

# CS exposure—clinical effects and management

Elsbeth Worthington, Patrick A Nee

## Abstract

**The number of people exposed to CS spray presenting to accident and emergency departments is on the increase. Its effects, though usually minor and short lived, involve several systems and can occasionally be life threatening. It is therefore important that staff are able to manage these patients and know when and how to protect themselves and others from further contamination.**

(J Accid Emerg Med 1999;16:168-170)

**Keywords:** CS spray; incapacitant; emergency management

The use of hand held defence sprays to incapacitate violent offenders has become widespread among many UK police forces. Accident and emergency personnel are therefore increasingly treating patients who have been exposed to CS spray. A basic understanding of its clinical effects is essential to permit the appropriate triage and emergency care of such patients.

O-chlorobenzylidene malonitrile was named CS after the two chemists Corson and Stoughton who synthesised the compound in 1928. In its natural state it is a fine white solid similar to talcum powder with a pepper-like odour. Its chemical formula is represented in fig 1. It can be disseminated as a fine dust via an aerosol or, when mixed with a pyrotechnic compound, as a smoke or fog of minute particles from a grenade or canister.

The "CS incapacitant spray" currently in use by the UK police forces contains a solution of CS in a solvent of methyl isobutyl ketone propelled by compressed nitrogen. In legal terms this is a firearm and requires a licence for its possession.<sup>1</sup> In minute doses it acts as a severe irritant and lacrimator causing a severe local reaction within seconds of contact with mucous membranes and skin. There are other compounds with a similar range of irritant

properties, namely chloroacetophone (CN), capsaicin, and chloropicrin.

The mechanism of action of CS in humans is not fully understood. Hydrochloric acid is produced by reduction of chloride ions on the skin and this may cause marked local irritation.<sup>2-4</sup> CS alkylates intracellular sulphhydryl groups, competitively inhibiting the enzymes dependent on this group.<sup>4-7</sup> There is also a cyanide moiety within CS molecule. Although this may contribute to the local irritative effects of the compound it is not thought to enter the central nervous system under normal conditions of exposure.<sup>2,8</sup>

CS sprays were designed for use by the police to incapacitate violent opponents who could not be restrained without risk to life.<sup>9</sup> Short, low dose exposures have the required rapid onset deterrent qualities with few medical complications.<sup>5</sup>

Police guidelines specify that a warning must be given before using the spray and that it should not be administered at a range of less than 3 feet due to increased risks of toxicity, especially to the eyes. After the use of CS spray the victims should be promptly removed from the contaminated area to avoid prolonged exposure. During transportation the prone position should be avoided because of the danger of asphyxia and police are advised to leave the windows open to aid dispersion.<sup>10</sup> When in police custody, attendance by a police surgeon is mandatory for anyone suffering any complications as a result of CS spray exposure.<sup>9</sup>

Guidelines for police surgeons specify that anyone suffering with a pre-existing pulmonary or cardiac condition should be examined and monitored by a doctor and referred to a hospital as necessary.<sup>1</sup>

## Effects

The irritant effects of CS are of rapid onset even in low concentrations and are short lived (15-30 minutes) if individuals are moved into fresh air,<sup>1</sup> though the time for complete recovery has been questioned.<sup>10</sup> Area decontamination is not required after the use of CS gas, however the incapacitant spray used by the police adheres to surfaces within its vicinity and when used indoors people are at risk of recontamination if the area is not thoroughly cleaned. Both agents are widely held to be safe when used appropriately; irritant symptoms are produced at concentrations at least 2600 times lower than the lethal dose.<sup>6</sup> There are said to be no additional hazards in elderly subjects or those with a history of allergies, hypertension, jaundice, or hepatitis.<sup>11</sup>

## EYES

CS and similar agents are known as lacrimators. They are intended for use against an

Accident and  
Emergency  
Department, Royal  
Liverpool University  
Hospital  
E Worthington

Accident and  
Emergency  
Department, Whiston  
Hospital, Prescot,  
Merseyside L35 5DR  
P A Nee

Correspondence to:  
Mr Nee.

Accepted 11 February 1999

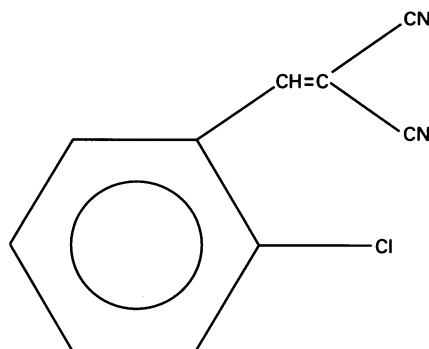


Figure 1 Chemical structure of o-chlorobenzylidene malonitrile (CS).

aggressor and their main target is the eyes. They cause an intense irritation of exposed mucous membranes resulting in lacrimation, blepharospasm, conjunctival erythema, and periorbital oedema.<sup>5,8</sup> These symptoms are more severe in those victims wearing contact lenses. Permanent eye damage is uncommon and there are no reported cases of blindness in humans as a consequence of exposure to CS gas or spray.<sup>5</sup> However, raised intraocular pressure may occur and may precipitate acute angle closure glaucoma. Longer term potential problems include cataracts, vitreous haemorrhage, and traumatic optic neuropathy.<sup>12</sup>

