

Preventive measures against the mustard gas: a review

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Abstract

The main aim in this study was to collect the experiences of Iranian researchers about sulfur mustard (SM) and provide a guideline for the prevention of abuse for this dangerous agent. We searched valid national and international databases using related key words in the two languages. We found 193 articles which had been published in medical journals. Among them, 25 articles had some implications about prevention measures. In this study, we have mentioned 8 preventive points before the attacks, 10 points during and 2 points afterwards, we also found 12 points for the prevention of people who were exposed with SM and suffering from respiratory, ocular, dermatologic and psychological complications. In conclusion, most of the published studies on chemical war victims in Iran are focused on diagnosis and treatment of late SM-induced complications. Hence, a research should be conducted separately in relation to the prevention.

Keywords: Mustard gas, Chemical warfare, Prevention and control, Wounds and Injuries.

Introduction

Sulfur mustard (SM), is a toxic, vesicant, blistering, alkylating, nucleophile, and a strong lipophilic chemical agent known as the king gas of the wars (1).

This agent has been abused in the wars, due to ease of preparation, and use, low production cost, broad absorption, multi-organ effects, rapid penetration, environmental stability, delayed effects on biological systems, and its power of disabling the military forces in battle fields (2).

Longitudinal studies have shown that this agent can lead to a wide variety of early and late complications including respiratory, ocular, dermatological, hematological and psychological disorders in exposed people. The late effects can continue for

even 40 years after the initial exposure (3-5).

Preventive measures regarding exposure to mustard gas at various stages (before, during, and after chemical attacks) are important and related to presence or absence of predisposing factors. Predisposing factors for contamination with SM can include: high environmental temperature, lack of wind in the attacked area, being female and younger, white race (light complexion), stress, excessive sweating, oily skin, high PH of the skin, skin folds and thin areas of the body, skin infections, previous dermatitis, duration of exposure, dose of the poison, wider contact with the poison, scratching and massage of the involved skin area (6-7).

Iraq used SM in Iran – Iraq war (1980 –

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1988) which left more than 50,000 chemical victims (8). During the 24 years passed from the last chemical attack against people, Iranian researchers have acquired many valuable experiences in dealing with chemical attacks with sulfur mustard. In this study, we review these experiences in prevention domain at various stages (before, during, and after chemical attacks) and also in injured victims.

Methods

A community medicine specialist and an expert with bachelor degree performed the literature search. They searched English databases including MEDLINE, ISI and Scopus and Iranian databases including IranMedex and Irandoc. The keywords were chemical war, chemical warfare, chemical combat, chemical fight and sulfur mustard in the two languages. The titles and abstracts were evaluated and those with irrelevant base on both topics were excluded. The full texts of other articles were assessed according to the project goals. No specific evaluation was conducted on the quality of the reviewed manuscripts and their publication in accredited journals (according to The Commission for Accreditation and Improvement of Medical Journals affiliated to Iranian Ministry of Health & Medical Education). Most of the evidences used were in the first 4 levels of 7 defined levels for evaluation of documents. In other words, the included articles were randomized controlled trials, cohort and historical cohort, case – control, case series and case reports and correlational studies.

Results

We found 193 articles in regard to chemical warfare against Iranian people which were published in approved medical journals. Most of these articles were focused on the epidemiology and treatment of sulfur mustard complications, and only 25 articles had some implications about preventive measures against sulfur mustard effects. We have collected the information and concluded from performed investigations

and presented a preventive guideline containing 5 parts about 5 stages (before, at the time, and after the incident and also on early and late biological effects of the victims).

