# MUSTARD GAS

## GUIDELINES FOR ACTION IN THE EVENT OF A SUSPECTED DELIBERATE RELEASE

**Contents:**

# 1 Background

## 1.1 Introduction

Mustard gas is a vesicant i.e. it is a blister- forming agent and may cause damage to skin, eyes and the respiratory system. Sulphur mustard is the chemical warfare agent that is normally referred to as mustard gas. There are several other toxic mustard compounds, including nitrogen and sesqui mustard. Of this group, only sulphur mustard has been extensively used as a chemical warfare agent.

The development of sulphur mustard as a chemical warfare agent was undertaken during world war I and used for the first time at Ypres on the 12th.July, 1917. It was generally recognised as the most effective of chemical warfare agents in World War I. This related to its incapacitating ability, as death rates following exposure were in the region of 2-3% [1]. It has also been reported to have been used in the Italian-Ethiopian conflict of 1936, the Sino-Japanese conflict during World War II and in the Iraqi-Iranian conflict during 1984-1986.

## 1.2 Physical and Chemical Properties

Although often referred to as mustard gas, sulphur mustard is a volatile liquid at room temperature. Being denser than air, it accumulates at ground level.It is oily in appearance, its colour ranging from colourless to dark brown, with the odour of mustard, horse radish, garlic or leeks. Toxicity is greater at higher tempertaures, whilst at low temperature, mustard freezes, thus increasing its persistence. The vapour given off by sulphur mustard has considerable penetrating powers and rapidly passes through clothing, affecting skin beneath. It also penetrates substances such as wood and leather. Metal, glass and glazed tiles are generally impervious. Mustard gas is only slightly soluble in water, but is soluble in fat and other common organic solvents [2]. Oxidising agents react with mustard gas to produce the corresponding sulphone and sulphoxide. The sulphone is produced by stronger oxidising agents e.g. hypochlorite and may produce lacrimation and sneezing; the sulphoxide is not a vesicant [3].

## 1.3 Summary of Human Toxicology

- Vesicant chemical warfare agents incapacitate more people than they kill[4]. The toxic effect of mustard gas is primarily due to its alkylating ability i.e. the ability to cross link to strands of DNA. This is a key factor in the cell injury producing mechanisms of mustard.

- Following skin exposure, 80% of liquid mustard gas placed on the skin evaporates, 10% becomes fixed to the skin and the remainder absorbed systemically.

The table overleaf illustrates the correlation between exposure (product of concentration and time) and observed clinical effects:

*Estimated Concentrations and Clinical Effects of Mustard Gas*

| **Type of exposure** | **Concentration** | **Clinical effects** |
|---|---|---|
| Vapour in eyes | 50 $mg.min.m^{-3}$ | Maximum safe exposure |
| | 70 $mg.min.m^{-3}$ | Mild reddening of the eyes |
| | 100 $mg.min.m^{-3}$ | Partial incapacitation due to eye effects |
| | 200 $mg.min.m^{-3}$ | Complete incapacitation due to eye effects |
| Liquid on skin | 50 $\mu g.cm^{-2}$ for 5 min | Slight erythema |
| | 250-500 $\mu g.cm^{-2}$ for 5 min | Blistering |
| Vapour on skin | 100-400 $mg.min.m^{-3}$ | Erythema of skin |
| | 200-1000 $mg.min.m^{-3}$ | Blistering |
| | 750-1000 $mg.min.m^{-3}$ | Severe, incapacitating skin burns |

Accident and Emergency Guidelines (AEGLs) for mustard gas are available. The table gives values in ppm [$mg/m^3$]:

| | 10 MIN | 30min | 1h | 4h | 8h |
|---|---|---|---|---|---|
| AEGL 1 | 0.060 [0.40] | 0.020 [013] | 0.010 [0.067] | 0.0026 [0.017] | 0.0012 [0.0083] |
| AEGL 2 | 0.090 [0.60] | 0.030 [0.20] | 0.015 [0.10] | 0.0038 [0.0025] | 0.0020 [0.013] |
| AEGL 3 | 0.59 [3.9] | 0.41 [2.7] | 0.32 [2.1] | 0.080 [0.53] | 0.041 [0.27] |

## 1.4 Clinical Features

### 1.4.1 Acute

Mustard gas does not usually cause pain at the time of exposure; symptoms may be delayed for 4 to 6 hours [5]. Keratitis can be delayed for years following ocular exposure, although this is unusual.