#### RESPIRATORY

On inhalation the spray initially causes nasal congestion and rhinorrhoea. As it reaches the mouth its burning acidic taste precedes the stinging effect on the throat. Progression into the larynx, trachea, and pulmonary tree can cause coughing, the production of copious secretions, bronchospasm, and laryngospasm.<sup>5,8</sup> Excessive exposure can result in pulmonary oedema, which may be delayed up to 24 hours, chemical pneumonitis or congestive heart failure.<sup>5</sup> Patients with pre-existing respiratory disease such as asthma or chronic obstructive pulmonary disease are at particular risk of more severe reactions and exacerbation of their underlying conditions.<sup>4,13,14</sup> There are several reports of reactive airways dysfunction syndrome in previously healthy individuals exposed to CS gas, and prolonged cough and impaired respiratory function may last for many months.<sup>15</sup>

#### SKIN

Contact of CS with the skin produces a burning sensation and erythema usually settling within 24 hours.<sup>14</sup> Prolonged contact, especially in association with wet skin or clothing, worsens the effect and can result in chemical burns.<sup>16,17</sup> These are usually minor but extensive damage up to 20% of the body surface area has been reported.<sup>17</sup> Allergic contact dermatitis as a result of repeated exposure to both CS gas and spray has been reported.<sup>3,14</sup>

#### GASTROINTESTINAL

Gastrointestinal disturbances with loss of appetite, nausea, vomiting, and diarrhoea have occurred after CS gas exposure.<sup>5,16</sup> These are also known effects of the propellant used in the police incapacitant spray.<sup>18</sup> Acute hepatocellular damage and associated enzyme changes have also been reported.<sup>5</sup> However no evidence of chronic liver damage has been found in subjects exposed to CS gas.<sup>11</sup>

#### OTHER SYSTEMS

Experiments in a chemical defence establishment did not reveal any significant changes to cardiovascular parameters or to the electrocardiogram except a mild short lived tachycardia,<sup>19</sup> although in persons with pre-existing cardiac disease hypertension may be exacerbated.<sup>1</sup>

There is no substantial evidence in animals or humans that CS gas is carcinogenic or

teratogenic.<sup>4,20</sup> No increase in the incidence of spontaneous abortions, stillbirths, or congenital abnormalities has been found in the geographical areas of CS gas use.<sup>11</sup> There have been no reported cases of CS gas or spray precipitating seizures in people with epilepsy nor of any significant psychiatric disturbance attributed to its use.<sup>4,9</sup>

#### CHILDREN

There are only a few case reports of infants and children exposed to CS gas and its effect seems similar to that in adults. Chemical pneumonitis was found in a toddler after prolonged exposure, but a full recovery was made.<sup>21</sup>

#### Complications

CS spray is thought to be a safe agent when protocols governing its use are adhered to. Protocol violations are usually concerned with the duration and concentration of exposure and failure to remove victims from the contaminated area. Adverse reactions are more frequent and more severe when the spray is used in enclosed spaces.<sup>4,12,14</sup> There are no reports of death directly attributable to CS gas or spray in the current literature.<sup>6,11</sup>

Most safety studies have been performed in North America where CS gas has been used by police forces for many years.<sup>6</sup> The effective deterrent concentration in adult subjects is 10–20 mg/m<sup>3</sup>.<sup>6</sup> In higher concentrations there is an increased risk of longer lasting effects such as corneal damage, skin burns, and respiratory damage.

The solvent base of the CS incapacitant spray now being used in the UK is also an irritant to the eyes and the effects it may have on the skin, that is irritation, erythema, drying, flaking and blistering, may be delayed in onset for up to eight hours and can last for up to one week.<sup>1,14</sup>

#### Management of CS exposure

On reaching fresh air, recovery from these agents is usually complete in 30 minutes; thus the most important early action in managing victims of CS spray exposure is their removal from that site into clean areas.<sup>4,14,19</sup>

Exposed victims should be placed in a well ventilated area, preferably with a free flow of air to aid dispersal of the gas and no unprotected attendants downwind.

