune system.
- Antidotes are required to be procured to neutralize chemical effects. Antidotes required for nerve agents are physostigmine, obidoxime, atropine and pyridostigmine. Vesicants may require dimercaprol, sodium thiosulphate while cyanide based agents may require dicobalt edetate.

- Biological agents require antibiotics and vaccines. Recombinant protective antigen vaccine and anthrax immuno-globulin for anthrax, recombinant F1-V antigen vaccine for plague and vaccines for Q fever, tularemia, botulism, viral hemorrhagic fever and small pox should be catered.

Treatment

Earmarked hospitals should have specialized CBRN treatment centres with trained specialist and paramedics for management of CBRN casualties. Some of the advance care and diagnostics facilities for CBRN casualty management are as follows (2):

- Radiation injury treatment center.
- Advanced blood bank facility. Some of the important facilities include, blood component separation, apheresis, stem cell harvesting, immuno haematological, Infection markers screening, leucodepletion and gamma irradiation. The cold chain system also needs to be created such as an adequate storage unit including deep freezer (-33 deg C): ultra deep freezer (-83 deg C) platelet agitator cum-incubator (+22 deg C) and adequate blood transportation boxes.
- Advanced laboratory facility. This facility should have a genetic and

molecular laboratory and other specialized diagnostic facilities for CBRN management.

- Burn Centre
- Selected hospitals should develop bone marrow facilities.

Chemical Warfare

Chemical weapons are a potent means of mass destruction. The chemical agents used may be lethal agents like Sarin which generally kills the targeted group or incapacitating agents such as Distilled Mustard which temporarily incapacitate the victims.

Historical Facts

Blister agents were used by the German against the British during the First World War. There were almost 1,68,000 casualties due to this, with a death rate of two to three percent. Phosgene accounted for eighty five percent of deaths attributable to chemical weapons during the First World War. Mycotoxins are alleged to have been used in military warfare in Laos (1975-1983), Cambodia (1978-1983) and Afghanistan (1979-1983). They are the causative agents which have been allegedly responsive for the mysterious "yellow rain" phenomenon in these places.

The agents used in chemical warfare may be grouped as follows:

Nerve Agents

These interfere with the functioning of the nervous system and thus adversely affect human body functions such as respiratory and muscular activities. The main action of nerve agents is through inhibition of the enzyme cholinesterase. Acetylcholine is thus not neutralized and hence, continuously acts on receptors in the smooth muscles. Examples of this group are Tabun (GA), Sarin (GB) Soman (GD) and Vx. Their main route of entry in the human body is through the respiratory system and the skin. The principles of treatment include termination of exposure to toxic substance, establish/maintain ventilation and specific antidotal therapy such as atropine (acts by blocking the effects of excess acetylcholine at muscarinic receptors) and oximes which reactivate the organophosphate inhibited phosphorylated enzyme. The standard antidote kit contains injection Atropine 2 mg and Injection 600 mg PAM-C.

Blister Agents

These are so called since they cause blistering of the skin. Examples of this group are Distilled Mustard (HD), Nitrogen Mustard (HN) and Lewisite (L). They affect by interfering with DNA

synthesis and cellular division. They are cytotoxic as well as mutagenic. They gain entry in the human body through the oral, respiratory system and the skin. These agents were successfully used by the Germans against the British during the First World War. The antidote used for Lewisite poisoning is BAL (Dimercaprol).

Blood Agents

These agents are absorbed by inhalation and prevent body tissues from utilizing the oxygen in the blood e.g., Hydrogen Cyanide (AC), Cynogen Chloride (CK) and Arsine (SA). These agents combine with cytochrome oxidase enzyme which is essential for oxidative process of the tissues and hence oxygenation of the tissues is affected. Amyl nitrite and sodium nitrite with or without sodium thiosulfate are used as antidotes for cyanide.

Choking Agents

These affect the respiratory system, e.g. Diphosgene (DP), Chloropicrin (PS) and Phosgene (CG). The result is pulmonary edema, hypoxia and haem concentration. Phosgene was used as a major chemical warfare agent during the First World War.

Tear Agents

These are often used as riot control agents.

Incapacitating Agents

These include substances such as BZ and LSD. They produce physiological or mental effects or both rendering individuals incapable of performing their assigned duties. The signs and symptoms include those associated with anti cholinergics, indoles and cannabinoids.

