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REVIEW ARTICLE

HOW MILITARY HOSPITALS GET READY FOR CHEMICAL WEAPON VICTIMS

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Summary

The deliberate use of chemical weapons has emerged as a significant threat especially in last decades, mainly after the terrorist attack on 11th September 2011, and the use of these agents in future wars and terror attacks still remains a realistic concern. Despite the existence of many conventions and aggreements like Chemical Weapons Convention and 1925 Geneva Protocol against the use of chem-bio weapons, they have been used in many wars and conflicts. From this point of view, other than civilian state hospitals, military hospitals should be aware and get prepared to manage the victims injured due to chemical weapons. Military hospitals must be prepared to give support to health care system as well as military troops in treating and preventing casualties resulting from chemical weapons. Moreover, military hospitals are required to possess protective suits, masks, antidotes and other drugs. This article summarizes some important aspects which might be useful not only for military hospitals but also for civilian hospitals and public health organizations.

Key words: Military Hospital; Chemical Weapon; Victim

INTRODUCTION

Chemical warfare agents are toxic chemicals which through its chemical action on life processes can cause death, incapacitation or permanent harms on humans and animals. They may be used in a battlefield, in a terrorist attack or in any individual assassination.

These chemical warfare agents can be classified based on their mechanism of action (1, 2).

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1. Nerve agents (tabun, sarin, soman, Vx)
2. Vesicant / Blister agents (sulphur mustard, lewisite)
3. Choking / Pulmonary agents (chlorine, phosgene)
4. Blood agents (Hydrogen cyanide and cyanogen chloride)
5. Incapacitant / Psychomimetic agents (3-quinoclinidinyl benzoate-BZ, Lysergic acid diethylamide-LSD)
6. Lachrymatory agents (oleoresin capsicum, 2-chlorobenzalmalononitrile)
7. Herbicide agents (Cacodylic acid, picloram)
8. Cytotoxic proteins (saxitoxin, ricin)

The threat from unconventional warfare agents including radiological, chemical and biological agents has traditionally been considered as a military issue (3). However, several recent events, including chemical

weapon use in first Persian Gulf War and the release of sarin vapor in the Tokyo subway system, have shown that civilians may also be exposed to these agents. Among these agents, the intentional release of chemical weapons may cause hundreds of casualties leading to the overload on local health and medical resources, particularly military medical facilities. Accordingly, an effective medical defense and first-aid system especially in military hospitals should be set up for possible chem-bio attack victims. Although medical defense approach against chemical weapons has some significant countermeasures, including medical care, triage, treatment, decontamination which are different from each other deserves a detailed discussion. There are too many common points amongst biological and chemical agents in terms of medical care and defense. From this point of view, military hospitals in response must be prepared against these chem-bio disasters with a detailed preparedness plan. The aim of this paper is to present the importance of the role of military hospitals following a chem-bio attack rather than that of civilian medical facilities along with the medical management of the agents and to discuss the elementary issues concerning planning, preparedness, and reaction to such disasters (4, 5, 6).

Chemical weapons (CW) are the weapons that can be used not only for military purposes, but also against both soldiers and civilian populations owing to their toxicities and rationale effects. Terrorist interest in the use of chem-bio weapons has also grown substantially since the Tokyo Subway attack in 1995 and attack to twin towers on 11 September 2001 in New York City. In addition to death and physical injury, the use of these weapons may also give rise to fear, panic and psychological trauma throughout the entire population. Under the threat of misuse of CW, the States and Public have taken several measures against any possible attack including purchasing protective equipment, giving lectures and any other items related to the economical distress. Beyond this, medical preparedness is a very essential countermeasure which needs to be taken in advance. Successful management of casualties in a chem-bio attack depends on preparedness, planning, technology-equipment standard operation procedures, training and education. Medical care of casualties depends on knowledge of the agent and timely intervention (7, 8).

Potential sources of exposure to chem-bio agents include accidental release from military factories and stockpiles, direct military attacks, industrial accidents, and intentional release as an act of terrorism. The potential targets of CW detailed in Table 1 also include mainly civilian population centers and key infrastructure installations.

Table 1. Potential targets for an incident where a chem-bio weapon can be released.

Crowded places	Embassies/Diplomats' residencies
Subways	Governmental facilities
Airports	Ceremonies
Shopping Malls	Universities/Schools
Research/Medical Facilities	Amusement Parks
Theaters, movies	Sport stadiums/arenas

Hospitals were considered to be sacred private areas both in peace and war times either in urban environment or in the operational field according to the international regulations like Convention (IV) relative to the Protection of Civilian Persons in Time of War signed in 1949. But, in a war scenario, military hospitals would represent one of the attractive targets for both modern terrorists and enemies. By attacking hospitals you can destroy the prospects of the people involved in a CBRN incident, so it is something like killing them twice. So, military hospitals should take their protective measures with respect to both protecting itself and increasing the preparedness level to give the required medical assistance (9).