The table overleaf shows the evolution of symptoms and signs that might be expected following severe exposure to sulphur mustard vapour.

| Time after vapour exposure | Signs and Symptoms |
|---|---|
| 20-60 min | Nausea, retching, vomiting and eye smarting occasionally reported, sometimes no initial symptoms |
| 1 h | First appearance of erythema |
| 2-6 h | Nausea, fatigue, headache, inflammation of eyes with intense pain, lacrimation, blepharospasm, photophobia and rhinorrhoea; erythema of face and neck; sore throat, hoarse voice or total loss; tachycardia and increased respiration; definite erythema |
| 8-12 h | Raised erythema (oedema) |
| 13-22 h | Inflammation in areas where tight clothing was worn and inner thighs, genitalia, perineum, buttocks and axillae followed by blister formation which may be pendulous and filled with clear, yellow fluid; death within 24 hours is rare and extremely unlikely under civilian conditions |
| 42-72 h | Maximum blisters or necrosis; coughing appears: muco pus and necrotic slough may be expectorated; intense itching of skin; increase in skin pigmentation |
| 6-9 days | Possible complete skin surface denudation |
| 20-28 days | Removal of scab |
| 22-29 days | Usually complete skin healing |

**Inhalation**

- Coughing (which may be worse at night and become productive), wheezing, dyspnoea, paroxysmal coughing, and pulmonary oedema may be delayed for 1 to 12 hours.

- Fever, headache, hoarseness or loss of voice may be delayed for 24 hours.
- Adult Respiratory Distress Syndrome
- Broncho-pneumonia, complicated by bone marrow suppression
- Symptoms may persist for 1 or more years[4].

**Dermal**

- Erythema - This typically occurs within 2-48 hours post exposure. It may be very striking and reminiscent of scarlet fever. Slight oedema of the skin may occur, whilst itching may be common and intense. As the erythema fades, areas of increased pigmentation are left.

- Blistering - Blisters are not generally painfull but may feel uncomfortable and tense. The blisters are delicate and are easily de-roofed by contact with bed linen, bandages or during transportation of casualties. Crops of new blisters may appear as late as the second week post exposure. Blister fluid does not produce secondary blisters if applied to skin of patient or carer.

- Deep Burning - Full thickness loss is likely if mustard gas is applied to the penis and scrotum.

Lesions tend to be painful and heal slowly. Previously erythematous areas darken and become hyperpigmented. These areas tend to disappear over several weeks with desquamation leading to hypopigmentation.

**Ocular**

The eyes are the organs most sensitive to mustard gas, although no clinical indication of injury may become evident until several hours later.

The corneal epithelium may become oedematous; lids and conjunctiva become red and swollen. Burning, discomfort, photophobia, lacrimation, blepharospasm

Exposure to vapour induces extreme discomfort and temporary disablement, but in most cases recovery is complete.

In more severe cases, injuries have involved not only the epithelium but also deeper layers; corneas may become cloudy and infiltrated, and in extreme cases eyes may become totally opaque

**Long term effects include corneal opacities and chronic conjunctivitis.**

**Oral**

- Ingestion of food or water contaminated with mustard gas may cause nausea and vomiting, pain, bloody diarrhoea and, in severe cases, dehydration

**Systemic**

Dizziness, generalised malaise, anorexia and lethargy can occur after acute exposure
CNS excitation with convulsions may occur, followed by CNS depression; AV-block and cardiac arrhythmias

- Irreversible bone marrow depression may occur. Anaemia occurs within 4 days.