Contamination of the eyes with CS gas should be treated by blowing dry air directly onto them with an electric fan if available,<sup>12</sup> however CS spray may require irrigation of the eyes with isotonic fluids or water for its complete removal.<sup>14,22</sup> Once the irritant symptoms settle usually only mild conjunctival injection or minor corneal abrasions persist. These patients can then be discharged with a short course of broad spectrum antibiotic eye drops. Older subjects should be monitored for symptoms and signs of acute glaucoma.<sup>12</sup>

The skin should be showered with soap and copious flowing water. Any burns should be managed in the same way as thermal burns. Topical steroids and antiseptic solutions may be used for dermatitis and erythema.<sup>14</sup>

Patients with persistent respiratory symptoms should be admitted for observation; humidified oxygen may provide symptomatic relief.<sup>14</sup> Aminophylline or inhaled  $\beta_2$  agonists may be necessary in the management of acute bronchospasm in patients with pre-existing respiratory problems.<sup>4</sup> Mechanical ventilation may rarely be indicated. Exposed persons are at risk of secondary pneumonia but there is no definite evidence that prophylactic antibiotics are of any benefit.<sup>4</sup>

Pulmonary oedema and reactive pneumonitis should be managed with supportive measures as above depending on its severity. It is essential to admit those individuals at risk of late development of pulmonary oedema to hospital for monitoring. Those at greatest risk are older people with pre-existing cardiac or respiratory disease and those who have had a substantial exposure in confined space.<sup>4 14</sup>

Protection of medical staff is fundamental in managing these patients. The use of disposable rubber gloves, close fitting protective goggles, and garments covering the full length of arms and legs is usually sufficient.<sup>5</sup> Contaminated clothing should be removed and sealed in plastic bags and later rinsed several times in cool water with conventional washing powder.<sup>1 14</sup> If clothes are washed in a washing machine a cool cycle is preferred as hot water will cause any residual CS to vaporise with a risk to nearby individuals.<sup>12</sup>

In patients requiring intubation all medical attendants should protect themselves from contamination. The anaesthetist should wear close fitting eye protection and a facemask. Other procedures such as tube thoracostomy merit similar precautions.<sup>2</sup>

### Summary

Victims exposed to CS spray, after its recent introduction as a crowd control agent by UK police forces, are presenting to emergency departments with increasing frequency. Clinical staff involved in the care of these patients

should be aware of the effects of such exposures and their management. Staff must also ensure that they have access to appropriate personal protection equipment in order to avoid becoming exposed themselves.

Conflict of interest: none.  
Funding: none.

- 1 Anonymous. CS incapacitants. *Guidelines for police surgeons. Advice sheets for victims*. London: HMSO, 1996.
- 2 Bhattacharya S, Hayward A. CS gas—implications for the anaesthetist. *Anaesthesia* 1993;48:896–7.
- 3 Ro YS, Lee CW. Tear gas dermatitis. *Int J Dermatol* 1991;30:576–7.
- 4 Folb P, Talmund J. Tear gas—its toxicology and suggestions for management of its acute effects in man. *S Afr Med J* 1989;76:295.
- 5 Vaca F, Myers J, Langdorf M. Delayed pulmonary edema and bronchospasm after accidental lacrimator exposure. *Am J Emerg Med* 1996;14:402–5.
- 6 Danto BL. Medical problems and criteria regarding the use of tear gas by police. *Am J Forensic Med Pathol* 1987;8:317–22.
- 7 Anonymous. Toxicity of CS. *Lancet* 1971;ii:698.
- 8 Yih J-P. CS gas injury to the eye. *BMJ* 1995;311:276.
- 9 The truth of CS. *Dispatches Channel 4*, 1996.
- 10 Anonymous. "Safety" of chemical batons. *Lancet* 1998;352:159.
- 11 Himsforth H, Black DAK, Crawford T, et al. *Report of the enquiry into the medical and toxicological aspects of CS (ortho-chlorobenzylidene malonitrile). II: Enquiry into the toxicological uses of CS and its use for civil purposes*. London: HMSO, 1971.
- 12 Gray PJ. Treating CS gas injuries to the eye. *BMJ* 1995;311:871.
- 13 Hu H, Christani D. Reactive airways dysfunction after exposure to tear gas. *Lancet* 1992;339:1535.
- 14 Medical Toxicology Unit Chemical Incident Response Service (London). *Crowd control agents*. London: Medical Toxicology Unit Chemical Incident Response Service, 1998.
- 15 Howard H, Fine J, Epstein P, et al. Tear gas—harassing agent or toxic chemical weapon? *JAMA* 1989;262:660–3.
- 16 Punte CL, Owens EJ, Gutentag PJ, et al. Exposures to ortho-chlorobenzylidene malonitrile. *Arch Environ Health* 1963;6:366–74.
- 17 Holland P, White RG. The cutaneous reactions produced by o-chlorobenzylidene malonitrile. *Br J Dermatol* 1972;86:150–4.
- 18 Medical Toxicology Unit Chemical Incident Response Service (London). *Methyl isobutyl ketone*. London: Medical Toxicology Unit Chemical Incident Response Service, 1998.
- 19 Beswick FW, Holland P. Acute effects of exposure to ortho-chlorobenzylidene malonitrile. *British Journal of Industrial Medicine* 1972;29:298–306.
- 20 Anonymous. Tests on CS for carcinogenicity. *BMJ* 1973;i:129.
- 21 Park S, Giammona ST. Toxic effects of tear gas on an infant following prolonged exposure. *Am J Dis Child* 1972;123:245–6.
- 22 Breakall A, Bodiwala GG. CS gas exposure in a crowded night club: the consequences for an accident and emergency department. *J Accid Emerg Med* 1998;15:56–7.