Biological Warfare / Bio Terrorism

Biological warfare / bioterrorism is the use of living organisms or their toxic products to cause death, disability or damage to man. Though the biological weapons have seldom been employed, there is ample evidence that there are nations and terrorist groups that have the capability and already have stocks of these weapons. The biological agents may be lethal and transmissible, lethal and non transmissible, incapacitating and transmissible and incapacitating and non transmissible. The review of the events related to bioterrorism reveals the following (3):

- Bioterrorism is more likely in use than ever before and far more to be feared than either explosives or chemicals.
- Civil population has scarcely been targeted and the subject of bioterrorism is hardly discussed publicly.

- Recipes for making biological weapons are now available on the internet.
- Detection or interdiction of those intending to use biological weapons is extremely difficult.

Historical background

Biological warfare has been used since long. In the 14th Century, the targets besieging the Italians in a fortress in Crema threw over the wall the bodies of plague victims forcing abandonment of the fortress. The Italians also published a tactical manual describing how to construct artillery shells for delivery of disease carrying organisms. It has also been documented that the Red Indians in North America were surreptitiously given small pox infected blankets. Limited biological warfare is reported to have been carried out by Japan during World War II. In the recent past, mycotoxins have been reported to be used in Afghanistan.

In 1972, Biological and Toxic Weapons Convention attended by almost all the countries agreed to cease bio-weapons research programs and to destroy stocks of bio-weapons which they possessed. In spite of this, it has been reported that even in 1990s, countries had stockpiled tons of dried spores of anthrax, smallpox, plague and tularemia.

Biological Agent Dissemination and Delivery Techniques

The main methods for disseminating the agents are through aerosols or by the use of disease carrying vectors (4). Explosive bomblets in which there is burster, surrounded by biological agents and enclosed in thin case, explode upon impact and disseminate the biological agent as an aerosol. Spray tanks carried by aircraft and missiles may also be utilized for producing aerosol containing the biological agent. Disease carrying vectors such as mosquitoes, mites, ticks and lice may be delivered by aircraft or missiles in containers which rupture on impact. The biological agents may also be introduced into the food chain or water.

Biological Warfare Agents

Various micro-organisms have been studied as biological warfare agents such as the Dengue virus, Ebola virus, Lassa virus, Haemorrhagic Fever viruses, Rickettsia prowazekii, Coxiella burnetii, Bacillus anthracis, Vibrio cholerae, Yersinia pestis, F. tularensis, Salmonella typhimurium and so on. The agents most likely to be used are spores of smallpox, anthrax and plague. The bacterial toxins that are utilized are Botulin, Staphylococcal, and Tetanus whereas the mycotoxins include aflatoxins and trichothecenes.

Diagnosis

Biological agents can multiply only in a living host and there is no definite sensor available to detect the agents. An early accurate diagnosis is the key to manage casualties of biological warfare. Samples from patient suspected to have been affected by biological warfare agent must be sent to designated medical facilities. The confirmatory laboratory diagnosis may be done by antigen, antibody detection. By application of fluorescent antibody technique (FAT), the identification of biological warfare agents such as virus causing smallpox may be done in one to two hours.

Epidemiological Clues of a Biological Warfare or Terrorist Attack

These include the following

- The presence of a large epidemic of a disease, in a discrete population.
- Many cases of unexplained diseases or deaths.
- Disease more severe than is usually expected for a pathogen or failure to respond to standard therapy.
- Unusual routes of exposure for a pathogen, such as the inhalation route for disease that normally occur through faeco-oral route.
- A disease that is unusual for a given geographic area or transmission season.
- Disease normally transmitted by a vector that is not present in the locals area.
- Multiple simultaneous or serial epidemics of different diseases in the same population.
- A single case of disease by an uncommon agent. (Small pox, some viral hemorrhagic fevers).
- A disease that is unusual for an age group.
- Unusual strains or variants of organisms or antimicrobial resistance patterns different from those circulating.
- Similar genetic type among agents isolated from distinct sources at different time or locations.
- Higher attack rates in those exposed in certain areas, such as inside a building if released indoors, or lower rates in those inside a sealed building if released outside.
- Disease outbreaks of the same illness occurring in non contiguous areas.
- A disease outbreak with zoonotic impact.

- Intelligence of a potential attack claims by terrorist or aggressor of a release, and discovery of munitions or tampering.

