

Unintended cutaneous reactions to CS spray

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CS spray (2-chlorobenzylidene malononitrile 5% w/v in methyl isobutyl ketone) has been used by the police force in the UK as an incapacitant for nearly a decade. It causes a number of well-recognized cutaneous reactions, which are generally regarded as short-lived. These include skin burning, erythema and blistering. However, a range of unpredictable cutaneous reactions to CS spray may also occur. We have found contact allergy, leukoderma, initiation or exacerbation of seborrhoeic dermatitis, and aggravation of rosacea following CS spray exposure in 6 police officers and 1 doorman. These skin reactions have required long-term changes in working practice for the affected individuals. Police officers may have repeated exposure to CS spray during their training and in their work, and designated police officers carry CS spray canisters daily in the line of duty. They may therefore be at greater risk of exposure to CS spray and its unintended effects than many assailants.

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CS (2-chlorobenzylidene malononitrile) spray has been used by the police force in the UK since September 1996, primarily as a deterrent in riot control. CS itself is a white powder, which is poorly soluble in water. The initials are rumoured to represent Carson and Stoughton, the chemists who developed the chemical in 1928 (1).

The spray consists of a 5% w/v solution in methyl isobutyl ketone (MIBK) within a pressurized canister with nitrogen as propellant (2). It incapacitates by causing intense lacrimation, blepharospasm, photophobia, burning of the eyes, nose and throat, coughing and dyspnoea. Erythema and blistering may also occur. These symptoms arise within 20–60 s of exposure and usually cease within 30 min in an open, outdoor environment.

We describe a series of 7 patients who developed unintended cutaneous reactions following exposure to CS spray and were later referred to our department for patch testing.

Patients and Methods

Patient no. 1

A 31-year-old police constable received CS training in 1998, whereby a solution was sprayed onto the floor and the patient had walked over it. He developed runny eyes immediately afterwards,

which settled quickly. He experienced an accidental 2nd exposure and then a 3rd exposure, following use of the spray on an assailant. He subsequently developed some flaking of the scalp, which resolved with 1% hydrocortisone cream.

1 week later, he wore the jumper that he had been wearing at the time of his most recent CS exposure. He developed some skin irritation on the right arm, which progressed over the next day or so with blistering. He also had some facial involvement. Oral and potent topical corticosteroids were required and his skin settled over the next few weeks.

6 months later, he had a further exposure to CS spray. After 2 days, he had blistering on the left wrist, which responded to treatment with a potent topical corticosteroid. As a result of his skin reactions, the patient was transferred to office duties.

He was patch tested with a serial dilution of CS in acetone (acet.) and a dilution of MIBK. His patch tests at D2 and D4, compared to a volunteer control, were as in Table 1, unequivocally demonstrating contact allergy to CS.

Patient no. 2

A 39-year-old police officer described stinging of the eyes and pruritus when handling exhibits

Table 1. Patch test results in patient no. 1 and control, read according to international guidelines (13)

	Patient	Control
CS 0.1% acet.	NT	IR
CS 0.01% acet.	+++	-
CS 0.001% acet.	++	-
CS 0.0001% acet.	+	-
MIBK 1% acet.	-	-

previously exposed to CS spray, or on entering a room which had earlier been occupied by a prisoner on whom the spray had been used. CS spray had been introduced into his police unit 8 years earlier, at which time he had been exposed in the course of his training. At that time, he developed a painful, weepy nose and eyes, and also difficulty in breathing.

Over the ensuing years, he had at least 10 further exposures. 1 year prior to presentation, exposure to CS spray was followed 12 hr later by painful erythema and oedema of the face, neck and forearms, in addition to the initial expected reactions. He was patch tested and gave a graded series of positive patch test reactions to CS from 0.01% to 0.00001% acet. w/v at D2 and D5, thus demonstrating contact allergy to CS (Table 2).