If the location of military hospital is very close to the incident area, then reaction and response time will be almost at minimum. It means that the assigned rapid response staff of the hospital must be able to go to "red alert" within minutes. It needs a lot of training, specialized equipment, detailed planning and open minded individuals that comprehend the magnitude and the nature of the event. Hospitals that are in more distant areas may have enough time to get prepared although in many instances nobody would like to go there no matter how well prepared they are. It is obvious that all hospitals involving both public and military hospitals should be equally prepared to accept mass CBRN casualties in case of a terrorist event.

The chemical agents carrying the potential for use in a deliberate release are listed previously (2) and scheduled in the Chemical Weapons Convention banning development, production, and deployment of these scheduled chemicals. The impact of the attack depends on a number of factors like

the agent type used, method of delivery, and the responsiveness level of the health system. In cases involving the intentional release of agents, effective management has to include a rapid and coordinated response among state, local and military organizations. From the perspective of disaster planning and preparedness, these should cover Emergency Department preparedness, setting up medical care and decontamination unit including a shower system, providing pharmaceutical stockpile containing antibiotics, antidotes, vaccines and personal protective equipment (PPE), training of medical care providers, updating the analytical and detection laboratories, establishment of CBRN Medical Response Team and linkage with other military health care facilities in addition to surveillance system of long-term medical sequelae (10, 11).

Organization and coordination between role-playing institutions in CBRN emergency response is essential.

Some certain statistics estimated that after any CBRN incident, approximately 20 % of the casualties would remain at the incident site (dead, severely wounded and / or contaminated) and the remaining 80 % move to all possible directions seeking medical assistance or go home if they were not wounded or contaminated. These people will soon overwhelm hospitals and collapse even the most organized and advanced medical systems. Tokyo sarin release event showed that 84.5 % of those involved went to 169 hospitals and clinics all over the city by their own means. The number beyond this would emphasize the need to invest in hospitals' CBRN response capacity instead of classic "golden hour" first responders for the purpose of giving a prompt and effective treatment. The latter would certainly go there but they would arrive late and CBRN casualties who are severely contaminated / wounded could be probably dead (12, 13).

It has been widely accepted that most prehospital and emergency medical personnel should be well prepared, trained or equipped to respond to such incidents. These personnel must involve mainly physicians, emergency medical technicians, emergency nurses and they have to be aware of the following crisis management and medical issues related to prehospital management of a attack:

a) Event recognition
b) Incident medical command and control
c) Safety and protection
d) Decontamination
e) Isolation of the incident area
f) Sampling and detection
g) Psychological management
h) Communication and coordination
i) Triage
j) Treatment
k) Transportation
l) Recovery activities
m) Fatality management

First of all, the attack must be well recognized as a chemical weapon attack and medical responders should be familiar with the indicators of a possible agent use (Table 2). As long as the incident is related to a CW use, the medical personnel performs the required intervention as first-aid and treatment (2, 12).

Table 2. General indicators of possible chem-bio agent use.

Unusual occurrence of dead or dying animals (like dead birds)
Unexplained casualties (multiple victims with the similar signs and symptoms)
Unusual liquid or vapour (droplets, unexplained odor)
Suspicious dispersal devices or packages (spray devices and munitions)
Data suggesting a massive point-source outbreak
High morbidity and mortality relative to the number of personnel at risk
Multiple disease entities in the same patients
Sudden appearance of a disease that is unusual or that does not occur naturally in a certain geographic area

The important parameter in hospital protection is to keep contamination out of the hospital area, working medical personnel and existing patients. In that respect, the CBRN Medical Response Team of the hospital is to be able to get deployed outside the hospital. The response unit is composed by

several stations that facilitate the arriving casualties. At that point, some information regarding our Medical CBRN Response Team established in our Military Medical Facility which has been very active for about 10 years should be given as an example. Our Military Medical Academy is a multidisciplinary medical facility organized to provide Turkish Armed Forces with up-to date medical care and to act as a part of the national healthcare system. As CBRN warfare agents are still accepted as a threat which requires that all health care units should be prepared for, our Military Medical Academy established a CBRN Medical Response Team in order to provide medical first-aid and perform medical procedures in a CBRN event. That team is composed of military physicians and military nurses to perform medical aid and paramedics specifically to conduct decontamination. The team is to serve all military units and civilian populations (with the permission of Commandership of Gulhane Military Medical Academy) in any CBRN incident. The team also joins efforts with the Ministry of Health to treat chemical victims. A storage building and a training unit is allocated for the Team logistics and exercises which might be a role model for similar hospitals in our country.

