

17 Management of Nuclear Biological Chemical Casualties: Overview

Abstract: Under the prevailing scenario there is a high possibility of Nuclear, Biological and Chemical (NBC) warfare agents falling in the hands of terrorist groups, imposing great challenge of NBC terrorism. Terrorists may sabotage a chemical or nuclear plant. Use of NBC agents during the war is a very remote possibility. Chemical and nuclear agents can be used as **Dirty Bomb** where these agents are packaged with explosive material. On explosion "Dirty Bomb" will cause contamination of environment causing hazardous effects on health. Nuclear agents can be used as **Suitcase Nuke** having a weight of 10 kg only, while it will have a yield of 10-20 KT, with radiation effect up to 4-5 km radius. Usually, Cesium-137 or Cobalt-60 are the nuclear materials used in the dirty bomb which has got a long half life causing the delayed radiation effect in the form of cancer, cataract, genetic damage, premature aging and infertility.¹ The virulence of biological agent cannot be undermined as they are cheap, easy to produce and only small amount is required to play havoc.² Bacteria like anthrax, virus like smallpox, toxin like botulism toxin are most commonly used as biological agents.^{3,4} In addition to NBC terrorism, nuclear or chemical disaster can also occur due to accident either in nuclear reactors, chemical plants or during transportation of nuclear or chemical material. Accidental release of biological agents from a biosafety lab will cause biological disaster. NBC disaster will cause tremendous devastation to human and other living beings, flora fauna and environment including air, water and soil. Management of casualties in nuclear, chemical or biological scenario poses the great challenge because of the contamination. In NBC environment search, rescue and quick reaction medical team has to put on protective clothing, respiratory masks, boots and gloves which reduces the working efficiency. Personal protection, detection, decontamination, decorporation, vaccination and antidote administrations are the extra special requirements for the management of NBC casualties along with the usual care of heat, blast and infection effects. Nuclear agents mainly cause acute hemopoetic, gastrointestinal, cutaneous and CNS syndrome while chemical agents adversely affect eyes, skin, respiratory and nervous system, of course biological agents can severely infect any part of the body causing casualties in pandemic proportion. Every physician needs to be prepared to handle NBC casualties. Brief description about NBC agents is very essential to understand the subject.

NUCLEAR RADIATION

Radiation injuries are caused by external irradiation or by internal irradiation by beta emitters. External irradiation may be acute or chronic, whole body or only superficial. Internal irradiation by beta emitters may be caused by ingestion, by inhalation or by entering through wounds. Severity of injuries depends on radiation dose. Depending on the system involvement and severity of exposure various acute radiation syndrome occurs.⁵

Cutaneous Syndrome

- Skin lesion may appear within hours of exposure.
- Erythema, itching, blistering, edema, desquamation, necrosis, ulcer, hair loss and onycholysis are the main skin manifestation of radiation (Fig. 1).

Hemopoetic Syndrome

- Occurs due to bone marrow destruction caused by acute exposure in lower doses of 200-500 Rads.
- Characterized by marked reduction in white blood cells, platelets, RBC's.
- Petechiae, immunosuppression, sepsis, hemorrhage and anemia.

Gastrointestinal Syndrome

- Destruction of intestinal mucosa occurs by acute exposure in doses of 500 to 2000 Rads
- Characterized by nausea, vomiting and bloody diarrhea.
- There is severe dehydration and high fever.
- Death occurs in 1 to 2 weeks from enteritis, sepsis, toxemia and disturbances of body fluid.

Central Nervous System Syndrome

- Acute doses of over 2000 Rads damage the brain severely.
- Headache occurs in minutes to an hour.
- There is drowsiness, severe apathy and lethargy.
- Loss of muscular coordination, coma, convulsions and shock.
- Death is within a few hours to a few days.
- There is no treatment possible.

In case of nuclear explosion, there will be radiation contamination of environment as well as buildings and grounds.⁶ Underground metro stations could be utilized as a protected area for the shelter of victims as well as for emergency medical first aid. Provision need to be made to cordon off the both ends of the underground metro station by a shutter fitted with NBC filter. In case of any eventuality, the running of train would be discontinued and both ends could be closed. The provisions of safe water supply, stocking of food, drugs, medical equipments, power back up shall have to be planned.