Patient no. 3

A 35-year-old doorman at a nightclub had repeated exposure to CS spray in the course of his work. His first exposure had been 5 years earlier, at which time a canister had been discharged in his pocket. He developed severe blistering at the site of contact. Subsequent exposures resulted in dramatic eyelid swelling and scalp reactions. He had graded positive patch test reactions to CS diluted in acet. at 0.001%, 0.0001% and 0.00001% (Table 2).

Patient no. 4

A 51-year-old detective constable attended a CS training course, which involved a single exposure to CS spray. He immediately experienced dyspnoea and a burning sensation on the face. Later in the day, he also developed erythema on the forehead, cheeks and sides of the nose. After 2 days, he had some blistering on the left side of the nose. Treatment with a moderately potent topical corticosteroid helped to settle the rash. However, the erythema was recurrent and he occasionally developed pustules. It tended to flare with heat and alcohol ingestion.

Table 2. Summary of patch test results with CS in acet., read according to international guidelines (13)

Patient number	Sex	Age (years)	Patch test results at D2 and D4-5	Diagnosis
1	Male	31	CS 0.01% acet. w/v (+++) CS 0.001% acet. w/v (+++) CS 0.0001% acet. w/v (+) MIBK 1% acet. v/v (-)	Allergic contact dermatitis from CS
2	Male	39	CS 0.01% acet. w/v (+++) CS 0.001% acet. w/v (+++) CS 0.0001% acet. w/v (+) CS 0.00001% acet. w/v (+) MIBK 1% acet. v/v (-)	Allergic contact dermatitis from CS
3	Male	35	CS 0.001% acet. w/v (+++) CS 0.0001% acet. w/v (+++) CS 0.00001% in acet. w/v (+++) MIBK 100% (IR)	Allergic contact dermatitis from CS
4	Male	51	CS 0.01% acet. w/v (-) CS 0.001% acet. w/v (-) CS 0.0001% acet. w/v (-) CS 0.00001% acet. w/v (-) MIBK 100% (-)	Rosacea, with resulting susceptibility to CS spray exposure on face
5	Male	35	CS 0.001% acet. w/v (-) CS 0.0001% acet. w/v (-) CS 0.00001% acet. w/v (-)	Chemical burn from CS spray, resulting in leukoderma and dysaesthesia
6	Female	33	CS 0.01% acet. w/v (-) CS 0.001% acet. w/v (-) CS 0.0001% acet. w/v (-) CS 0.00001% acet. w/v (-)	Seborrhoeic dermatitis initiated or aggravated by CS spray
7	Male	44	CS 0.01% acet. w/v (-) CS 0.001% acet. w/v (-) CS 0.0001% acet. w/v (-) CS 0.00001% acet. w/v (-)	Irritant contact dermatitis from CS spray, with possible rosacea

On examination, he had telangiectasia on the upper cheeks and some red papules and pustules sparsely distributed over the forehead. Repeated patch tests to CS in acet. were negative (Table 2). Patch tests to the European standard series and a face series were also negative. Clinically, this patient had rosacea and it is possible that his heightened susceptibility to CS exposure on the face may have been due to the rosacea.

Patient no. 5

A 35-year-old police sergeant was sprayed on the face and neck at close range with most of the contents of a CS spray canister during a police weapons training exercise. The exposure was accidental, as it had been intended to use a water substitute rather than the actual spray. The patient immediately experienced painful watery eyes and a burning sensation of the skin. His skin continued to feel like severe sunburn and he developed a large bulla at the exposed site. He went outside to allow his skin to cool and also splashed his face with cold water.

The sprayed areas of skin on his face and neck became scabbed. Once this scabbing fell away, he was left with persistent areas of paler skin. The exposed skin remained sensitive to touch, shaving, sweating and sunburn. He had no past medical history of vitiligo. He had had previous exposure 4 or 5 years earlier, when CS spray was discharged at his feet in a training session, and then again at a further firearms demonstration exercise.