Preventive points

Preventive measures before the incident are as follows:

To provide the necessary infra-structures such as:

Strengthening the hardware and software facilities for rapid health-related reactions;

Prediction of required preventive equipment and devices in the stocks of passive defense organization and update them with a checklist periodically;

Designing and manufacturing the standard protective equipment against chemical agents in the factories throughout the country;

Preparation of the new standard containers equipped with experienced trained personnel and portable emergency defense sites particularly for washing and decontaminating the victims (the current checklist should be revised);

Educating people, especially military and passive defense forces properly. The content of such training can be focused on early detection of chemical attacks signs, the first necessary critical measures, self-protection, properly transferring the injured victims, patient resuscitation and communicating with agencies and authorities for coordinated actions. It should be noticed that people should not be exposed to unnecessary distress during these educations;

Strengthening the passive defense scientific network;

Implementing effective training exercises and periodic organized educational maneuvers particularly for passive defense volunteers and military forces;

Early preventive measures immediately after the accident; include:

Antidote: No specific antidote is available (9). Some researchers have used calci-

um chloride and magnesium oxide powder as anti-gas powder for skin exposures (10);

Use of the standard protective devices, particularly standard masks and wind wards; Ghasemi Boroumand et al in a descriptive study conducted on 498 selected male veterans from 13 provinces in Iran evaluated the protective effects of both wind wards and masks in preventing ocular and pulmonary complications. They stated that the use of protective equipment (masks and wind wards) reduce the severity of lung and eye lesions. Namely, when the rate of using of the protective equipment rises, severity of ocular and pulmonary lesions will significantly reduce (11).

Use of the fine and thin texture and if possible, plastic clothes

According to published researches, mustard gas can penetrate ordinary or even leather clothing and thus, after a few minutes can reach the body tissues. This is while the rubber sheath can, at least for a few hours, protect the body. Also this agent can percolate from ordinary and plastic masks (12).

Going to a high altitude area

Because mustard gas is heavier than air, at the time of release, fighters should climb to a height of at least 10 meters above the ground in the attacked area (13). This comment also was recommended by Iranian researchers.

Removal of clothes as soon as possible:

Sulfur mustard may remain in the liquid form on contaminated clothing and other devices for many hours or even days and it may affects the biological tissues (14-15). Therefore, When exposure occurs, all contaminated clothes should be removed from the body in the shortest possible time and should be destroyed. Plastic gloves can be used to remove clothing. Rescues and medical personnel are at risk for adverse effects, especially for skin blistering, if their bodies or their clothes come in contact with contaminated victims (10,15).

Immediate body wash

Affected people should wash their body with plenty of fresh and clean water as soon as possible. During chemical attacks on Iran, some of the Iranian fighters had washed their hands and faces by the water available in the area, while they were not aware that the water was contaminated by the SM toxin. This was a reason for eye and skin problems in these veterans. Thus, we should make sure that the water is not contaminated before using it for eye and skin irrigation (16). In these conditions, using mobile tanks or vehicles carrying clean water and showers will be very useful. Also, field centers equipped with healthy water should be established at the nearest safe place for treatment and rehabilitation facilities around the combat area. Washing the skin with 0.5% household bleach is also useful (10).

Transport the injured people

With usage of adequate protective equipment, injured people should be transferred to areas with humid climates (12).

Post preventive measures after the incident:

Decontamination of the area

To reduce environmental pollution, Calcium hypochloride, stilbestrol or permanganate can be used to decontaminate areas (10).

Protective measures for residence in contaminated area:

The environmental sustainability of sulfur mustard is high. Hence the agent is able to remain in soil for at least 10 years (17) and it can persist in the clothes and be active in soil even for months at low temperatures. It can be found with the concentrations of 1 to 25 milligrams per cubic meter in 6 to 12 inches in the soil around the combat zones. In addition, on the basis of the available researches, people who live in polluted areas, even with no obvious symptoms at the time of exposure, may eventually develop mustard-induced complications,

especially pulmonary complications (18). Therefore, residence in high traffic areas should be prohibited in coming to the polluted area, until complete decontamination of area is performed.

Early preventive measures for injured people:

In cases of severe acute respiratory problems, a pseudo-membrane may be formed in upper respiratory tract which may cause laryngospasm and stridor. This complication may lead to asphyxia and death. For prevention of death, there may be need for an urgent tracheostomy and immediate treatment of the ICU (18-19).