Chemical Agents

Knowledge of the exact nature of the chemical will facilitate proper antidote administration and effective treatment for early recovery. Stocking and turnover of antidotes needs to be maintained. A mobile laboratory for chemical analysis is required to be introduced so that type of toxicant can be identified at the site itself.⁷ Brief description of chemical warfare agents are given in Table 1.

Biological Agents

They cause infective diseases in a pandemic proportion. There is a need for strengthening public health system and biosafety laboratories for the management of outbreak of infectious diseases, either occurring naturally or due to an act of biological terrorism. Health department should be equipped with state of the art tools for rapid epidemiological investigation and control of suspected or confirmed acts of bio-terrorism. Genetically modified strains of micro-organism used for bioterrorism would pose difficulties in the diagnosis and treatment.⁸ Biological agents can rapidly invade large community. Prophylactic vaccination, use of appropriate antibiotics, immunomodulators and supportive therapy are mainstay for biological disaster management. Characteristics of most commonly used biological agents are given in Table 2.

Table 1: Chemical warfare agents

<i>Chemical agents</i>	<i>Exposure</i>	<i>Effects</i>	<i>Antidotes/ Methods of treatment</i>
<i>Blister agents:</i> Sulphur	Skin contact, in-	Pain is not immediate. Skin blisters, coughing, respiratory	Decontamination, ointments to soothe blisters.

Mustard (HD), Lewisite,	halation	failure and causes itching in eyes, burning and corneal damage	Mustard has no known antidote
Nerve agents: Tabun, Sarin, Soman and Vx	Skin contact, inhalation	Miosis, pain, blurred vision, running nose and chest tightness, nausea and vomiting	Ventilation, atropine, pyridostigmine and supportive therapy
Choking agents: Chlorine, Phosgene	Inhalation	Dyspnea, irritation of mucous membranes; coughing; tightness chest, pulmonary edema	No antidote, airways clearance, oxygen, Rx of pulmonary edema
Blood agents: Cyanogen chloride, HCN	Inhalation	Eyes irritation, convulsions, respiratory failure, sudden loss of consciousness leading to death	<i>Antidotes:</i> Sodium nitrite and sodium thiosulfate

Management of Mass Casualties in Case of NBC Eventuality

Proper planning and preparedness is required for medical response in case of NBC incidence. The preparedness aspects will focus on the of NBC detection, protection, decontamination equipment and material required for the management of the casualties at the site of incidence, during evacuation and for treatment at hospital.

NBC Training for Doctors and Paramedics

All medical and paramedical staff needs to be made aware about the type of illness, injuries, burns and other health problems caused by NBC agents and their preventive measures. Proper training and mock drill needs to be carried out about use of NBC detection, protection equipment. Decontamination alongwith resuscitation measures is an essential component of medical response emergency plan. Super- specialists in the field like hematology, gastroenterology, neurology, pulmonology, dermatology, oncology and ophthalmology require training for the management of effects of radiation and chemical injuries affecting different body systems.

Table 2: Biological warfare agents characteristics

<i>Disease</i>	<i>Incubation period</i>	<i>Duration of illness</i>	<i>Lethality</i>	<i>Persistence of organism</i>	<i>Vaccine efficacy</i>
Anthrax	1-6 days	3-5 days (usually fatal if untreated)	High	Very stable- spores remain viable for > 40 years in soil	2 dose efficacy against up to 1,000 LD ₅₀ in monkeys
Plague	1-7 days (usually 2-3 days)	1-6 days (usually fatal)	High unless treated within 12-24 hours	For up to 1 year in soil; 270 days in live tissue	3 doses not protective against 118 LD ₅₀ in monkeys
Smallpox	7-17 days (average 12)	4 weeks	High to moderate	Very stable	Vaccine protects against large doses in primates

NBC Detection and Protection Equipment (Fig. 2)

Nuclear agent cannot be seen, has got no smell, these can be only detected by certain equipment like pocket personal radiation dosimeter, team radiation survey meter and radiation survey vehicle. Biological aerosol warning system, rapid onsite biological agent detection system, etc. will be required to detect biological agents. Chemical agent can be detected by chemical agent

monitor, portable gas and vapor indicator, etc. NBC personal protective suit, boots, gloves, mask and charcoal underwear are very essential for quick response medical team before entering into NBC contaminated environment.