Decontamination and Self-Protection are essential issues in CBRN response

Medical people entering the dirty area must wear protective clothing and must be very well decontaminated before coming back to the clean area. In the hot zone (fully contaminated zone), demarcated by the detection team having special detectors like CAM (Chemical Agent Monitor) and sensors, the main objective is to remove the victims to the clean area immediately. Besides, the specific first-aid and antidotal treatment can be applied simultaneously.

Decontamination is the reduction or removal of chemical agents by physical means or by chemical neutralization or detoxication. Transferring the patients from the incident site directly to a hospital might be a mistake since contamination could be spread to other staff and the hospital interior. Success in performing decontamination of chemical victims marks the line between life and death. Taking into consideration that patients are generally poorly decontaminated at the site, military hospitals have to be ready with decontamination facility and personnel trained and assigned to do this task and have to conduct these functions based on a specified measures detailed in Table 3.

Table 3. Essential measures which are required to be taken for the consideration during hospital decontamination system development as a countermeasure against chemical terrorism.

Hospital staff must be familiar with the protocol
A decontamination area and a route that will be used to take the patient to that area should be determined
A sufficient warning system should be established
Adequate information about the agents involved, mechanism of contamination, degree of contamination, patient's status and any suspected coexisting injuries or illnesses should be given to concerned staff.
The members of the decontamination or medical response team should be set up along with the necessary clean-up procedures
All clothes, disposable suits should be placed in specially marked containers
The routes of removal for waste items should be arranged

A 0,5% solution of hypochlorite (1 part household bleach to 9 parts water) should be gently applied and rinsed off with water at the last station. Open traumatic wounds contaminated with CW should be subjected to through wiping with 0.5 % hypochlorite and subsequent irrigation with normal saline. The fact that rubbing and scrubbing the skin may sometimes enhance the agent absorption must be kept in mind (14).

A Military Hospital must have the ability to immediately decontaminate and treat persons exposed to agents. Decontamination methods which are applied in the hospital environment should contain some specific requirements different than requirements applied in the incident site, a shower system with specialized water and chemical container in which the chemical content must be removed following a neutralization process. A specific decontamination site must be established close to a suitable place where the victims could be taken under care before medical maintenance is provided prior to acceptance to the hospital interior.

In this decontamination center, the required equipment and drugs must be stored or handled as soon as possible. A similar decon system is under service in our Military Medical Academy which is strongly connected with the Emergency Department. A total of 420 mobile and 60 littered patients can be thoroughly decontaminated in an hour before accepting into the inside of the hospital (15) (Figure 1).

Figure 1. A decontamination unit associated with the Emergency Department is in use as a model for hospital decontamination site for chemical injuries.

Decontamination facility should be operational ready within 2-3 minutes. Decontamination solutions used for chemical decontamination will be usually suitable for biological decontamination. Chlorine is the recommended disinfectant and decontaminant for use in outbreak response. An all-purpose disinfectant should have a concentration of 0.05% (i.e. 1 g/ litre) of available chlorine, a stronger solution with a concentration of 0.5% (i.e. 10 g/litre) of available chlorine being used for example, in suspected outbreaks of Lassa and Ebola virus diseases. The use of the solution with 0.5% of available chlorine is recommended for disinfecting excreta, cadavers, and spills of blood and body fluids (6, 14, 15).

The most important rule for any responder to a WMD event is the self-protection. There are three basic methods for that:

a. Wearing adequate personal protective ensemble (PPE).
b. Being sure that the casualty is thoroughly decontaminated.
c. Using shelters if provided.

The protective suit should have an interior layer of activated carbon that adsorbs CW. The staff should wear the protective clothing with level C at least (Table 4). One of the pieces of protective equipment is a gas mask which is especially effective against volatile agents, and improper fitting of the mask may cause psychological stress and a possible exposure to CW. Therefore, continuous exercises and training with this equipment are essential to overcome a great part of discomfort and reduction in performance related to their uses (16). In our Military Medical Academy, protective masks produced by Turkish Gas Mask Factory are available and ready to use by our team staff.

Table 4. The levels of protection in a chemical incident.