After chemical attacks, even exposed people without symptoms should irrigate their eyes for 5 - 15 minutes with copious amounts of healthy water, as soon as possible (3,10,15). Solutions other than clean water that are recommended for washing the eyes include: normal saline, sodium bicarbonate solution 1.5%, Dichloramine T 0.5 percent, sodium sulfate or magnesium sulfate, and zinc or boric acid (20-22). Also, diluted infant shampoo have shown to be useful for eye decontamination (9).

Application of topical anesthetic eye drops should be avoided for both healthy and damaged cornea (22).

Local steroids should also be avoided except in the presence of chemosis and epithelial edema (23).

Pads and bandages should not be used for eye lesions, as the toxic effects of sulfur mustard may exacerbate its effect due to raised temperature in the injured eye leading to ocular lesions (21).

In the case of skin exposure, initially, we should use calcium chloride or magnesium oxide powder as the anti-gas agents immediately on the exposed areas of skin followed by washing with soap and water (10).

In the case of gastrointestinal (GI) involvement, emesis should not be induced. After feeding 100 to 200 ml of milk, gastric lavage would be indicated.

Activated charcoal is not proven but not

contraindicated, as well (9).

Post preventive measures for injured people:

Acute effects of sulfur mustard-induced lesions gradually turn into a chronic phase. In this phase, our efforts should be focused on preventing further complications. For this purpose, the following points are suggested:

In the late phase, scarring and stenosis of the airways may occur. In these cases, removing debris by bronchoscopic maneuvers would be very useful and life-saving (24).

In the treatment of chronic lesions caused by sulfur mustard, corticosteroids are widely used. The long-term use of these drugs may cause undesirable effects such as growth inhibition, diabetes, muscle atrophy, osteoporosis, salt retention, dementia and opportunistic infections. Therefore, during the application of these medications, the injured victims should be made aware for these complications (25).

More than two-thirds of the chemical veterans with chronic bronchiolitis, are overweight or obese. These patients should reduce their weights to prevent superimposing complications (26)

Treatment of magnesium deficiency in sulfur mustard induced asthmatic patients can decrease the side effects of asthma (27).

Some of the common medications used in lung diseases such as Theophylline have a negative impact on the quality of sleep for the victims (28). Therefore, such drugs should be substituted with other appropriate medications.

In patients with photophobia, using dark sunglasses is recommended (15).

The use of petroleum jelly to prevent sticking of the eyelid edges is useful.

To prevent corneal perforation, victims with the mustard eye injuries should not stay in hot and dry areas and use artificial tears. In addition, exposed people should avoid jobs such as sewing and driving for long hours since these conditions exacer-

Table 1. Preventive measures against the mustard gas before and during of chemical attacks by MS agent.

Complications	Comments	Ref.
Exposed eyes	not using bandages	32-33
Scarring or stenosis of the airways	Bronchoscopic maneuvers	24
Corticosteroids complications used for respiratory problems	Monitoring of growth inhibition, diabetes, muscle atrophy, osteoporosis, salt retention, dementia obesity and opportunistic infections.	25
Magnesium deficiency in sulfur mustard induced asthmatic patients	Administration of magnesium	27
Drug induced sleep disorders	Not administering Theophylline before the sleep	28
Photophobia	Using dark sunglasses	15
Corneal perforation	Use of artificial tears	29
Promotion of quality of life	Exercise	30
Suicide	Treatment of depression	31
Mental complications	Strengthening religious behaviors, patriotism and social supports.	SA*

*SA. Suggested by the authors.

bate the dryness of the eyes and increases the risk of corneal perforation (29).

Some complications such as COPD, pruritus, visual problems and mental disorders affect the quality of life in exposed people. In addition, quality of life in victims who exercise has been improved compared to those who are not active enough (30).

