CHEMICAL CROWD CONTROL AGENTS

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Introduction

Safe and effective chemical restraint for large numbers of individuals is more challenging than restraining the individual. The goal of restraint of large numbers is to control the crowd by encouraging dispersal into smaller, less threatening numbers. Agents used should have almost immediate effects in low concentrations. The agent should be noxious enough that exposed individuals are quickly aware of their exposure. It should also be noxious enough that those exposed should be motivated to leave the area quickly or follow other commands from law enforcement officers. Injury to the crowd, bystanders, and law enforcement officers from the agent should be minimal. The effects of exposure should be short-lived and readily reversible. The agent should have a short half-life and should be easily degraded, minimizing environmental contamination. There are a few agents that meet these criteria, and their use is discussed in this article.

Chemical restraint methods have been used throughout history. Early forms included drifting clouds of arsenical smoke used by Hunyadi in 1456, arsenical projectiles used in 1672 by the Bishop of Munster's soldiers, and the use of hypnotics by the Danes against King Duncan I in the eleventh century. Even in these early times, weather and wind conditions were appreciated so that the offensive was not to be affected by the agent used. Despite references made to these agents, the best historical account of chemicals used as restraint or for war is from World War I.

Modern chemical crowd control agents were first employed by the French in 1912 when the Paris police used ethylbromoacetate (EBA) against violent offenders. In the early months of World War I, the French launched chlorobenzylidene (CS: tear gas) grenades against the German army. In addition to CS, World War I also introduced chlorine gas and mustard gas, which caused significant morbidity and mortality and resulted in the development of precursors of modern personal protective equipment and riot gear used by law enforcement personnel.

Over the years, chemical restraint agents for control of the individual or crowds have become less lethal and safer than earlier compounds. The three most commonly used agents are chlorobenzylidene (CS), oleum capsicum (OC), and chloracetothenon (CN). Modern incendiary devices and other dispersal methods have made these compounds useful for restraint of the individual violent offender and for mass dispersal for crowd control. There are, however, concerns about the use of these agents by law enforcement officers. These concerns include their possible toxicity to the offender, potential for exposure to the person administering the agent, the potential for any ancillary exposure to healthcare providers or to bystanders, the expansion of their use to nonviolent offenders such as peaceful protesters, and concern about the long-term effects from repeated exposure and from occupational exposure. Some of these issues become more complicated as chemical control agents are increasingly popular with civilians as readily available, often legal, nonlethal, self-defense weapons.

There have been several well-publicized incidents that question the appropriateness of the use of chemical crowd control agents. In one reported incident in the USA, law enforcement officers applied OC liquid via a cotton-tipped applicator directly to the periorbital area of protesters who were illegally trespassing.

The protesters were linked together and refused to disperse. The use of OC against these nonviolent offenders when other methods of control failed generated negative publicity and resulted in legal action against the law enforcement officials. Law enforcement officers opted for this type of application so that exposure to others would be limited rather than to disperse an aerosol in the enclosed space occupied by the protestors.

When used appropriately, crowd control agents have a good safety margin and generally do no permanent harm. In addition to the debate over the agents themselves, there has been some concern over the safety of the delivery vehicles, particularly methylisobutyl ketone (MIBK). While chronic exposure to MIBK has been associated with neurological and respiratory effects, there are no data to support the theory that acute exposure to the low concentrations that occur with CS spray poses these same problems. Flammable compounds used as early vehicles have largely been replaced by water-soluble, less toxic vehicles. Despite all of the controversy surrounding chemical control agents, they offer a less hazardous method of restraint than other potentially lethal alternatives such as firearms. Because some agents can be used from a distance, they provide a method of control for the law enforcement officer without direct contact with a potentially violent individual.

Clinical Features and Treatment

As mentioned above, the three main chemical restraint compounds are OC, CN, and CS. These agents are available in varying concentrations, with several vehicles, in aerosols or foams, and in particulate form with dispersal devices. Some of these are listed in Table 1.

