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Personal defense sprays: Effects and management of exposure

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Abstract

Background: Defense sprays have become quite popular for both police use and personal protection. Officers in more than 2000 law enforcement agencies now carry sprays, and the public spends millions of dollars per year on them. As more and more people carry sprays, it is inevitable that optometrists will be called upon to treat the ocular consequences of accidental or intentional exposure.

Types of Sprays: Most defense sprays contain o-chlorobenzylidene malononitrile (CS), o-chloroacetophenone (CN), oleoresin capsicum (OC), or a combination of these ingredients as the active agent. In addition, they contain propellants such as isobutane and/or propane, along with carriers such as isopropyl alcohol, hydrocarbons, or water.

Management of Exposure: All of the sprays cause significant ocular irritation, lacrimation, conjunctivitis, and blepharospasm. Initial management of spray victims involves a determination that there is no significant systemic distress, followed by ocular irrigation and decontamination. Recovery from the acute effects of the sprays typically takes 30 to 60 minutes; significant consequences of uncomplicated spray exposures are rare.

Effects of Sprays on Contact Lenses: Based on reports from police trainers, rigid gas permeable lenses can be cleaned and reworn after spray exposure. However, decontamination of soft lenses is more problematic. Gas chromatography and mass spectroscopy revealed residual capsaicin in lenses that had been cleaned two times after exposure to a spray containing OC. Therefore, it is recommended that exposed soft lenses be discarded.

Summary: The ocular consequences of exposure to defense sprays typically resolve without complications, and can usually be managed either by a telephone consultation or an in-office evaluation.

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Personal Defense Sprays: Effects and Management of Exposure

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PERSONAL DEFENSE SPRAYS:
EFFECTS AND MANAGEMENT OF EXPOSURE

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KEY WORDS

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INTRODUCTION

It's 4:30 on Friday afternoon and your receptionist tells you that a hysterical patient is on the phone. When you get the patient calmed down enough for intelligent communication, she tells you that her child was playing with a key ring and accidentally sprayed himself in the face with tear gas. The child is screaming and can't open his eyes.

What do you do? Should you tell the mother to call 911 because this is a life or vision threatening emergency? Should she take the child to a hospital emergency room as fast as she can? Or should you tell her to perform some simple first aid measures at home and then bring the child in if symptoms persist? To answer these questions and to formulate management plans for spray exposure cases, an understanding of the composition of the various defense spray products and how they affect the body is required.

PERSONAL DEFENSE SPRAYS

Most of the currently available defense sprays contain CN, CS, OC, or a combination of these as active ingredients.[1] Percentages of active ingredients vary among different brands, but typical concentrations range from 0.5% to 10%.

There is currently a controversy about the most effective concentrations and combinations of active ingredients. Some suggest that higher percentages make sprays more effective. Others suggest that raising the concentration beyond an optimum level does not increase the effectiveness of the product, and might only increase the potential for side-effects.

In addition to their active ingredients, defense sprays contain a carrier in which the active ingredient is either dissolved or mixed, and a propellant. Typical spray canisters range from 1/3 ounce "undercover" sizes to 10 ounce "the neighborhood is going bad" sizes. Figure 1 shows some typical personal defense spray canisters.

Insert Figure 1 about here

Spray Patterns

Products vary with respect to the type of spray pattern produced; the three principle patterns are stream, burst, and mist. A stream nozzle produces a thin stream of the agent; to be effective, it must be aimed directly at the face of the intended target. A burst type nozzle, sometimes referred to as a fogger, produces a dense, focused cloud of aerosol particles. This nozzle dispenses a high volume of agent in a relatively focused area, and does not require precise aiming to be effective. As compared to the burst nozzle, mist or cone nozzles produce a less concentrated, more widely dispersed, cone-shaped pattern.

The maximum direct spray range of personal defense products is generally 2-5 meters, but irritant effects can be produced up to 30 meters away, depending on factors such as canister size and pressurization, nozzle type, and wind conditions.

Manufacturers of some products recommend minimum distances for use of their sprays. These distances typically vary from 1 to 2 meters and represent the distance required for most of the propellants and carriers to dissipate, leaving primarily the

active agent in the spray to make contact with the subject. Increasing distance also lowers the velocity of any large droplets in the spray.

Active Ingredients

The active agents found in personal defense sprays belong to a class of compounds variously referred to as harassing agents, riot control agents, or lacrimators. Their effects are felt almost immediately upon exposure and generally resolve rapidly upon removal of the agent.[2-4] Harassing agents were used extensively during WW I, and have been widely used throughout the world by the police and military for crowd control and special operations since the early 1960's.[5,6]

Most agents in this category are popularly referred to as "tear gas." The term is a misnomer because the agents are not gases but are actually dispersed as aerosols or fine particulate sprays. Another commonly misused term is "Mace®." Mace is the brand name for a specific product containing CN, and should not be used as a generic term for all defense sprays.

Until the last decade, most personal defense sprays contained either CN or CS. More recently, OC has replaced CN and CS as the agent of choice for personal defense use because it seems to be more effective and has less potential for causing toxic side effects or environmental contamination.

A standardized color coding system has been adopted to assist in identifying the active agent in personal defense sprays. The color code is red for CN, blue for CS, and orange for OC. This color code usually appears as a dot or band on the spray canister.