On examination, the patient had irregular areas of depigmented skin and hair on the chin, neck and scalp, but with no evidence of scarring. He was patch tested with non-irritant dilutions of CS in acet. and also to the European standard series. All patch tests were negative at D2 and D5 (Table 2). A diagnosis of chemical leukoderma from CS spray was made. As CS is more irritant than the solvent MIBK, it was thought that the chemical leukoderma was more likely to be attributable to CS than to MIBK.

Patient no. 6

A 33-year-old police constable was exposed to CS spray for the 1st time at a police training session, where it was directed at waist height. She experienced immediate stinging of the eyes and a burning sensation of the skin. Over the next hour or so, her face became swollen and erythematous. The facial erythema persisted for the next few days and was associated with scaling and pruritus. 2 days later, she also developed bullae on the

elbows, which settled with 1% hydrocortisone cream.

Despite treatment, her eyelids continued to relapse intermittently with erythema and oedema. Relapses occurred not only on direct exposure to CS spray, but also indirectly, following her occupation of a room recently vacated by a CS-using police officer. She denied a past medical history of any skin complaints.

On examination, she had telangiectasia on the upper cheeks and erythema of the left upper eyelid. She also had erythema and some red papules on the neck, back and chest and in the axillae.

The patient was patch tested to the European standard series and also to CS diluted in acet. She had positive patch tests to nickel and cobalt at D2 and D5, but negative patch tests to CS (Table 2).

Although an initial diagnosis of seborrhoeic dermatitis was made, it was somewhat atypical in that it dated from a well-documented contact irritant exposure and also relapsed acutely despite treatment. On balance, it was considered that seborrhoeic dermatitis might have been initiated in some way following exposure to CS, and that this remained susceptible to relapse from environmental factors.

Patient no. 7

A 44-year-old police constable was inadvertently sprayed with CS in a police training exercise. He was exposed across the face, back and arms, and experienced immediate pain in the eyes, erythema and burning of the skin and shortness of breath. He showered and spent some time in an open environment. Several hours later, he continued to experience conjunctivitis, facial erythema and burning, tender lips, as well as numbness of the tongue.

This was followed by scaling, at which point he sought help from his general practitioner. He had little benefit from mild topical corticosteroids, but his symptoms eased with time. However, he experienced persistently increased skin sensitivity and described ready burning of his face when exposed to the wind and sun. He had no further CS exposure.

On examination, 4 months later, he was noted to have red papules in a malar distribution and telangiectasia. These were thought to be due to possible rosacea or secondary to topical corticosteroid application.

The patient was patch tested to the European standard series of allergens and to serial dilutions of CS in acet. His patch tests were negative to 0.01%, 0.001%, 0.0001% and 0.00001% CS in

acet. (Table 2) as well as to the standard series of allergens. Diagnoses of irritant contact dermatitis from CS and possible rosacea were made.

Discussion

While tingling, erythema, rashes and blistering are recognized consequences of CS exposure, it has generally been accepted that such symptoms are short lived (2). In our series of 7 patients, however, the cutaneous manifestations of CS exposure have had longer term implications. 3 patients developed an allergic contact dermatitis, necessitating changes in their day-to-day practice. 1 patient had been transferred to office duties, while 1 was able to avoid relapses by wearing appropriate protective gloves and mask. 2 patients with rosacea appeared to show greater susceptibility to the cutaneous effects of CS spray. Therefore, it may be wise for personnel with a previous history of rosacea to be excluded from CS spray training programmes. In 1 patient, exposure to CS spray seems to have triggered seborrhoeic dermatitis, which was then exacerbated by further direct or indirect exposure. 1 of our patients had developed a disfiguring leukoderma and dysaesthesia secondary to CS spray exposure, both of which are likely to be irreversible.