Essentially a means of nonlethal chemical warfare, chemical crowd control products are used as defensive agents to incapacitate individuals temporarily, or disperse groups without requiring means that are more forceful. The clinical effects are short-lived once exposure has ended. These agents share common effects, including lacrimation, ocular irritation and pain, dermal irritation, blepharospasm, conjunctivitis, transient impairment of vision, and mild to moderate respiratory distress. Some corneal defects after exposure have been noted, but whether this is a direct tissue effect of the agent or a result of rubbing the ocular surface is unknown. Contact dermatitis and periocular edema can also result. There have also been reports of allergic reactions to either the compounds themselves or the vehicles used for dispersal. Other more severe effects such as pulmonary edema have been documented when concentrations are several hundredfold above what produces intolerable symptoms or with trauma associated with the explosive device used to deliver the chemical agent.

All of these clinical effects produced by chemical crowd control agents render the recipient temporarily unable to continue violent action or resist arrest. Since they all share a high safety ratio, are effective at low concentrations, and can be used without direct forceful contact by the law enforcement officer, they are ideal agents either for control of the individual offender or for riot control. Because of their relative safety, these agents are generally excluded from international treaty provisions that address chemical weapons. The USA, UK, Ireland, France, China, Korea, Israel, and Russia are just some examples of countries that utilize these compounds as crowd control agents. The legal availability to law enforcement officers and the general public differs between countries; however, most can be easily obtained through international markets or ordered on the internet.

Chemical restraint compounds differ from most agents because some, such as CS, are solid particles with low vapor pressures. They are usually dispersed as fine particles or in a solution. For large crowds, “bombs” have been developed that can be dropped from aerial positions, producing wide dispersal of the compound. They are also formulated in grenades or canisters that can be propelled by either throwing or with a projectile device. The most common method of dispersal is by individual spray cans that deliver a stream, spray, or foam containing the agent. These individual dispersal units were designed to render

Table 1 Examples of chemical restraint products available

Brand name	*Ingredients*	*Delivery system*
Cap-Stun	5% oleoresin capsicum	Spray
Alan’s Pepper Spray	10% oleo capsicum pepper	Spray
Pepper Foam	10% oleo capsicum	Foam spray
Pepper Gard, Triple Action Spray	10% oleo capsicum plus 10% chlorobenzylidene	Spray
Mark III	5% oleo capsicum plus 5% chlorobenzylidene	Spray

immediate incapacitation to an offender without the use of more forceful methods. Canisters containing a lower concentration of the active ingredient have been marketed to civilians for personal protection. Since there is no formal training for civilians on the use of these devices, there is a significant risk for exposure to the users as well as bystanders.

There are different spray patterns available for practicality of use. A full cone spray pattern is usually a formulation of microscopic droplets that allows a wide dispersion pattern of delivery of the agent. This wide dispersion makes it easy for agent delivery from a distance of 1–3 m (3–8 ft). Full cone sprays are more likely to be affected by wind conditions and generally do not have as many bursts per canister as other delivery systems.

A ballistic stream spray pattern is a concentrated stream that can be used effectively from distances as short as 1 m (3 ft) to as far as 4 m (12 ft). This spray pattern, while having a fairly long range of effectiveness, allows for accuracy in selecting the target while minimizing the risk of contaminating other subjects.

A foam formulation has a greater skin or surface adhesion than other formulations and also reduces cross-contamination. Its effective range is 1–2 m (3–5 ft). A foam product is appropriate for climate-controlled environments and enclosed spaces where contamination of bystanders is likely. An additional benefit of the foam formulation is that it is easy to see the application, especially in low-light conditions.

A fog delivery system uses a full cone spray but is adapted to disperse the chemical agent over a large area, typically an outdoor area. It can contain up to 0.454 kg (1 lb) of agent, and has a range of 2–5 m (6–15 ft). It is not indicated for use in confined spaces or where there are large numbers of bystanders.