CN

The chemical agent CN (ω-chloroacetophenone) was first discovered in 1869 and was used extensively in WW I.[3,7] At normal temperatures, CN is a white crystalline solid that is only slightly soluble in water, and it is said to have an odor resembling that of apple blossoms.[8,9] CN is classified as a lacrimator because of its ability to cause intense tearing at very low dosages.

CN has been used in personal defense products since the 1920's. Among the first such products were tear gas pens and pistols that used a ballistic device, generally a blank pistol cartridge, to propel solid CN particles at an attacker.[2,6,10] Not surprisingly, numerous mechanical and chemical injuries to the eye resulted from the use of these products.

Unfortunately, reports on the toxic ocular effects of CN from this type of exposure were usually confounded by traumatic injuries from the blast effect of the delivery device, and this makes it difficult to determine with certainty the exact extent of ocular damage resulting from CN exposure. In addition, the blast effect can drive CN into the deeper layers of the cornea or even into the globe.[9-12] Such injuries would not be expected with exposures produced by personal defense sprays.

CN was marketed as a personal defense spray in 1965 by General Ordinance and Equipment Company under the brand name Mace. This product gained wide-spread popularity in the 1960's, and the term Mace is still incorrectly used as a generic term for all aerosol defense sprays.

A possible problem associated with the use of CN for personal defense is that it has been reported to have limited effectiveness against some individuals, notably those under the influence of alcohol or drugs, or those with certain mental disturbances.[13] Additionally, it can take several seconds for CN to achieve its full effect,[2,3] and the person using the spray would be vulnerable to attack during this time.

Exposure to CN at concentrations that might be produced by a defense spray usually results in extreme irritation of the eyes, burning pain, conjunctival hyperemia, lacrimation, and possibly blepharospasm. Concentrations of CN above those usually provided by defense sprays can cause more severe ocular complications including sloughing of the conjunctiva, corneal edema, and keratitis with subsequent risk of scarring. CN has also been reported to be capable of causing neuroparalytic keratopathy.[12]

High concentrations of CN can also cause significant non-ocular effects including respiratory tract irritation, a burning sensation and erythema of exposed skin, irritation and burning of the oral and nasal mucousa, nasal congestion, and cough. Some individuals can experience nausea, vomiting, and headache following CN exposure, and primary contact dermatitis, allergic dermatitis and blepharitis have also been reported.[3,12,14-17]

Extremely heavy exposure to CN (well beyond the levels that could be produced by typical personal defense sprays) can cause severe inflammation of the respiratory tract and cerebral edema. Several deaths have resulted from exposure to extremely high concentrations of CN in confined spaces.[18] The severity of the

effects produced by CN are concentration and time dependent with routine symptoms remitting rapidly after removal of the agent. The more severe pulmonary and cerebral effects are delayed responses which take hours or days after exposure to develop.[2,7,19]

Dispensers containing CN are color coded red.

CS

CS was first prepared in 1928 by Corson and Stoughton, and it takes its designation from the initials of their names. It was further developed by the British as a riot control agent in the 1950's, in part due to dissatisfaction with the performance of CN.[5] CS came into widespread use in the 1960's, and, because of its greater effectiveness and lower potential for toxicity, largely replaced CN as the agent of choice for military and police crowd control missions. Also classified as a lacrimator, CS is a white crystalline substance with an odor of fine pepper. On a by weight basis, CS is approximately ten times as effective as CN.[6,8,9,20]

The effects of CS are similar to those of CN.[21] However, in part due to the lower concentrations required to achieve an equivalent response, CS is less likely to cause significant eye injuries, dermatitis, or toxic systemic effects.[3,22] Although CS exposure has been shown to be capable of causing death in laboratory animals,[5,7,19,23,24] controversy exists over reports of human fatalities directly attributable to the toxic effects of CS.

Like CN, the older literature suggests that some forms of CS can be relatively ineffective against persons under the influence of alcohol or drugs, or who have mental disturbances. It also suggests that CS can take several seconds to achieve its full effect,[2,3] and

this might be a significant concern when CS is used as a defense spray.

Products containing CS are color coded with a blue dot or band.

OC

OC is the newest addition to the list of active agents used in defense sprays. It is a reddish-brown liquid derived from plants of the genus capsicum, commonly referred to as hot peppers or chilies.[25] The active ingredient believed to be primarily responsible for the irritative properties of OC is capsaicin, a white crystalline compound that is virtually insoluble in water.[26,27] At least four separate, naturally occurring homologues of capsaicin have been isolated from pepper plants, the principle form (approximately 70%) being trans-8-methyl-N-vanillyl-6-nonenamide.[1,28,29] A synthetic version of capsaicin is also available which might have physiological effects somewhat different from the naturally occurring capsaicinoids.[30]

In addition to capsaicin, OC contains over 100 distinct volatile compounds which might interact to produce effects significantly different from pure capsaicin.[30] Since OC is a plant derivative, its exact chemical composition varies with the type of pepper used, its age, the parts of the plant from which the extract is obtained, and numerous other factors.[25,30] As a result, the Scoville Heat Unit (SHU) is often used to compare the relative potency of OC products. Using this system, pure capsaicin is rated at 15 million SHU's; the OC found in personal defense sprays typically has a rating of about 1.5 million SHU's.