### 1.4.2 Chronic

Chronic exposure has been associated with an increased risk of respiratory tract cancer (nasopharyngeal, laryngeal and lung), and skin cancer especially in ammunition factory workers; also chronic bronchitis, pigmentation abnormalities,

chronic skin ulceration and scar formation; bone marrow depression and sexual dysfunction due to scarring of the scrotum and penis [4.] In addition, psychological effects, visual impairment, permanent blindness,skin scarring may also occur.

IARC has determined that mustard gas is a Class I Human carcinogen and experimental teratogen [7,8].

# 2 Clinical procedures

## 2.1 Triage

Primary (first look) triage should be carried out using the standard triage sieve. In addition to normal discriminators, secondary triage should include the following:

Immediate:

Moderate to Severe Pulmonary Oedema

Urgent

Pulmonary Symptoms

Delayed

Less than 5% blistering

## 2.2 Decontamination

- Mass decontamination will probably be carried out by the Fire Service, using a high volume, low pressure approach, before being handed to adequately protected ambulance staff in the "warm" zone. Ambulance staff should not enter the "hot" zone, except under exceptional circumstances.
- Adequate and appropriate personal protective equipment, including respiratory and eye protection should be ensured before rescuers attempt to aid casualties.
- All contaminated clothing, including underwear should be removed urgently. Contaminated clothing should be placed in clear, labelled, sealed bags to prevent further contamination.
- Eye decontamination should be carried out using water or 0.9% saline.

- Skin decontamination should be carried out using the rinse-wipe-rinse technique with **dilute hypochlorite** (0.5%) solution (500ml household bleach to a 10 litre bucket of water). If thickened agents have been used, then remaining areas of agent may be scraped off with a blunt knife. Underlying skin should be decontaminated as above.

### 2.3 Sample collection and monitoring

Mustard gas or its metabolite, thiodiglycol, can be detected in urine up to a week after acute exposure. This may be of some use in differentiating blistering produced by other agents eg Lewisite. In severe cases, the full blood count should be monitored, as bone marrow suppression can occur.

### 2.4 Treatment

There is no specific therapy for sulphur mustard or nitrogen mustard poisoning.

### 2.5 Management

### 2.5.1 Dermal

Urgent decontamination is required.

For erythema and blisters, treat with emollients

Silver sulphadiazine 1% cream was used for casualties from the Iran/Iraq conflict and benefited in reducing infection 3.

Patients may develop a dermal hypersensitivity reaction which may require treatment with systemic or topical corticosteroids or antihistamines
Pain will require analgesia

Topical antiseptic solutions, and a regimen of oral vitamin E may be beneficial[6]
Observation is advised for the duration for the development of the blisters – particularly groin, axillae, around the neck – blister fluids are not a vesicant – consider draining under sterile conditions

Treat blisters as burns, which may require long healing periods

Large full-thickness burns will not heal satisfactorily without grafting[9].

- Dermal abrasion a few days after exposure, (removing the surface of the effected area until capilary bleeding is seen) may hasten the recovery of skin lesions. This should be discussed with the NPIS before attempted.

- Monitor WBC for severe exposures.

### 2.5.2 Eye

Irrigate thoroughly with running water or saline

Immediate referral to ophthalmologist who may consider the use of atropine eye drops. Posterior synechiae may form.

- For liquid contamination: Attempts to irrigate eyes 5 minutes after liquid contamination is likely to be of no value and may increase the severity of the injury [9].

### 2.5.3 Oral

Activated charcoal may be of use. Gastric lavage or emetics are not indicated,
Encourage oral fluids

Give IV fluids if dehydrated; analgesics for pain

- Symptomatic and supportive care

### 2.5.4 Inhalational

- Establish and maintain a clear airway and administer supplemental oxygen as required.

## 2.6 Admission criteria

All casualties must be triaged by a Triage Officer and/or designated health care professional.

*Mild symptoms:* minimal exposure on the skin with adequate early decontamination

- Observe for 2 hours
- Some individuals may suffer pain
- If symptoms improve or the patient has not deteriorated within 2 hours, then casualties should be discharged with information on criteria to seek further medical advice

*Moderate symptoms:* eye irritation without intense blepharospasm, minor skin erythema, small blisters less than 2 cm in size

- Should be kept in a 'holding facility' (i.e. a ward, chapel or other designated area with beds/mattresses)
- Medical staff must observe carefully for a deterioration in medical condition and be prepared to move to severe symptom group if necessary

- Administer symptomatic and supportive care as required.