Oleum Capsicum

OC or pepper spray (PS) selectively stimulates nociceptors in exposed mucous membranes, releasing substance P, bradykinin, histamine, and prostaglandins. The physiologic effects of these mediators result in vasodilation, increased vascular permeability, pain, and altered neurotrophic chemotaxis. Other common symptoms are listed in Table 2. The effects of OC are generally short-lived. The most common effects are a burning sensation and erythema at the site of contact. The effects of exposure can abate without treatment or anecdotally can be shortened by the direct application of baby shampoo followed by irrigation with water. Baby shampoo directly into the ocular area

Table 2 Common clinical findings with exposure to crowd control agents

Finding	*Chlorobenzylidene*	*Chloracetothenon*	*Oleum capsicum*
Ocular			
Lacrimation	✓	✓	✓
Blepharospasm	✓	✓	
Pain and/or burning	✓	✓	✓
Conjunctival injection	✓	✓	✓
Conjunctival edema	✓	✓	
Photophobia	✓	✓	
Corneal abrasion	✓	✓	✓
Impaired vision	✓	✓	✓
Upper airway			
Pain and/or burning	✓	✓	
Shortness of breath	✓	✓	✓
Increased secretion	✓	✓	
Congestion	✓		
Coughing	✓	✓	✓
Throat irritation	✓	✓	✓
Wheezing	✓	✓	✓
Irregular respiration[a]	✓	✓	
Dermal			
Pain	✓	✓	✓
Contact dermatitis		✓	✓
Blistering	✓	✓	✓
Miscellaneous			
Nausea/vomiting	✓		
Bad taste	✓		
Headache	✓		
Increased blood pressure	✓*		

[a]Initial response thought to be associated with pain.

and to other exposed sites is well tolerated. Thorough rinsing with copious amounts of water helps with decontamination. Reapplication of the shampoo product with repetitive rinsing may be needed.

Capsicum in its pure form is a crystalline material. The oleoresin extract of capsicum contains over 100 volatile compounds that act in a similar manner to capsicum. Because of the variability in the individual components of OC, and variation in quality control, products containing this extract have differences in efficacy. Some products describe the capsaicin amount by percentage in the product while others describe the amount of capsaicin in Scoville heat units (SHU). OC described by percentage may differ from preparation to preparation, since different peppers produce different pungencies or a burning sensation. The most consistent method of characterizing OC preparations is by the SHU, described by the American Spice Trade Association analytical methods. Most are formulated in a propylene vehicle to enhance adherence to the skin surface. PS is the most common spray marketed to civilians for nonlethal, noncontact self-defense. For law enforcement it can be purchased in a variety of sprays or foams, in various concentrations or combined with other crowd control agents such as CS (Figure 1).

Water-based products are used to reduce the use of more flammable solvents. Water-based agents usually have a lower SHU, and are easier to decontaminate. Oil-based products are ideal for formulating into fog dispersal units, tend to have a higher SHU, and are more difficult to decontaminate.

The most common complaint after PS exposure is irritation and pain at the site of exposure. The symptoms are transient, and very few require medical treatment. The most significant adverse effects that have occurred in exposure from law enforcement episodes are corneal abrasions, and these can be treated with topical anesthetics and topical antibiotics. There are no clinical data to support the concept that PS exacerbates pulmonary disease or that patients with reactive airway disease are more sensitive to the effects.

The few reports of severe reactions to PS are exceptions rather than the rule. In general, these cases involve exposure in the very young, or in those with other risk factors for poor outcome. Any compound, when used improperly, can cause severe symptoms. Thus far, severe adverse events after PS exposure have been rare.

Of concern were reports of violent prisoners who died after being sprayed with PS or other chemical restraints and then were physically restrained. It was assumed that the police used excessive force and that the prisoners died from "positional asphyxia" from the restraints or that the chemical agent played a role in their deaths. There is no evidence that PS or other agents cause any type of respiratory effects sufficient to cause death. A review of the circumstances

Figure 1 Examples of individual spray containers containing crowd control agents.

surrounding the deaths of the prisoners who died exhibited characteristics consistent with excited delirium from substance abuse. Other contributing factors, such as obesity, hyperthermia, extreme violence, and measurable cocaine on postmortem analysis indicate other causes of death rather than exposure to a chemical restraint. The lesson from these types of in-custody deaths should be that all violent prisoners, whether or not a chemical agent for restraint has been used, might warrant close monitoring and perhaps evaluation by healthcare professionals. A small population of acutely intoxicated individuals is at risk of sudden death, independent of their treatment. Other causes of death or contributing factors should be investigated in cases such as these.