Emergency Medical Response to NBC Casualties

Pre-hospital care: In case of NBC disaster, the crisis management group is to be immediately activated by triggering inbuilt mechanism for prompt emergency medical response. The steps taken in the first few minutes will determine the effectiveness of mitigation. Quick response medical team with personal protective equipment should reach the incident site immediately along with Resuscitation, protection, detection and decontamination equipments and materials. After resuscitation, casualties must be decontaminated as early as possible. Decontamination is very important step for the management of nuclear and chemical casualties because any extra second contact of these agents with the body is detrimental. The aim of decontamination is to rapidly and effectively remove poisonous substances from the body. An absorbent powder such as bentonite (Fuller's Earth) can be used for the decontamination.

Special Provision for NBC Casualty Evacuation (Fig. 3)

The specialized ambulance with life support system be made available for the evacuation of NBC casualties. The standard operating procedures (SOPs) shall be laid down for attending such casualties. The casualty should be put into an evacuation bag fitted with NBC filter before loading into the ambulances.

NBC casualties treatment in the hospital: In hospital casualty will be finally decontaminated and kept in a clean special ward. The decontamination room must be at the entry of the hospital and should be sealed off from other premises and should have a separate ventilation system. Initially based on early symptoms treatment will be given. Blood is to be analyzed to find out the effect of exact NBC agents and further treatment must be modified accordingly. All supportive treatment must be given in the hospital immediately. Hospital disaster management plan in earmarked hospitals needs special attention for management of NBC casualties. Facilities like radiation injury treatment center, blood bank facility, NBC filter fitted ward, disposal system for contaminated biowaste shall be made available. The nuclear radiation mainly causes acute hemopoietic, gastrointestinal, cutaneous and CNS syndrome which needs specific facilities and super-specialists in different fields to manage radiation injuries. The facilities of bone marrow/stem cell transfusion also require to be established. Routinely these facilities could be utilized to manage hematological diseases like leukemia, anemia and thrombocytopenia, etc. For the management of biological agent, a microbiologist is an essential requirement. Chemical agents will mainly affect the respiratory system; nervous system, eyes and skin, therefore specialist in these fields along with equipments are also to be catered.

Specialized Therapy for NBC Casualties

In addition to usual drugs special medical stores need to be created for the treatment of NBC casualties. Amifostine significantly decreases radiation toxicity in patients receiving radiotherapy for cancer, when 200 mg/m² given intravenously 15-30 min prior to each radiation fraction. Decorporation agents diethylene triamine-pentaacetate (DTPA), prussian blue eliminates radionuclides entered inside the body thus reducing internal contamination. The decorporation agents act as diluting, blocking, mobilizing and chelating agents. The decorporation should be initiated as soon as practical. Gastric lavage, emetics, purgatives, laxatives and enemas can also be used to eliminate radioactive material from the body. Prior administration of potassium iodide

prevents damage to thyroid from radiation. Growth factors, colony stimulating factors, and other radiation recovery agents are very useful for restitution of immune system. Antidotes are required to be procured to neutralize the chemical effects.⁹ Antidotes required for nerve agents are physostigmine, obidoxime, atropine, and pyridostigmine and vesicant may require dimercaprol, sodium thiosulphate and cyanide may require dicobalt editate. Biological agents require antibiotics and vaccines. Recombinant protective antigen vaccine and anthrax immunoglobulin for anthrax, recombinant F1-V antigen vaccine for plague, vaccines for Q fever, tularemia, botulism, viral hemorrhagic fever and smallpox need to be catered.

Medical Response in Aftermath of NBC Incidence (Fig. 4)

The importance of effective hygiene and sanitation in a NBC contaminated environment cannot be overemphasized. Following an NBC attack, all foods except canned or otherwise well-protected foods should be thoroughly inspected to ensure that adequate protection was provided. Safe food preparation and use of purified water, protection from contamination is to be taught to the community. Close monitoring is required to observe post-traumatic stress disorders or any long-term health effects of NBC agents like blindness, interstitial lung fibrosis, genetic damage, cataract and neurological deficiencies, etc. need to be treated.