Personal defense sprays containing OC were first developed in the 1970's as an alternative to CN and CS sprays, and have gained widespread acceptance by law enforcement agencies and the public. The manufacture and use of OC sprays increased dramatically following the 1989 publication of a favorable three year FBI study on the use of CAP-STUN®, an OC based product. In the FBI study, over 800 subjects were either sprayed directly in the face with aerosols containing from 1% to 5% OC or were exposed to 1% to 10% OC disseminated from aerosol grenades in an enclosed space. No long-term adverse medical effects were noted in either situation, and no medical treatment was required by any of the subjects.[a]

Following release of this study, the use of OC sprays became so popular that a 1992 Washington Post article reported over 2000 law enforcement agencies were using pepper sprays.[31] The popularity of OC sprays has now increased so much that current industry estimates indicate at least 15 million defense spray canisters (a majority containing OC) were manufactured in the three year period from 1992 through 1994.[b]

One of the reasons for the widespread acceptance of OC sprays is the fact that they overcome some of the problems associated with CN and CS products. Specifically, the OC sprays are effective in producing immediate blepharospasm and incapacitation of almost all subjects including those who are intoxicated or mentally ill,[32] and they are also effective against animals. Beyond these advantages, there are no known long-term toxic effects produced solely by the topical application of OC, and there are no environmental contamination problems associated with its use.[32]

When applied topically, capsaicin produces an immediate inflammatory reaction in mucous membranes. In the eye, it produces blepharospasm probably caused by irritation of corneal nerves, extreme burning pain, lacrimation, conjunctival edema, and hyperemia. In animal studies, it has also been shown to produce miosis and aqueous flare.[33]

In the nasal mucousa, capsaicin produces burning pain, sneezing, and a dose dependent serous discharge.[34,35] Contact with the skin produces burning pain and erythema without vesiculation.[36] Capsaicin inhalation results in transitory bronchoconstriction, cough, and retrosternal discomfort.[37-40] In dogs, direct administration of extratracheal capsaicin aerosol has been shown to produce apnea, bradycardia, and hypotension.[41]

To date, no substantiated cases of human death resulting strictly from OC sprays are known. However, several cases of in-custody deaths following exposure to pepper sprays have been widely publicized. In these cases, positional asphyxia and/or prior drug use were generally implicated as the direct causes of death.[42]

Products containing OC are coded with an orange stripe or dot.

Combination Products

For marketing purposes, or to increase their effectiveness, some personal defense sprays contain a combination of the active ingredients described above. Most commonly, CS or CN is combined with OC in these products.

Carriers

In addition to the active ingredients, personal defense sprays contain some form of carrier vehicle in which the active ingredient

is dissolved or suspended. Common carriers include alcohol, water, organic hydrocarbons, and methylene chloride.[32,43] In addition to keeping the active ingredient in an appropriate state for aerosol dispensing, the carrier can also increase the effectiveness of the spray by improving penetration, removing skin oils, or prolonging contact time. If they reach the eyes, some carriers can also cause temporary ocular irritation or superficial keratitis.

Propellants

The third component in personal defense sprays is the propellant used to expel the active ingredient from the canister. Commonly used propellants include propane, butane, and compressed gases (e.g., carbon dioxide or nitrogen).[43] Virtually any propellant found in common household aerosol products can be used in personal defense sprays.

Legal Aspects of Personal Defense Spray Possession and Use

In 1994, 49 states and the District of Columbia allowed citizens to possess some or all types of personal defense sprays. New York is the only state that specifically prohibits all types of sprays that contain "tear gas."[44] Information on those states known to have restrictions on who can carry, purchase, or sell defense sprays is shown on Table 1.

Insert Table 1 about here

Federal laws prohibit the transportation of defense sprays on commercial aircraft.[44] The reason for this prohibition is obvious;

given the fact that most aircraft recirculate a considerable percentage of cabin air, a leaking or ruptured canister could incapacitate the flight crew as well as passengers.

Although no state is known to have laws requiring that use of a defense spray must be formally reported to the police, reporting the circumstances of such a use would never-the-less be advisable. It is also advisable for health care providers treating spray expsure cases to consider making a formal or informal report of the treatment to the police, especially if it is suspected that a "hostile" spray exposure occurred.

EFFECTS OF OC SPRAY ON THE EYES

Many police departments provide defense spray training classes for their officers and members of the public in which volunteer officers are sprayed with OC. To assess the effects of OC on acuity, corneal integrity, and conjunctival appearance, a total of 22 subjects participating in two separate police training sessions were evaluated.

The first training session was conducted on a warm, dry day. During this session, 13 subjects were examined before and after being exposed to a training spray containing methyl salicylate (wintergreen) in place of the OC, and to a product containing 5% OC (Punch II, manufactured by AERKO International, Inc., Ft Lauderdale, FL) (Figure 2).

Insert Figure 2 about here

After being sprayed with the Punch II, all 13 subjects experienced immediate and intense blepharospasm, conjunctival injection, burning pain, mild respiratory difficulties, excessive mucus secretion, and incapacitation. These effects were transient and lasted between 30 to 45 minutes. Figure 3 shows a typical example of conjunctival injection 15 minutes after exposure to the spray. The injection resolved in about 60 minutes.