Treatment of exposure to PS is based on severity of symptoms. The first order of treatment should always be the removal of contaminated clothing. Copious irrigation of affected areas will attenuate the burning sensation. However, one must use caution not to contaminate other sites with the irrigant; for example, washing PS from the hair into the eyes or oral pharyngeal mucosa. As mentioned previously, baby shampoo can help to remove PS from skin and eyes and shorten the duration of its effects. A slit-lamp exam of the anterior chamber is warranted to rule out corneal abrasion in patients who remain symptomatic. If present, the abrasion should be treated appropriately with topical antibiotics, cycloplegics, analgesics, and follow-up.

Dermatitis associated with PS can be managed with topical corticosteroids, systemic antihistamines, and analgesics but these cases are relatively rare. An example of rather severe PS dermatitis and ocular swelling is shown in Figure 2. This particular patient was sprayed during arrest by police officers and brought to an emergency department for evaluation. He was treated with irrigation, systemic antihistamines, and steroids with resolution of his symptoms within 4 days.

Intense ocular and facial burning prevented opening of the eyes for a short period of time. Decontamination after several minutes of exposure was performed using baby shampoo and rinsing with water. Effects abated about 15 min after using this method of decontamination.

Figure 2 Effects of full-face spray of 10% chlorobenzylidene/10% pepper spray before and after decontamination with baby shampoo.

Chlorobenzylidene Malononitrile and Chloracetophenone

CS or tear gas is frequently used by the military and law enforcement officers as a method of controlling both individuals and crowds. The military also uses it during exercises to train personnel in the use of protective equipment. CN, known by its proprietary name Mace, is the oldest of the crowd control agents. CS was developed in the 1950s, and it has largely replaced CN.

CS and CN are both lacrimating agents. CS is usually mixed with a pyrotechnic compound for dispersal in grenades or canisters as a fine particulate that forms the characteristic smoke; CN is usually prepared for aerosol dispersal by individual canisters. Both agents are available in individual containers or large bombs, or they can be dispersed through a handheld aerosolizer. They are formulated with a variety of solvents such as alcohol, ether, carbon sulfide, and methylchloroform or can be dispersed as solid particles. In the USA, a combination of CS (10%) and PS (10%) is used by some law enforcement officers for chemical control.

CS and CN are highly soluble in a variety of agents. When contact with mucous membranes is made, the symptoms described in Table 2 occur. Even though there is a perception of shortness of breath, pulmonary function tests performed shortly after exposure to either agent have shown minimal alterations. Its mechanism of irritation is not fully understood. The effects of CS are thought to be related to the formation of highly irritating chlorine atoms and hydrochloric acid when it comes in contact with water from mucous membranes. CS and CN have also been described as alkylating agents, targeting sulfhydryl groups. In addition, there is some controversy surrounding the production of cyanide molecules at the tissue level with exposure to high concentrations of CS. Regardless, like OC, the effects of CS and CN are usually manifested without permanent tissue injury. Exposure is most often limited as individuals flee the scene. Exposure can be significant if the affected person is forced into a confined space for extended periods of time.

Most of the dispersal methods achieve concentrations far below what is considered to be lethal. Concentrations achieved in close proximity to grenades or other delivery devices or for those who cannot or will not leave the exposure area may be significantly greater. Based on animal studies it is generally thought that a concentration of 25 000–150 000 mg m^{-3} min^{-1}

or 200 mg kg^{-1} body mass represents the median lethal dose for CS. A grenade can generate a concentration of 2000–5000 mg m^{-3} at the center, with concentrations becoming significantly less within a few meters from the center of the explosion.