Depression is very common among the chemical victims and the most important complication is suicide which could be prevented to some extent.

Tavallai et al, in a retrospective study conducted on 1463 deaths among the chemical victims, have investigated the causes of suicide. The mechanism of suicide were self-hanging, intentional self-poisoning, suffocation and use of firearms with de-

creasing order of frequencies. These researchers have stated that suicide is one of the causes of death among the veterans that occur at young ages (less than 40 years) (31). Therefore, in order to prevent the suicide in victims with chemical injuries, especially those who are suffering from depression, they should be monitored regularly.

Strengthening of religious behaviors, patriotism and social supports are useful in prevention of wide variety of the mental complications.

Tables 1 & 2 show all suggested preventive measures.

Discussion

Unfortunately, most studied articles have

Table 2. Post preventive measures for injured people by sulfur mustard.

Complications	Comments	Ref.
Exposed eyes	not using bandages	32-33
Scarring or stenosis of the airways	Bronchoscopic maneuvers	24
Corticosteroids complications used for respiratory problems	Monitoring of growth inhibition, diabetes, muscle atrophy, osteoporosis, salt retention, dementia obesity and opportunistic infections.	25
Magnesium deficiency in sulfur mustard induced asthmatic patients	Administration of magnesium	27
Drug induced sleep disorders	Not administering Theophylline before the sleep	28
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emphasized on diagnostic and therapeutic implications in chemical victims, with little preventive measures to recommend.

Centers for disease control and prevention (CDC) in the United States has emphasized on immediate departure from the area where the sulfur mustard is released, sealing the contaminated clothing in a plastic (Polyethylene) bag, and then keeping that bag inside another plastic bag, going to a higher ground, removing the clothes, immediate washing of the body (particularly skin and eyes), not using bandages for eye lesions, using dark glasses, and not to induce vomiting in GI involvement (32-33). All these recommendations are compatible with the aforementioned points in conducted studies. In addition, disposable clothing kits should be available (33). According to Iranian reports, there were no such disposable clothes available to the combatants.

Cutting off contaminated hair is recommended, too (35), but there were not any reports regarding this in Iranian reports. Polk County Health Department has emphasized on removing the shoes, and even the contact lenses (35), but similarly, there were not any recommendations for these points in considered studies.

According to published articles, during chemical attacks in Iran contaminated clothes were burnt in some medical centers. Nevertheless, while the fire may destroy the agent, breathing the fumes is very dangerous and contact with liquid or vapor of the agent may be fatal. Thus, burning of the material should be avoided (36).

Iranian researchers emphasized on transportation of the victims to an area with humid climates (11). In CAMEO (Computer Aided Management of Emergency Operations) Chemicals software there has been emphasis on the movement of the victims to fresh air area, as soon as possible (36). Ghasemi Boroumand et al have pointed the mask as a preventive tool. Moreover, Zarchi et al in a retrospective cohort study conducted on 1337 Iranian soldiers with a history of mustard gas exposure estimated that the risk of pulmonary complications

were increased among soldiers who had not worn masks (7). These researchers have not mentioned the specific type of the masks required. In encyclopedia Britannica, a typical gas mask for protection of sulfur mustard toxicity is described as having a tight-fitting face piece equipped with filters, an exhalation valve, and transparent eye pieces (37). Based on papers, probably the masks used in Ghasemi's study, were ordinary masks and lacked the essential specifications. According to fact sheets on Chemical and Biological Warfare Agents report, masks alone do not provide adequate protection against sulfur mustard (38).

The most useful preventive recommendations suggested by Iranian researchers are the points for preventing the exacerbation of sulfur mustard-induced chronic complications.

Conclusion

Performed studies on chemical war victims in Iran are mainly focused on diagnosis and treatment of late sulfur mustard-induced complications. Although the issue of prevention is very important, the literature related to this topic was limited to scattered facts within published papers. It is suggested that more research is needed in relation to preventive measures against sulfur mustard attacks.

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