Detection

Accurate intelligence is required to develop an effective defense against biological warfare. Once an agent has been dispersed, detection of the biological aerosol prior to its arrival over the target, in time for personnel to don protective equipment, is the best way to minimize or prevent casualties. However, interim systems of detecting biological agents are just now being fielded in limited numbers. Until reliable detectors are available in sufficient numbers, usually the first indication of a biological attack in unprotected soldiers will be the ill soldier.

Detector systems are evolving and represent an area of intense interest with the highest priorities within the research and development community. Several systems are now being fielded. The biological integrated detection system (BIDS) is vehicle mounted and concentrates aerosol particles from environmental air then subjects the particle sample to both genetic and antibody based detection schemes for selected agents. The long range

biological standoff detection system (LRB SDS) will provide a first time biological stand off detection capability to provide early warning. It will employ infrared laser to detect aerosol clouds at standoff distance up to 30 km. An improved version is in development stage. This system will be available for fixed site applications or inserted into various transport platforms such as fixed wing or rotary aircraft and short range biological standoff Detection System (SRB SDS) is in the research and development phase. It will employ ultraviolet and laser induced fluorescence to detect biological aerosol clouds at distance effective range 5 km. The information will be used to provide early warning, enhance contamination avoidance efforts and cue other detection efforts.

The principal difficulty in detecting biological agent aerosols stems from differentiating the artificially generated BW cloud from the background of organic matter normally present in the atmosphere. Therefore, the aforementioned detection methods must be used in conjunction with intelligence; physical protection, and medical protection (vaccines and other chemo prophylactic measures) to provide layered primary defenses against a biological attack.

Networking of laboratories under Integrated Disease Surveillance Program (IDSP)

Under the IDSP of Government of India, a laboratory net work has been established at various levels of health care as given below and this network is to be used for disease surveillance/outbreak investigation even during disaster. The network comprises of Peripheral Laboratories and Microscopy Centers (L1 labs); District Public Health Laboratories (L2 Labs); State Laboratories (L3Labs); Regional and Quality Assurance Laboratories (L4); Disease based reference laboratories (L5). There are 8-10 laboratories of repute in the country which will be acting as National Reference Labs. The IDSP will support the biological disaster management also, in order to set up the district laboratories initially there will be strengthening of 3-4 priority laboratories for each state and model district labs will be set up which will later on be expanded to all the district laboratories.

Personal Protection

If outdoors, personnel should keep the head covered, wear a scarf and cover the nose with a handkerchief/cloth. The currently fielded chemical protective equipment, which includes the

protective mask, battle dress over garment (BDO), protective gloves, and over boots will provide protection against a biological agent attack. At the earliest, refuge should be taken in a closed shelter. Ultra high efficient filter masks which are capable of filtering more than 99 percent of particles of 1-5 microns should be utilized.

Collective Protection

All doors and windows of buildings must be closed when a biological attack is imminent. For effective protection persons should take shelter in a building with an efficient air filtration system.

Decontamination

Decontamination involves either disinfection or sterilization to reduce microorganisms to an acceptable level on contaminated articles. BW agents can be decontaminated by mechanical, chemical and physical methods:

- Mechanical decontamination involves measures to remove but not necessarily neutralize an agent. In a BW context, the use of an air filter to remove aerosolized anthrax spores, or water to wash agent from the skin.
- Chemical decontamination renders BW agents harmless by the use of disinfectants that are usually in the form of a liquid, gas or aerosol.

- Physical means (heat, radiation) are other methods than can be employed for decontamination of objects.

Immunoprophylaxis

Vaccines against a number of potential biological warfare agents have been developed; anthrax, small pox and some including polyvalent vaccines are in various stages of research. Troops of the multinational force in the Gulf War were reported to have been protected against Anthrax.

Chemoprophylaxis

Chemoprophylaxis would be useful if the biological warfare agents have been identified, such as Anthrax, Plague, Q Fever, Glanders and Melioidosis.

General Measures of Protection

The general population should be educated and the concerned must understand that biological warfare/bio-terrorism is a possibility.

- Only cooked food should be consumed.
- Boiled / chlorinated / filtered water should be consumed.
- Insect and rodent control measures must be initiated at the earliest.
- Isolation of suspected / confirmed cases preferably in negative pressure isolation.

Major Components of CBRN Management (2)

CBRN Emergency Van

Hospitals with CBRN casualty treatment centres must have a CBRN emergency van equipped with CBRN detection, protection and decontamination equipment and material.