CONCLUSION

NBC disaster management can only be possible by full involvement and total commitment of various organizations like fire services, police, communication, health services including ambulance service, hospitals. Multi-dimensional impact of NBC disaster requires multi-sectorial and multi-disciplinary approach for the development of trained manpower, equipment and other facilities needed for the handling of NBC disaster. Provision of clean water supply, safe food, hygiene and sanitation, environmental health and control of vectors is to be planned to prevent any epidemic in the aftermath of NBC disasters. Health care facilities are an essential component of emergency medical response system, but at the present, are poorly prepared for an incidence. The greatest challenge may be the sudden presentation of large number of contaminated individuals. Special facilities to treat NBC casualties are to be created in the hospitals including NBC filter fitted ward and biowaste disposal system. Earmarked hospitals are also to be geared up for restitution of immune system, bone marrow/stem cell transfusion, medical stores containing antidotes, vaccines, decorporation agents and antibiotics. Management of post-traumatic stress disorders is also to be catered. Planning is to be done to deal with long-term effects of radiation like cancer, cataract, genetic damage and premature ageing. Documentation, research and analysis is to be carried out in post-disaster scenario for future lessons.

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MULTIPLE CHOICE QUESTIONS

1. Is dirty bomb a nuclear weapon?

Ans. No, nuclear weapons involve a complex nuclear fission/fusion reaction and are thousand of times more devastating. Cesium 137 and cobalt 60 are most commonly used radioisotope in making a dirty bomb.

2. What is the likely impact of dirty bomb?

Ans. The number of deaths and injuries from dirty bomb explosion might not be substantially greater than from a conventional bomb explosion. But panic over radioactivity will cause mass self evacuation of population, loss of business thus paralyzing local economy.

3. What is radiobiodosimetry?

Ans. Radio biodosimetry includes lymphocytes estimations along with the other formed elements of the blood. Chromosomal study is an important tool for radiation biodosimetry. Chromosome exchange resulting in unstable aberration such as dicentric, rings, acentric fragments and other asymmetrical rearrangements may be measured using the technique of fluorescence *in situ* hybridization (FISH) which is currently the essay of choice for definitive biodosimetry. Measurement of radiation induced apoptosis in human lymphocytes is also considered the most sensitive reproducible biodosimeter. Counting the frequency or number of micronuclei in the cytoplasm of irradiated cells, electron spin resonance detection of free radical formation in tooth enamel.

4. How to differentiate bioterrorism epidemic from a natural outbreak of infective disease?

Ans. Certain clues mentioned below may indicate that the infective disease outbreak, is artificially created.

Epidemiologic clues:

- Greater caseload than expected of a specific disease.
- Unusual clustering of disease for the geographic area.
- Disease occurrence outside of normal transmission season.
- Simultaneous outbreaks of different infectious diseases.
- Unexplained number of dead animals or birds.
- Rapid emergence of genetically identical pathogen from different geographic areas.

Medical clues:

- Unusual route of infection.
- Unusual age distribution or clinical presentation of common disease.
- More severe disease and higher fatality rate than expected.
- Unusual variants of organisms.
- Unusual antimicrobial susceptibility patterns.
- Single case of an uncommon disease.

Miscellaneous clues:

- Intelligence report.
- Discovery of munitions or tampering.
- Increased number of visits with similar symptoms to emergency departments and ambulatory health care facilities.

5. Is there any facility for rapid detection of biological agents?

Ans. Yes, Biological integrated detection system is available for this purpose. It is a high mobility multi-purpose wheeled vehicle-mounted system that concentrates aerosol particles from environment air, then subjects the particle sample to antibody-based detection schemes for selected agents. It is presently capable of detecting eight BW agents within 45 minutes.

6. What is mode of action of nerve agents?

Ans. The toxic effect of nerve agents depends on the substance inhibiting the enzyme acetylcholinesterase in the cholinergic nerve system. Under optimum conditions, each enzyme molecule hydrolyzes about 15000 acetylcholine molecules per second. Nerve agents decrease hydrolyzation of acetylcholine to the negligible. Consequently, the enzyme becomes irreversibly inhibited, with the nerve agent. Inhibition of acetylcholinesterase is thus a progressive process and the degree of inhibition depends not only on the concentration of nerve agent but also on the time of exposure. So man is the most potent inhibitor of acetylcholinesterase among the nerve agents.

7. What are the common modes of entrance for a chemical agent in the body?

Ans. Most of the agents enter through inhalation, few like nitrogen mustard may enter through skin and eyes also.

8. Where can a physician get training to handle NBC casualties?

Ans. For chemical and biological agents training is imparted in Defence Research and Development Establishment, DRDO Gwalior, for nuclear, training facilities are available in DRDO, INMAS, DL Jodhpur and BARC Mumbai.