Insert Figure 3 about here

Visual acuity was measured approximately 15 minutes after spray exposure and was unchanged from pre-exposure levels for all subjects. The corneas of 10 of the 13 subjects showed no epithelial staining or edema as a result of spray exposure. However, the corneas of 3 subjects who had been sprayed using burst nozzles showed several 1 to 2 mm diameter areas of superficial epithelial fluorescein staining that resembled water spots. (Figure 4) These epithelial defects resolved completely within 24 hours without treatment.

Insert Figure 4 about here

To determine the source of the water spot staining, video tapes of the training session were reviewed. They revealed that in many cases the subjects had been sprayed with the methyl salicylate training units from distances considerably closer than the minimum of 1 to 2 meters recommended by the spray manufacturer.

Accordingly, there was an increased potential for large droplets of the spray carrier to come in contact with the subjects' eyes. Both the methyl salicylate and OC spray units contained isopropyl alcohol as a carrier. This can be of significance because isopropyl alcohol is toxic to corneal epithelial cells.[45-47]

To help in determining whether the OC, the alcohol carrier, or possibly the methyl salicylate in the training spray units had caused the staining, AERKO International, Inc. provided an aerosol containing only the carrier (isopropyl alcohol) and the propellant (isobutane). Examination of a subject exposed to this spray from a distance of approximately 80 cm revealed water spot staining similar to that previously noted. This suggests that the staining was produced by components in the spray other than the methyl salicylate or the OC.

To further evaluate the cause of the staining, 9 subjects at a second police training session were examined. This session was conducted on a cold and wet day, and had two phases: an exercise involving exposures at relatively short distances (30 to 150 cm) to burst type training sprays containing methyl salicylate in place of the OC, and an exercise involving exposures at longer distances (1.5 to 2.0 meters) to burst sprays of Punch II containing OC. Following the first exercise, 8 of the 9 subjects had superficial epithelial defects, most of which had a water spot appearance. For the 8 subjects who had staining, no additional corneal defects were noted following the second exercise during which Punch II spray containing OC was used. However, the ninth subject who had no staining after exposure to the training spray did have several water spots on one

eye after exposure to the OC spray. None of the subjects experienced any acuity reduction as a result of spray exposure, and all recovered from the acute effects of the OC within an hour after being sprayed. Twenty-four hours after spray exposure, none of the subjects reported any ocular or systemic problems; the epithelial defects had presumably resolved without sequelae.

It is interesting to speculate on why only 3 of the 13 subjects in the first session showed staining, whereas 8 of the 9 in the second session had epithelial defects. The reason might be that the high-volume burst nozzles were used for all subjects in the second session, but only for some of the subjects in the first session (all of the subjects in the first session who showed staining had been sprayed with burst nozzles). It is also possible that the sprays were administered from closer distances in the second session, or that the cold weather prevented the alcohol carrier from dissipating before the spray contacted the subjects' eyes. Whatever the reason, it is clear that when burst type sprays are administered at distances shorter than those recommended by the manufacturer, spray components other than the OC can cause superficial corneal epithelial defects.

IMMEDIATE MANAGEMENT OF SPRAY EXPOSURES

Though frightening, the direct result of defense spray exposure is rarely serious or life threatening. Anxiety, fear, and disorientation, sometimes to the point of panic, are normal reactions in untrained individuals,[3,6,32] therefore providing reassurance is a valuable part of any immediate intervention. Victims should be moved away from any continuing source of

exposure, and then checked for signs or symptoms of serious systemic distress such as cardiac or respiratory problems beyond those typically associated with spray exposure. Transient and self-correcting increases in blood pressure and heart rate can be expected as a result of anxiety,[6,48,49] but it is also possible that pre-existing cardiac or respiratory conditions could be aggravated in susceptible individuals.[6,19,32]

The goal of immediate aid is to make the patient more comfortable and speed the recovery from spray exposure; however, almost all patients will recover completely in an hour or less, even if no aid is provided. (First aid procedures are summarized in Table 2.) Although the risk of complications is low, patients should be advised that problems could develop and should be instructed to seek further aid if unexpected signs or symptoms occur.

Insert Table 2 about here

Patient Decontamination

The emphasis in immediate treatment is to remove the source of irritation. Simply guiding the patient to an uncontaminated area and allowing fresh air to circulate over exposed areas will assist in recovery. Increasing circulation by fanning the exposed area will also speed the process. Contaminated clothing should be removed and bagged in plastic until it can be cleaned or discarded. Then the affected skin and mucous membranes should be irrigated with copious amounts of cool water to help soothe the burning sensation and flush away spray residual. If the patient was sprayed with CS,

irrigation can result in temporarily increasing the burning sensation, but it should still be attempted. With any spray exposure, patients should avoid rubbing affected areas because this tends to spread any residual agent and work it into open pores.[12,19,21,23,50,51]

In field situations, police officers use a technique in which a person exposed to OC places their face in a full pail of water and attempts to open their eyes. (Figure 5) A hose is used to provide a continuous flow of fresh water into the pail. This helps prevent recontamination from the oily OC residue on the surface of the water since it is removed with the overflow.