There are a number of reports of severe cutaneous reactions to CS spray (3–6). Facial pain, oedema, erythema and periorbital swelling may be extensive, requiring hospital admission for treatment with systemic corticosteroids and intravenous antibiotics (3). A persistent, multisystem hypersensitivity reaction has also been reported (7). A patient became erythrodermic several days after CS spray exposure, and then developed a widespread dermatitis which resolved gradually after 6–7 months. Systemic involvement included pneumonitis, hepatitis and hypereosinophilia (7). In France, 11 patients over a 3-year period were hospitalized for bullous dermatitis following exposure to CS spray (4). Their mean duration of hospitalization was 6 days, predominantly for what was considered to be irritant contact dermatitis. Little difference was noted in the timing and clinical appearance in previously exposed and non-exposed individuals. However, patch tests were not performed (4). In a study of 28 chemical plant workers manufacturing CS, dermatitis of the neck and arms occurred in 25 of the workers (8). While 2 of the 25 had positive patch tests, the majority proved to have an irritant contact dermatitis (8).

Factors expected to contribute to increased severity of cutaneous, ocular and respiratory complications of CS spray include the physical properties of the spray itself, duration and proximity of exposure, pre-existing skin, eye or lung problems, and speed of appropriate decontamination procedures. An important property of the spray to be considered is the mass of CS delivered. There is conflicting literature regarding the physical properties of CS formulations (2, 6). The terms aerosol and spray tend to be used interchangeably. However, an aerosol is properly defined as a suspension of small solid particles (usually <50 µm in diameter) in a gas or vapour, whereas sprays are contrastingly comprised of coarse droplets (9). Sprays tend to deliver a higher concentration of CS than aerosols. Furthermore, sprays used in the UK contain 5% w/v CS, whereas the US product is a 1% w/v CS spray. There are no specific data comparing the relative efficacy or safety of 1% CS and 5% CS sprays. Information is based on experience with CS itself, and, to a lesser extent, MIBK. Although the individual propellant and active ingredient of a formulation may be non-toxic when tested separately, their use in combination may have different properties. For example, the influence of the formulation may affect the absorption of a drug due to an increased rate of solubility of particles (9). There are no metabolic, kinetic, acute toxicity or skin irritancy data available on the combination of CS with MIBK (2). MIBK itself may cause erythema and dryness of the skin, and irritation caused by CS may be potentiated by the solvent.

Further controversy arises in elucidating optimal decontamination. Although poorly soluble in water, CS is hydrolysed to inactive products. Tiny particles attach to moist mucous membranes and skin to act as potent sensory irritants. Sprayed individuals are advised to remove contaminated clothing and to move to an open, uncontaminated environment. It is claimed that CS particles can then be blown off the body in fresh air (10). However, this simple manoeuvre is more likely to prevent further exposure to CS spray than to result in decontamination. Evaporation of the solvent may not necessarily be accompanied by loss of the CS powder. Alternative recommendations are to irrigate the exposed areas with copious water, normal saline or with sodium metabisulfite, and to prevent secondary exposure by wearing protective clothing and sealing contaminated clothing in plastic bags (1, 3, 11).

The use of CS spray in the police force in the UK is governed by specific guidelines (12, 13).

Its use as an incapacitant is to provide officers with a tactical advantage in a violent encounter in subjects who cannot otherwise be restrained (14). Assaults on police officers issued with CS spray have fallen significantly (15). Canisters are issued to those police officers who have been trained and certified by a certified instructor, and are carried by such officers at all times when on duty (13). In our study population, most of the patients referred had been accidentally exposed in the course of their training, or in the line of duty, or purposely exposed as part of their training.

To summarize, we report a number of unlooked-for cutaneous problems associated with CS spray exposure, many of which have had long-term implications. Current information regarding the physical and toxic properties of the spray and decontamination procedures is limited and the literature conflicting. The overall benefits of its use must therefore be carefully balanced against potential risks.

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