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Medical management of incidents with chemical warfare agents

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Abstract

Successful management of incidents with chemical warfare agents strongly depends on the speed of medical help and the ability of helpers to react properly. Though the general principles of clinical toxicology, such as decontamination, stabilization, patient evaluation and symptomatic treatment are similar for many toxicants, chemical warfare agents deserve special attention because of their very high inhalative and cutaneous toxicity, rapid onset of the disease and multiple organ failures.

This article describes the medical management of mass casualties with blister agents, nerve agents and blood agents from the viewpoint of a clinical toxicologist. Characteristic diagnostic signs, decontamination procedures and therapeutic schemes for these agents are described. Treatment options are discussed. The importance of planning (e.g. antidote availability) and preparedness is emphasized.

Keywords: Chemical warfare agent; Poisoning; Diagnosis; Treatment; Clinical toxicologist

1. Introduction

After the terrorist attacks of Matsumoto (1994), Tokyo (1995) and of September 11th, 2001 with the subsequent anthrax letters there is an increased awareness that terrorists might use chemical warfare agents or other very toxic materials in future homicidal attempts. Though prevention and mitigation are in the focus of planning activities, the medical toxicologist must be ready to treat poisoned victims in the case of a chemical incident according to the state of the art.

Some of the diagnostic and therapeutic experiences with chemical warfare agents are based on the outcome of their former use. The devastating effect of chemical warfare agents such as chlorine and mustard gas which even surprised the first users is well-known from World War I (Koch, 1921; Muntsch, 1939). The nerve agents were developed just before the second World War in search of insecticides by Schrader (Schrader, 1950). When they were used by the Iraq Forces during the Iraq–Iran War (1983–1988) nobody had much experience with their effects on humans. Also sulphur mustard claimed many deaths and 100,000 injured (Balali Mood, 1988) in the Iran–Iraq War. In 1995, Japanese terrorists used the nerve agent sarin in two terrorist assaults. The first one happened in Matsumoto (Okudera et al., 1997). The second attack was launched in the subway of Tokyo. More than 5000 persons needed medical care and 12 died (Nozaki et al., 1995; Ohbu et al., 1997).

The mechanism of action of selected chemical warfare agents will be briefly discussed in this paper. Diagnostic and therapeutic options in case of mass poisoning will be considered from the viewpoint of a clinical toxicologist in an emergency poison center.

2. Management principles of incidents with chemical warfare agents

Management of chemical incidents requires specific knowledge of the toxicants and their biological effects

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Table 1
General principals for management of chemical agent casualties

1	Rescue teams need respiratory and skin protection
2	Antidotes should be given intramuscularly on the spot where available, possible and necessary (e.g. nerve agents, cyanide)
3	Rescue of the victims to contamination free areas is mandatory
4	Undressing and whole body decontamination in contamination free areas should follow as soon as possible (water shower; not to warm). Blankets to prevent hypothermia should be available. Patients must be contamination free before entering of treatment facilities is allowed. In the case of exposure to gases undressing is sufficient (e.g. hydrocyanic acid)
5	For wound decontamination, 1–2% hypochlorite solution is adequate. It should not to be brought in eyes or body cavities as it causes irritation or adhesions, respectively
6	For eye decontamination, a sterile 2% bicarbonate solution is adequate. In emergency situation clean tap water may suffice
7	Porous foreign bodies in wounds may contain active agents. Removal and immediate immersion in concentrated hypochlorite solution is necessary

as well as clinical experiences in the diagnosis and treatment of intoxications. Compared to common medical emergencies, the management of chemical incidents is aggravated by requirements of decontamination and personal protection. Stockpiled antidotes and protective equipment must be immediately available (Table 1).

In the initial phase of a chemical mass casualty, the identity of the toxicant is usually unknown. Therefore, the experienced observation of symptoms is essential to get early information on the type of toxicant and to start specific treatment. Even in mass casualties, the clinical toxicologist should make individual considerations with each patient. This is especially true in the case of babies, children and elderly people, where dose-adjustment and risks of antidote treatment have to be taken into account. In any case, early planning combined with training in clinical toxicology are important preconditions for effective medical management of chemical incidents.

3. Groups of chemical warfare agents

Chemical warfare agents include nerve agents, blister agents, blood agents and lung agents. Blister agents include sulphur mustard and nitrogen mustard. Nerve agents include tabun (GA), sarin (GB), soman (GD) and VX. Blood agents are hydrogen cyanide (AC) and cyanogen chloride (CK). Lung agents include phosgene and diphosgene (Helm and Weger, 1980).

4. Intoxication by blister agents (sulphur mustard)

4.1. General

The term blister agents seems to be very euphemistic and describes only one of the visible symptoms of a potentially systemic poisoning. Many other organs are damaged not just the skin. Organs with proliferating epithelia like eyes, lungs and the bone marrow may be severely damaged. Death ensues either due to bronchial obstruction, bronchopneumonia or bone marrow aplasia (Zilker and Felgenhauer, 2002). The blistering agent sulphur mustard has the highest military significance in the group. It is a simple chemical compound by the name of dichlorodiethyl sulphide. Pure sulphur mustard is a colourless liquid, which is nearly odourless. Due to its technical impurities, it has a strong odour resembling mustard or garlic.

Sulphur mustard is a liquid at room temperature that may come to use either as liquid, vapour or aerosol. It is an alkylating agent, which in cells may rapidly react with various cell constituents. The prominent reaction is the alkylation of DNA.

4.2. Symptoms

4.2.1. Eye lesions

The eye reacts relatively fast to sulphur mustard exposure because the cornea can be more easily penetrated and is more sensitive than the skin. Eye symptoms develop within 30 min to 3 h. At a concentration of 10 $\mu g/m^3$ in the air effects on the eyes can be observed (Reed, 1920). First photophobia, lacrimation, irritation and blepharospasm will appear followed by a hemorrhagic conjunctivitis (Blodi, 1971; Geeraets et al., 1977) (Fig. 1). Corneal changes develop more slowly than conjunctival ones and begin with surface erosions followed by a clinical latent period of about 8 h after which corneal opacities may occur. Regeneration of corneal epithelium starts within days. The iris becomes oedematous, hemorrhagic and necrotic, and the lens opacifies (Borak and Sidell, 1992; Garigan, 1996; Vena et al., 1994). Corneal epithelial defects may persist for years. A delayed keratopathy can develop decades later and may result in loss of vision (Grant, 1974).