LEVELS	DESCRIPTION	CONTENT
A	Provides maximum level of protection and be used where the hazards are unknown or unquantifiable or in the area containing very high concentrations of toxic agents.	Fully chemical protective suit, positive pressure self-contained breathing apparatus, double layers of chemical resistant gloves and boots. Airtight seals between the suit and inner layer of face, hand and foot protection.
B	Should be used when the highest level of respiratory protection is necessary but a lesser level of skin protection is needed.	Full respiratory protection similar to level A excluding airtight seals.
C	Should be used when the concentration or type of airborne substance is known and the criteria for using air-purifying respirators are met.	Face cartridge mask, chemical resistant suit with gloves and boots.
D	Should be used only when there is no danger of chemical exposure.	Latex gloves, eye splash protection and no respiratory protection.

In the event of an attack with CWA, medical rescuers and health care providers must also consider first aid and treatment approaches including triage in the overall evaluation of contaminated casualties.

Basic vital functions should be aggresively supported and ABC (Airway, Breathing, Circulation) should be corrected. Antidotal therapy facilitates the ventilation by decreasing the constriction in the respiratory system. Antidotal regimen recommended for a chemical casualty is given in Table 5 (1, 2, 17).

After a CWA release, a triage station should be established in the warm zone to determine the priorities for resuscitation, decontamination, pharmacological therapy, and transport to the hospital (Table 6).

Table 5. Antidotal treatment suggested for the exposure of CWAs.

Agents	Antidote	Dosage
Nerve agents	Atropine	Atropine autoinjector IM (combination of atropine and oxime) up to 3 times in battlefield conditions for each 5-15 min.
		2-8 mg IM/IV. Full atropinization maintained at 2 mg doses every 3 to 8 min for several hours if required.
	Pralidoxime	1 g IV or 2 g IM maximum (0.5 g/min) in saline) (may repeat 30 to 60 min as needed.
	Diazepam (Valium)	5-10 mg IV/IM/p.o. (0.3 mg/kg)
	Pyridostigmine bromide	30 mg every 8 h. p.o.
Lewisite	BAL (Dimercaprol)	Commercial preparation of 10% BAL in peanut oil up to 4.0 ml IM. Repeat in 4, 8, 12 h. (3 mg/kg)
	BAL analogues (DMPS, DMSA, DMPA)	DMSA 300 mg p.o every 6 h for 3 days.
Hydrogen cyanide	Amyl nitrite	Inhaled for 30 s/min and maintained until the initiation of sodium nitrite infusion.
	Sodium nitrite	IV infusion of 10 ml over 3-5 min
	Sodium thiosulphate (25 %)	1,65 ml/kg IV infusion
	Hydroxocobalamin	70 mg/kg IV (max 5 g)
	4-DMAP	3 mg/kg IV injection
BZ (incapacitant)	Physostigmine	2 mg in 10 ml saline IV (over 5 min)

Table 6. Some items that have to be considered in a minimal patient care in the incident site if available:

Fast decontamination (15-30 min if available)
Basic life support measures and life-saving procedures must be performed in the decontamination area.
If medically indicated, cardiac monitoring, IV access route and oxygen support were administered.
Conditions such as tension pneumothorax or respiratory distress should be treated immediately.
In the case of trauma, blood for hemoglobin determination and crossmatch should be sent.
Anything in the decontamination area should be considered potentially contaminated.
Patient decontamination should be performed by first removing all the patient's clothes, this will take care of 70% to 85% of the contaminant. After sufficiently washed off, the patient may be transferred into the Emergency Department.

Triage is a dynamic process and should be performed in both hot and warm zones, and should be conducted by specially trained medical personnel who know the effects and treatment of CWAs.

Aim of triage is to classify the mass casualties in accordance with the medical care priorities by taking into consideration especially neurological, respiratory and circulatory status of injured people and available medical supplies that the government or any other organization can provide. The main aim is to give life-saving medical approach to those who need treatment for immediate or delayed categorized patients.

The triage (T) system commonly used by medical units (our medical CBRN concept also uses this classification) includes four categories which are based on the need for medical care; immediate, delayed, minimal and expectant (18, 19):

T1 (immediate): casualties who require medical care and advanced life support within a short time on the incident site and further in the hospital.

T2 (delayed): casualties with injuries which are in need of prolonged care and require hospitalization. Delay of this care does not affect the prognosis of the injury negatively.

T3 (minimal): casualties who have minor injuries who will not be evacuated and will be able to return to duty in a short time.

T4 (expectant): casualties with fatal injuries who will possibly not survive with standard medical care.

The category of the patient should be marked on triage tag. A sample triage tag specified for CBRN injuries used in our military medical units is illustrated in Figure 2.