Insert Figure 5 about here

Washing the face and eyelids with a mild, oil-free soap (e.g., Ivory) will help break down the oily OC resin and speed its removal from the skin. After any spray exposure, the skin should be blotted dry rather than rubbed and care should be taken to avoid recontamination from used towels.

As the symptoms abate and the patient is able to open the eyes, it is helpful to irrigate the upper and lower palpebral cul-de-sac because spray residuals tend to collect in these locations and become entrapped. If the patient is wearing contact lenses, they should be removed at this time.

Environmental Decontamination

No special decontamination procedures beyond laundering and/or exposure to fresh air are required for removal of OC from

clothing. Simple aeration of contaminated areas and materials for 45 minutes is reported to adequately disperse any residual OC from defense spray exposure.[32,43] Decontamination procedures for CN or CS formulations that might be found in personal defense sprays should also include laundering and aeration.

Procedures required for decontamination of environmental areas such as houses or cars exposed to CN or CS are dependent on the degree of exposure and the agent used. The quantities of CN or CS that would normally be generated by the use of a personal defense spray should require no more than aeration to remove any perceptible residue. Decontamination following extremely heavy exposures to CN or CS (beyond the levels that might be expected from the use of personal defense sprays) could be more of a problem. Although not considered to be a persistent agent, CN in formulations and high concentrations that might be delivered by pyrotechnic devices (e.g., gas grenades) can penetrate plaster and rubber-based products resulting in long-term contamination of vehicles or homes. Residue in furniture, carpets, and other fabrics can be neutralized by treatment with alkaline solutions and steam,[8,51] but this process could require the services of professionals.

CS is somewhat more persistent than CN and very heavy concentrations (again beyond the levels delivered by personal defense sprays) can be absorbed into most porous surfaces. Decontamination of clothing, homes, and vehicles contaminated by CS can be difficult and is best accomplished by using strong alkaline solutions or sodium hypochlorate with steam.[8,51] As with CN,

professional services could be required for comprehensive decontamination.

Decontamination of Contact Lenses

It is inevitable that patients wearing contact lenses will be exposed to defense sprays. Obviously, the lenses should be removed as quickly as possible following spray exposure, but there is a question about whether lenses can be decontaminated. Reports from police training exercises indicate that although rigid lenses can be cleaned and reused with no ill effects, soft contact lenses might retain sufficient contamination to make them unwearable.

Two previous studies have addressed this issue and found that soft lenses exposed to CN and CS did not retain any residual contamination. In fact, it was suggested that the lenses might even have provided some corneal protection for the wearers.[52,53] Unfortunately, the studies do not specify how the lenses were analyzed for residual contamination, and, therefore, do not provide a definitive answer regarding the ability to decontaminate soft lenses exposed to CN or CS.

To address the question of soft lens decontamination following OC exposure, samples of Punch II spray containing 5% OC and lenses representing each of the four FDA soft contact lens groups (CIBAsoft®, Bausch and Lomb 70®, DuraSoft 2®, and NewVues®) were furnished to the Bausch and Lomb Contact Lens Division for analysis. After exposure of these lenses to 2.0 second OC sprays delivered from a distance of approximately 70 cm, samples from each lens group were cleaned two times with MiraFlow®, Ciba Vision Cleaner®, or ReNu® according to manufacturer's instructions.

(MiraFlow was selected as a cleaner because it has an alcohol base and capsaicin is soluble in alcohol; the other cleaners represent brands commonly available.) Following exposure and cleaning, lens residues were extracted with 5 mL of tetrahydrofuran for a minimum of 24 hours, and gas chromatography was used to determine whether there was any residual capsaicin remaining in the lenses.[1] The majority of lenses remained slightly discolored after cleaning, and residual capsaicin was detected, but at fairly low concentrations.[c] It is possible that these concentrations would be too low to cause acute difficulties, but the risk of chronic problems cannot be ruled out. Therefore, it seems prudent to recommend discarding any soft lenses that have been exposed to OC. Although the ability to decontaminate lenses exposed to CN or CS was not specifically evaluated, soft lenses exposed to these agents should also probably be discarded.

IN-OFFICE MANAGEMENT OF SPRAY EXPOSURE PATIENTS

Some spray exposure patients will require an in-office evaluation. These patients could simply be concerned about the possibility of ocular damage or might be suffering from corneal, conjunctival, or dermatologic symptoms beyond those normally expected.

If at all possible, patients presenting for in-office examinations should be decontaminated prior to arrival; this will preclude exposure of other patients or office personnel.[23] It has been shown that residual contamination which does not affect the patient can still cause acute reactions in previously unexposed personnel.[54]

Examination of a spray exposure patient should follow a pattern similar to an examination for any chemical exposure, and should include history (with special emphasis on any potential legal issues regarding the circumstances of the exposure), acuity measurements, external evaluation of the eye and adnexa, and slit lamp evaluation of the anterior segment. Additional irrigation might be required if the patient complains of discomfort or if spray residual is detected. During the examination, practitioners and staff should wear gloves to prevent contamination and transfer of spray residual.[6,54] Even in the absence of a burning sensation on the skin, spray residue can still cause irritation of mucous membranes.[55] For this reason, patients should be cautioned that even after thorough washing, exposed fingers can still cause significant irritation if they touch mucous membranes.