Like OC, the treatment of CS exposure is based largely on the severity of clinical findings. The majority of patients will fully recover within minutes of removal of the agent and will not require medical attention. The most common lasting complaints are facial and ocular irritation. In contrast to other forms of chemical exposure, irrigating the affected area will only intensify and prolong the effects of CS gas or particles. For patients who require medical evaluation, the first order of treatment should always be removal of contaminated clothing with special attention to eliminating secondary exposure by using protective equipment and not placing a contaminated patient in a confined space. Clothing should be removed outside and placed inside a plastic bag, then bagged again. Blowing dry air directly on to the eye assists in vaporizing the dissolved CS gas. Some clinicians have recommended copious ocular irrigation with sterile saline, although this has been thought in some cases to cause an initial acute increase in ocular irritation. A careful slit-lamp exam of the anterior segment of the eye, including evaluation under the lids, should be done for persistent ocular irritation. If particles have become embedded in the cornea or under the lids, they should be removed. If corneal abrasions are present, a few days of topical broad-spectrum antibiotics, cycloplegics, and appropriate analgesics in addition to close follow-up should be prescribed.

Dermal irritation in the form of burning and blistering can be treated with irrigation, preferably with an alkaline solution other than sodium hypochlorite or common household bleach. Erythema can be common in freshly abraded skin, but resolves 45–60 min after exposure. Contact dermatitis can be effectively treated with topical corticosteroids and/or antihistamines. Typically, dermatitis associated with CS exposure resolves within a few days.

Home remedies such as application of cooking oils are contraindicated and pose an increased risk for irritation and infection. Sodium hypochlorite solutions will exacerbate any dermal irritation and should not be used. Plain soap and water is effective but, in most cases, removal of clothing in a well-ventilated area is all that is needed.

There are conflicting reports about the long-term effects of CS exposure. With an exposure to high concentrations, usually for prolonged periods in a confined space, pulmonary edema, pneumonitis, heart failure, hepatocellular damage, and death have been reported. There are no data to support any claims of teratogenicity. These agents do not appear to exacerbate chronic diseases such as seizure disorders, respiratory disease, or psychiatric illnesses.

The possibility of secondary exposure to healthcare and law enforcement providers exists with the use of chemical crowd control agents. Although published reports are few, effects can be minimized with common-sense practices such as decontamination before the patient is placed in a confined area such as a police car, ambulance, or a confined room in the emergency department. The use of protective personal equipment such as gloves, respiratory and eye protection when appropriate, and careful washing of exposed areas avoids cross-contamination.

The most important considerations in utilizing chemical crowd control agents is that they be used judiciously, in the correct manner, and in place of more forceful means of controlling violent or potentially violent prisoners or crowds. Law enforcement officers should be trained regularly and educated on the appropriate use of agents, their common clinical effects, and the appropriateness of seeking medical care. Medical care should never be withheld from those who request it or those prisoners who have lingering effects. Treatment of exposure is summarized in Table 3. To limit injury or potential

Table 3 Options for treatment for exposure to chemical crowd control agents

Treatment	*Pepper spray*	*Chlorobenzylidene*	*Chloracetothenon*
Removal of contaminated clothing	✓	✓	✓
Ocular irrigation	✓		✓
Dermal irrigation	✓	✓	✓
Alkaline-solution irrigation of skin		✓	✓
Soap and water decontamination	✓	✓	✓
Topical steroids for dermatitis	✓	✓	✓
Systemic antihistamines for dermatitis	✓	✓	✓
Systemic steroids for dermatitis	✓	✓	✓
Topical antibiotics for corneal abrasion	✓	✓	✓
Cycloplegics	✓	✓	✓
Analgesics for pain	✓	✓	✓

liability many police forces regulate the use of chemical crowd control agents by establishing policies to guide their use. One example is the "ladder of force." This continuum describes the sequential increase in force and is used to help guide the use of an appropriate method of restraint. Words are used first, followed by more defensive actions such as chemical agents, batons, and finally firearms. It is important to note that some individuals may require more than one exposure to the agent before the optimum effect is achieved or if the agent has been exposed to extreme environmental conditions or has not been replaced in a timely manner. Use of these agents should be monitored and formal reports filed when they are used. Like all equipment, chemical agents should be stored appropriately and replaced according to the manufacturer's guidelines. These agents afford control of violent offenders with much less risk to life and limb than do firearms, explosives, and battering.

See Also

Injuries and Deaths During Police Operations: Shootings During Police Stops and Arrests; **Restraint Techniques, Injuries and Death**

Further Reading

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