Radiation Detection

The following detection equipment is essential for rescue teams and QRMTs (Quick Reaction Medical Teams)

- **Personal Radiation Dosimeter:** It gives a direct visual reading and a safe radiation range can also be set on the equipment.
- **Thermo Luminescence Dosimeter (TLD) Badges:** The TLD gives the information about the cumulative radiation does.
- **Radiation Dose Survey Meter:** It can be hooked with a computer and data can also be transferred through telephone lines.
- **Micro Bomb Detectors:** It contains a real time alerting mechanism through a bright light and buzzer.
- **Vehicle Detectors:** A moving vehicle monitor designed for measuring and determining radioactivity of vehicles should be provided at all entry and exit gates.

- Whole Body Counters: Whole body counters will detect any radioactive material inside and outside the body.

Chemical Detectors

Chemical agents monitors, AP2C, 3 colour detector papers, portable gas chromatographs, residual vapour detection kits.

Biological Integrated Detection System

It is a high mobility, multi-purpose, wheeled vehicle mounted system that concentrates aerosol particles from air, then subjects the particle sample to antibody-based detection schemes for selected agents.

Protective Equipment

Protective equipment is required by rescue teams and QRMTs, for evacuation of victims from the contaminated area.

Creation of CBRN Decontamination Room

Earmarked hospitals must have a decontamination room having appropriate equipment and material. The decontamination room should have a lightweight durable, impermeable, washable and reusable fiberglass tabletop with a flexible drain hose, locking straps spray nozzle and wall mounting bracket. Two 100-litre waste

collection containers must also be available. All nuclear casualties should be decontaminated prior to shifting into the treatment ward.

CBRN dust filter fitted ward

CBRN casualty treatment ward must be fitted with CBRN filtration units to provide purified air with positive pressure inside so that contaminated air cannot come in.

Special Laboratories

- Radio Bio-dosimetry Laboratories – Radio Bio-dosimetry includes lymphocyte estimation along with the other formed elements of the blood. Chromosomal study is an important tool for radiation bio-dosimetry (3).
- Hematology Laboratories/Blood Banks. Blood and bone marrow are very sensitive to radiation. Following radiation exposures, neutropaenia will occur suppressing the immunity of the casualty leading to infection. Therefore a hematology laboratory/blood bank with a cell separator for granulocyte concentrates is an essential requirement for the management of radiation injuries.
- (a) Genetic Laboratories. Genetic studies must be carried out in a properly equipped genetic

laboratory for proper monitoring surveillance and counseling of victims.

(b) **Molecular Laboratories.** Radiation injuries damage DNA, therefore a molecular laboratory needs to be established in the radiation injury treatment centre for DNA and other molecular studies.

(c) **Immunology Laboratories.** The immunology laboratory will facilitate studies in cell mediated and humeral immunity. The laboratory will also be useful for antibody detection of various biological agents.

Bone Marrow Bank. For the restitution of the immune system, bone marrow transfusion is very important. The bone marrow of a person showing high risk of radiation exposure will be harvested, cryo-preserved and stored to transfuse at the time of requirement. Therefore, stem cell harvesting facilities and bone marrow banks are essential components of acute radiation injury treatment centres.

Immunoprophylaxis and Chemoprophylaxis. Prophylactic immunization is an important means for providing protection against biological

agents. For some biological agents the only available counter measures might be specific anti-serums. Chemoprophylaxis using broad spectrum antibiotics offers an additional option for biological agents. Some cases like anthrax may require coupling of antibiotics with vaccines.

CBRN Management Equipment for QRMTs (2)

These include the following

- CBRN Detectors
- CBRN Protection and Decontamination Equipment
- Material for Area and Equipment Decontamination
- Decorporation Drugs
- Chemical Casualty Treatment Kit

Conclusion

NBC warfare as a full fledged attack or as a limited tactical strategy by countries or terrorist groups is a possibility. The casualties will include the army personnel and the civilians. The magnitude of casualties and the complex nature of the injuries sustained as a result of NBC attack require a comprehensive management planning. Dissemination of information and training of all concerned i.e. army, general public, fire brigade, police and other organizations must be carried out

before a NBC disaster occurs. It is essential that a comprehensive planning is done for protection and management of NBC casualties. Networking including integration in the existing medical and administrative set

up must be planned and executed. Understanding, planning and implementation of NBC casualty medical management set is a national challenge for the present. The future of mankind may depend on its effectivity.

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