After the examination, office equipment that has come in contact with the patient should be thoroughly cleaned before reuse.

Complications Associated with Exposure to OC

Complications resulting from OC exposure appear to be quite rare. Despite its widespread usage, the lack of case reports in the medical literature involving OC sprays substantiates this. In fact, studies involving application of pure capsaicin directly to the human cornea have shown that it does not cause damage.[56] However, as previously noted, OC contains over 100 volatile compounds in addition to capsaicin, and some of these could conceivably affect the cornea.

Corneal trauma not related to the OC itself can result from eye rubbing following exposure, vigorous irrigation, or from the effects

of other spray components. Corneal exposure to an alcohol carrier could result in significant corneal epithelial erosion that might require treatment.

Management of any mechanical trauma accompanying the spray exposure should be based on presentation and could require the use of topical anesthetics, antibiotics, cycloplegics, topical corticosteroids, and/or pressure patching as appropriate. Topical antibiotic prophylaxis should also be considered in any case of corneal epithelial damage in which non-sterile irrigating solutions were used for first aid.

Although unlikely, OC spray exposure could result in dermatologic reactions on the face and eyelids. Repeated, prolonged exposure to capsicum extracts (e.g., in persons whose work requires them to handle peppers daily) is known to cause contact dermatitis, and numerous substances, including topical steroids, have been suggested to alleviate the symptoms or promote healing.[55,57-59] Only a single case of allergic dermatitis has been reported following exposure to a defense spray containing OC.[60]

Complications Associated with Exposure To CN

In cases of limited exposure to CN, such as would be produced by defense sprays, there is only a slight risk of complications. However, animal studies and human case reports have suggested that excessive or improper use of CN aerosols might cause ocular damage. For example, heavy or prolonged exposure, or application of sprays from close distances (e.g., at less than 2 meters) can result in loss of corneal epithelium, stromal edema, and iritis.[5,10,45,61-63] Beswick notes that a short-term rise in intraocular pressure can

occur as an infrequent consequence of exposure to riot control agents,[6] and Berger, et al, reported a single case of persistent elevated IOP in a police officer who experienced long-term systemic exposure to CN from a leaking canister of Mace.[64]

Evaluation of spray victims should also include examination of the skin around the eyes. CN has been shown to be a potent sensitizer, and contact or allergic dermatitis resulting from repeated exposure to it are well documented. Penneys reported that after initial sensitization, subsequent contact with CN exceeding one minute in duration could result in dermatitis.[15]

Treatment of allergic blepharitis or dermatitis involving the ocular adnexa might require the use of topical corticosteroids and/or oral antihistamines depending on severity.[3,50]

Complications Associated with Exposure to CS

As with OC and CN, complications associated with single exposures to CS from defense sprays are rare. Several studies have found no long-term ocular problems following application of this agent.[65-71] The ocular pain associated with exposure usually subsides within minutes after removal of the agent, but the conjunctivitis can persist for up to 30 minutes.[2,3]

Although not as potent a sensitizer as CN, CS can cause allergic blepharitis and contact dermatitis.[22] Severe exposure might even result in blistering of the skin.[3,24] Irrigating the skin with solutions in the pH range of 9-10 can help neutralize CS contamination,[21,24,50] but caution should be exercised if any of these neutralizing solutions are used near the eyes because they can cause corneal damage.[24]

SUMMARY

At least 15,000,000 Americans now carry personal defense sprays, the majority of which contain OC. The ubiquity of these sprays makes it almost certain that optometrists will be called upon to render first aid and/or office treatment for spray victims.

When providing first aid, it is important to keep several things in mind. First, potential helpers should avoid being contaminated by the active agent in the spray; it is difficult to help a spray victim if the rescuer is experiencing blepharospasm or ocular distress. Next, remember that moving the victim to an uncontaminated area and irrigating the affected areas with sterile saline or cool water will help speed recovery from the spray effects. Whether first aid is available or not, however, the vast majority of spray victims will recovery in an hour or less with no complications.

When complications do arise, they are usually caused by excessive or prolonged exposure, mechanical trauma, or pre-existing health problems. In these cases, emergency medical care or an office examination to check for ocular damage is appropriate. Such problems would be unlikely in simple cases of exposure to an OC spray, and only slightly more likely to occur with exposures to CN or CS sprays.

Office personnel should be taught to evaluate, reassure, and triage spray victims by telephone. Patients experiencing significant systemic problems (e.g., cardiac or respiratory) should be assisted in contacting emergency medical personnel. Others should be instructed to irrigate the affected areas with sterile saline or cool water while taking care not to recontaminate themselves with spray

residue from the irrigant. They should also be instructed to remove any contact lenses as soon as they are able to do so in a manner that will not recontaminate the eyes. Spray exposure patients should be contacted every 15 minutes for at least an hour to assure that decontamination and recovery are progressing normally.

During triage, it should also be determined whether the spray contained OC, CN, or CS because the possibility of complications is slightly higher with CN or CS. Finally, if after one hour recovery is not essentially complete, or if concerns regarding possible complications warrant it, the patient should be seen in the office for any required follow-up care.