- If symptoms improve or patient has not deteriorated within 24 hours, then casualties should be discharged with information on criteria to seek further medical advice

*Severe symptoms:* early eye irritation worsening to severe blepharospasm obvious skin blistering and respiratory difficulties

- These casualties will require admission.

- Supplemental oxygen with humidification may be required for respiratory distress.Ventilate if necessary

- Monitor WBC count – an initial rise may be followed by a significant fall

- Bone marrow suppression may occur

- Careful infection surveillance should be undertaken.

# 3 Public health procedures

## 3.1 Surveillance and detection of deliberate release

A deliberate release should be considered in the event of any cases, where there is no clear history of occupational or other exposure to vesicant materials. The likelihood of a deliberate release increases with the number of cases that are linked in time and place.

Mustard gas associated illness is a rare disease in the UK – the last cases seen in the UK were referred for treatment following exposure during the Iran-Iraq War in the 1980s.

Expert advice will be required in order to confirm the occurrence of a covert release and epidemiological investigations may be required to defined exposed zone in time and space.

## 3.2 Case definition

### 3.2.1 Possible case

Patient reporting possible exposure with mild symptoms, probably not admitted for continuing medical care.

### 3.2.2 Probable case

Patient reporting exposure and is symptomatic with skin eye or respiratory symptoms compatible with mustard gas, and likely to have required hospital care

### 3.2.3 Confirmed case

Symptomatic patient with exposure requiring hospital care with thiodiglycol detected in urine up to a week after acute exposure. (Not all patients identified as confirmed cases will have required hospital admission as long as laboratory data is available on the patient).

## 3.3 Public Health action

### 3.3.1 Removal from exposure

Minimisation of harm by removal from exposure and early decontamination are probably the most important public health measures. Evacuation from contaminated area is essential and is likely to be undertaken by the emergency services (or by self evacuation).

### 3.3.2 Epidemiological investigation

The value of obtaining epidemiological data from all exposed is immeasurable. A draft questionnaire has been provided to hospital trusts (Hospital Chemical Incident Response) and further advice may be issued. Health authorities may wish to collaborate with acute trusts in collating these data.

## 3.4 Environmental hazard summary

WHO reports a persistence of mustard gas for 12 to 48 hours at 100 C with rain and a moderate wind, 2 to 7 days at 15°C with sun and a light breeze, and 2 to 8 weeks at -10°C with sun, no wind, and a snow cover[9]

- Drinking Water Standards: no data available
- Soil Guidelines: no data available
- Air Quality Standards: no data available

## 4. National specialists

| Agency | Contact numbers | Area served |
|---|---|---|
| National Poisons Information Service | 0870 600 6266 | UK |
| **Chemical Incident Provider Units** | | |
| Chemical Incident Response Service, London | 020 7771 5383<br>020 7639 8999 (24hr) | Eastern, London, South East, South West, North West, Trent Regions |
| Chemical Hazard Management and Research Centre, Birmingham | 0121 414 3985<br>0121 414 6547<br>0845 330 8750 (24hr) | West Midlands Region |
| Chemical Incident Service, Newcastle | 0191 222 7195<br>0191 230 3761 (24 hr) | Northern and Yorkshire Region |
| Chemical Incident Management Support Unit, Cardiff | 02920 716 783<br>02920 715 278 (24hr) | Wales and Northern Ireland |
| Scottish Centre for Infection and Environmental Health | 0141 300 1100 (ask for on call consultant)<br>0141 211 3600 (24 hr) | Scotland |
| **Other** | | |
| National Focus for Chemical Incidents | 02920 416 388 | UK |
| Regional Health Emergency Planning Advisers | | UK |
| Emergency Planning Co-ordination Unit, Department of Health, England | 020 7972 3786 | UK |

## 5. References


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