A lack in Coordination and Planning in CBRN Medical Response gaps resolving the situation:

Detection and diagnosis of illness and injury caused by chemical weapons constitute a complex process that involves activities of many local and community resources which will assist in overcoming the hazard (10). Therefore;

- Public Health organizations
- Poison control centers
- Medical research centers
- Professional societies
- Emergency response units
- First responder organization
- Safety and medical equipment manufacturers
- Military organizations
- Intelligence services
- Law facilities, should be continuously present in a strong collaboration with each other.

Some critical information should be also provided which may be useful for hospitals or other local centers. If available, the following data should be obtained and transmitted:

- Number and types of casualties
- Chemical substance involved
- Estimated time of arrival of the casualty to the hospital
- Time of incident and incident site
- Method of contamination (vapor or liquid)
- Hazards to health care providers.

However, most hospitals or medical facilities even in developed countries are unfortunately insufficient and poorly prepared regarding setting up effective

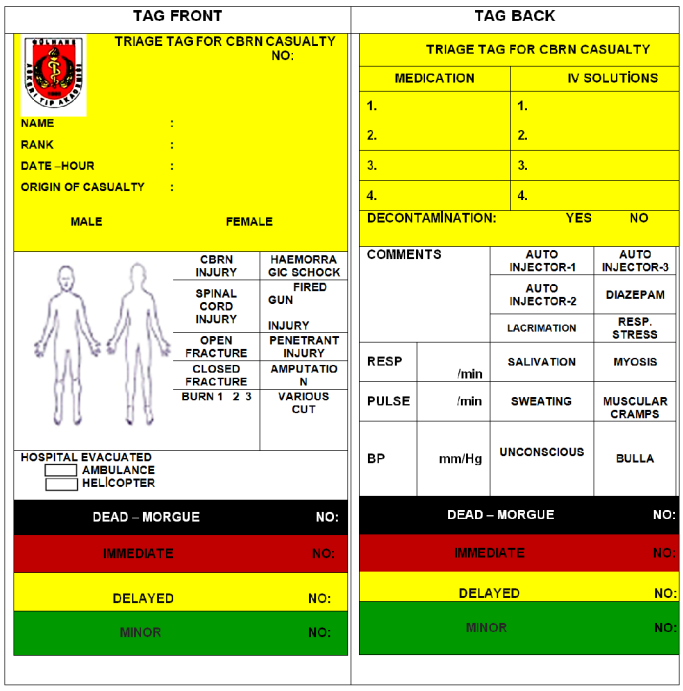

Figure 2. In massive chemical incidents, casualties should be tagged depending on the severity of the injuries. A sample of Triage Tag for CBRN Casualities used in Turkish Military Medical Units is illustrated.

medical defense including decontamination, treatment and laboratory service. Thus, in particular, military hospitals should have a plan that includes the medical treatment and service units with specialized staff experienced on the medical care of each chem-bio casualty, other than analytical laboratories and decontamination units. Taking different medical management for intervention to such casualties into consideration, different facilities may be required for each group showing generally different signs and symptoms. Military hospitals should have the capability at various levels in terms of medical care, treatment, laboratory support, and mobilized response team particularly. Military medical centers are supposed to be the points which are better organized and have much more capability compared to other civilian hospitals (6, 20).

Emergency department of a military hospital must be prepared to fight against chem-bio disasters with a detailed incident plan, decontamination facilities and protective equipment for all staff involved. These agents can cause a life-threatening disease and necessitate intensive hospital care, local availability of ICU (Intensive Care Unit) beds, ventilators and drugs in order to treat potentially hundreds or thousands of ill people. The preparedness has to include the mehod how to protect the hospital from contamination and how to prevent its personnel from becoming secondary casualties. Since hospitals could be overwhelmed with casualties, hospital contamination might occur due to a delay in recognising CWA exposure (19).

In the hospital response plan, some specific sites related to such disaster should be separated like an initial triage site located just outside the hospital building, a decontamination site, a secondary triage site and a treatment site.

CONCLUSION

Mass casualties requiring specific chemical antidotes, vaccinations, or antibiotics can quickly terminate available supplies. So, pharmacies in military hospitals will be required to provide antidotes, antibiotics, antitoxins, and other pharmaceuticals in large amounts and have the capability for accurate procurement. Staff should be also aware of medical treatment methods in case of such threats with respect to nerve agents, cyanide, pulmonary irritants, anthrax, botulism and other possible CBRN agents.

CBRN incidents are generally characterized as situations with sudden onset where hospitals and health staff are commonly unprepared despite its ongoing threat. Military hospitals having a higher level of readiness for such incidents are in need of maintaining this reputation with planning and practicing to manage CBRN patients.

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