In general, exposure to personal defense sprays is a painful, traumatic, and extremely unpleasant experience, but it is neither life or vision threatening. This fact should be kept in mind when rendering aid to spray victims.

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Dr. Lee was an officer in the United States Army Medical Service Corps. and a Masters student at Pacific University College of Optometry during the time this project was conducted.

The views expressed are those of the authors and do not necessarily reflect the views of the Departments of the Army or Defense. The Government is authorized to reprint copies of this paper, notwithstanding any copyright notice hereon.

FOOTNOTES

a. Sections of undated Department of Justice FBI reports entitled "Chemical Agent Research: Oleoresin Capsicum," and "Oleoresin Capsicum Training and Use."

b. Personal communication from Mr. Kevin Dallett, Vice President, AERKO International, Inc., Fort Lauderdale, FL, December 1994.

c. Personal communication from Dr. Frank Tasber, Bausch and Lomb, Inc., Rochester, NY, December 1994.

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TABLE 1

STATE LAWS REGARDING DEFENSE SPRAYS

(Information in this Table is derived and modified from a Table supplied by R.E.B. Security Training, Inc. Used by permission.)

Listed below are the states that have significant restrictions on the sale, purchase, and possession of self-defense sprays. For further information and to verify that these laws are still current, please contact your local police.

California: OC was recently approved for certified civilian use. Certification can be obtained by watching a video or passing a short exam. OC containers must also pass certain size and shape requirements.

Massachusetts: Any "tear gas" product is classified as ammunition. In order to purchase tear gas, a permit to purchase and carry the item must be obtained from any Chief of Police or similar officer. The buyer must be 18 years old and have a Firearms I.D. or Massachusetts license to carry hand guns.

Michigan: Use of tear gas for protection of person and property in sizes no larger than 35 grams is permitted.

Nevada: Products containing OC appear to be excluded from prohibitions. Aerosol products containing up to 2 oz. of CS are permitted for personal defense use.

New Jersey: Civilian use of tear gas in sizes no larger than 3/4 oz. is legal.

New York: It is illegal to possess any "noxious" material. This includes tear gas, but the law is vague. Violation of the statute is a Class B misdemeanor.

Washington, D.C.: Possession and use of aerosol propelled self-defense sprays (CN, CS, and OC) by persons 18 years of age or older for defense of a person or a person's property has recently been approved. The spray must be registered at the time of purchase.

Wisconsin: The possession and use of OC-pepper spray for self-defense has recently been approved. Possession and sale of all other tear gas products remains illegal. Persons must be over 18 years of age to possess or use OC sprays. Various concentration, size, range, appearance, and packaging restrictions exist.

TABLE 2

SUMMARY OF FIRST AID PROCEDURES FOR SPRAY EXPOSURE

1. Calm the patient.
2. Move the patient to fresh air and/or provide adequate ventilation.
3. Check for acute pulmonary or cardiac complications arising from aggravation of pre-existing conditions, or from trauma. If present, call for emergency medical personnel.
4. Flush affected areas with copious amounts of cool water. Irrigate the eyes with sterile saline if available. Skin should be washed with non-oil based soap if available.
5. Remove contaminated clothing and contact lenses.
6. Monitor. Significant improvement should be noted within 15-30 minutes after exposure. If symptoms persist or are severe, the victim should be evaluated by appropriate medical personnel.
7. Provide comprehensive ocular evaluation and treatment as for any suspected chemical injury.
8. Remember that the patient will recover even if no first aid is provided, so avoid "heroic" measures that could cause iatrogenic injury.

FIGURE CAPTIONS

Figure 1. Typical personal defense spray canisters.

Figure 2. Police training exercise showing use of a defense spray. (Photo courtesy of Mr. Paul Wilson, PW Distributing Inc., Salem, OR.)

Figure 3. Conjunctiva 15 minutes after exposure to 5% OC spray.

Figure 4. "Water spot" staining following exposure to a training spray administered from a distance of approximately 80 cm. This spray did not contain OC or methyl salicylate. Spots were probably caused by the alcohol carrier in the spray.

Figure 5. Field decontamination of a spray exposure subject during a police training exercise.

Figure 1. Typical personal defense spray canisters.

Figure 2. Police training exercise showing use of a defense spray.

Figure 3. Conjunctiva 15 minutes after exposure to 5% OC spray.

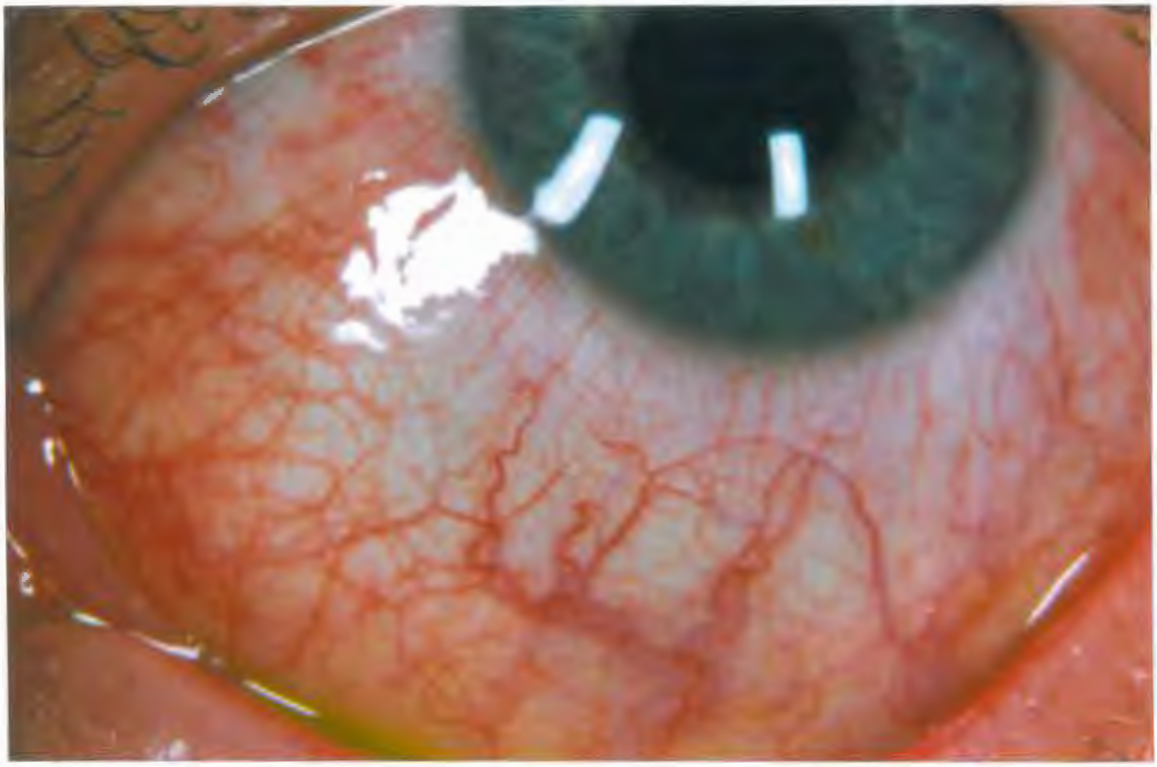

Figure 4. "Water spot" staining following exposure to a training spray administered from a distance of approximately 80 cm. This spray did not contain OC or methyl salicylate. Spots were probably caused by the alcohol carrier in the spray.

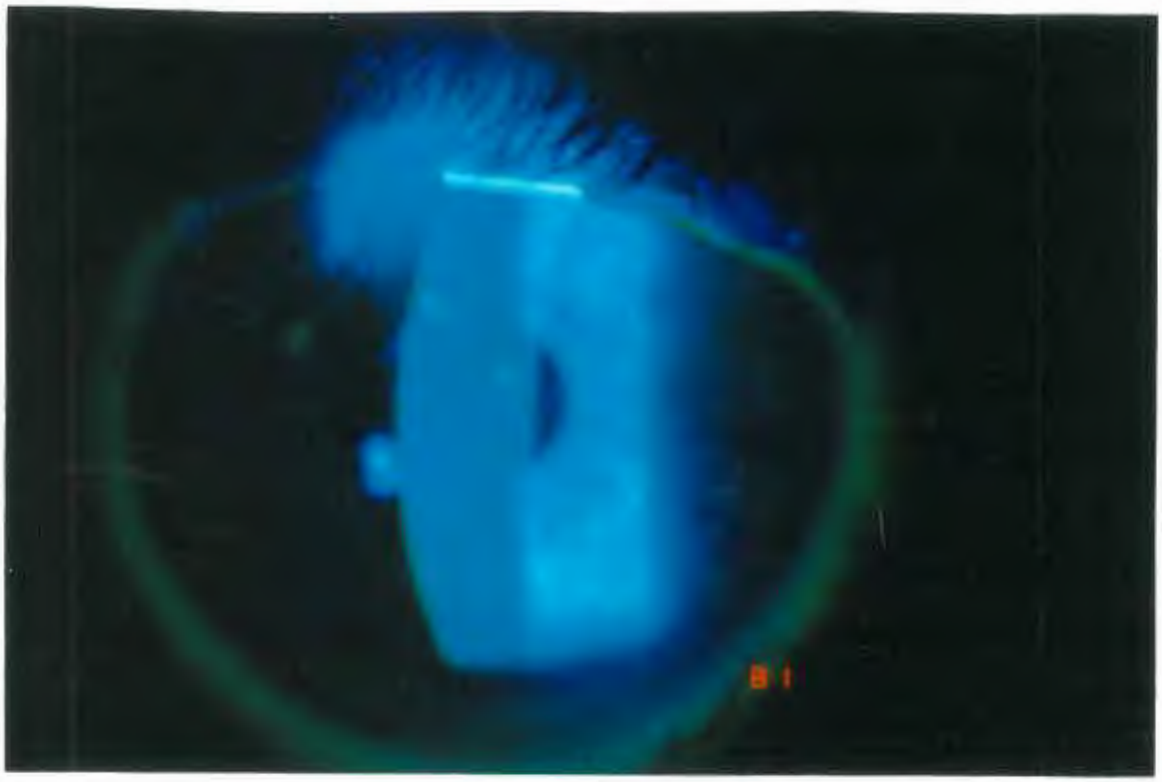

Figure 5. Field decontamination of a spray exposure subject during a police training exercise.

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