

REVIEWS

CHEMICAL RIOT CONTROL AGENTS: A NARRATIVE REVIEW FOR PREHOSPITAL PROVIDERS

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ABSTRACT

Background: There may be situations in which a prehospital provider may encounter a scene where certain chemical riot control agents (RCA) may be employed as a mode to produce rapid sensory and respiratory impairment during crowd-control operations. Recent years has seen an increase in utilization of RCAs by law enforcement agencies meaning prehospital providers may be called to respond to these situations, underscoring the importance of proper training and a fundamental understanding of the various RCAs that may be employed, their effect on biological systems, and how to protect themselves from secondary exposure in the field. In this review we cover the most common RCAs, their mechanism of action, biological effects and how to protect themselves in the field.

Methods: The PubMed and Cochrane Reviews databases were queried for articles related to protests, riot control agents, emergency medical services, and medical care from inception to January 2026. A narrative review methodology was employed to facilitate a broad overview of the most common RCA used today, their mechanism of action and effects on biologic systems, their potential to exacerbate pre-existing medical illnesses, and specifically how the prehospital providers should protect themselves during contact with these substances.

Results: The most common RCAs are chlorobenzilidinemalononitrile (CS), chloroacetophenone (CN), dibenzyl [b, F]- [1, 4] – oxazepane (CR), and oleoresin capsicum (OC) referred to in aggregate as ‘tear gas’ (CS, CN, CR) or ‘pepper spray’ (OC). Ocular, dermal, respiratory, and GI symptoms are usually mild and self-limited, although more severe reactions can occur. Treatment is focused on the safety of the prehospital provider first and foremost, and then extrication of the patient to a safe area free of exposure to any RCA. Ocular and skin effects are treated with copious irrigation with water, while respiratory and GI effects are treated symptomatically. Most symptoms should subside in 15 to 30 minutes, although persistent symptoms may indicate more serious complications. There is no known antidote to RCA exposure.

INTRODUCTION

The right to protest is inextricably woven into the fabric of a democratic society. The unfortunate reality is that situations may occur where force is deployed, increasing the risk of injury to all present. In this situation, certain chemicals riot control agents (RCA) may be employed as a mode to produce rapid sensory and respiratory impairment during crowd-control operations. The increased frequency of use of RCAs in recent years means

a prehospital provider may be called to respond in these situations, highlighting the importance of having a fundamental understanding of the types of RCAs, how they affect biological systems, the potential to exacerbate pre-existing illnesses, and how prehospital providers can protect themselves from being secondarily affected through exposure in the field. In this review we will present some of the most common RCA used today, their mechanism of action and effects on biologic systems, their potential to exacerbate pre-existing medical illnesses, and specifically how the prehospital providers should protect themselves during contact with these substances.

METHODS

A narrative, rather than systematic, review was chosen to allow for broad interpretation of the literature as it currently stands related to RCAs and prehospital providers. This was chosen in accordance with methodological considerations described in the International Journal of Clinical Practice (Motevalli, 2025). The PubMed and Cochrane Review databases were queried for all peer reviewed publications related to protests, riot control agents, emergency medical services, and medical care from inception to January 2026. "Riot control agents," "tear gas," "EMS," "prehospital," and "riot" were utilized as keywords with relevant articles being chosen for inclusion by senior authors (FR, DD). Citation matching from relevant articles was conducted to ensure seminal studies/reports were not missed.

MOST COMMONLY EMPLOYED RCAs

Table 1 depicts the most commonly employed RCAs (Hotchkins & Clapham, 2024). When discussing these RCAs, they are frequently referred to by their unique 1 to 3 letter military designation. These include dibenz [b, f] – [1,4] oxazepane (CR), chloroacetophenone-one (CN), chlorabenzilidinemalononitrile (CS) and oleoresin capsicum (OC) (Frey et al., 2022). The use of RCAs by law enforcement has been legal since 1975 when Gerald Ford signed executive order 11850, permitting the use of RCAs in selected defensive situations such as controlling rioting prisoners and other potential noncombat situations (Executive Orders, 2016). RCAs are often referred to as 'tear gas' and function by causing irritation to the eyes, mouth, airway, lungs and skin, rendering the recipient temporarily unable to function (CDC, 2024). The designation tear 'gas' is a misnomer as these compounds exist as liquids or solids (e.g. CN and CS are released in the air as fine droplets or particles). Primarily, exposure is through contact with the skin, eyes, or by inhalation, with effects seen within seconds and lasting around 15 to 30 minutes (CDC, 2024). It should be noted there is no antidote for these agents, despite the common myth that pouring milk, particularly in the eyes, can counteract the effects of a RCA ("Preparing for, Protecting Against, and Treating Tear Gas and Other Chemical Irritant Exposure," n.d.).

CN is a white crystalline solid which was popular as a RCA in the 1950s, however due to potential toxicity it has largely been replaced with CR and CS, with CS being the most widely used RCA in the world (Bessac et al., 2009; Frey et al., 2022; Olajos & Salem, 2001). That said, CN is still used in certain instances and is often labeled as 'mace' spray (2-Chloroacetophenone, 2000). CS, discovered in 1928, and is a solid white powder at room temperature (Blain, 2003). It has less deleterious health effects than CN and has largely replaced this agent as a RCA. CR is a yellow solid synthesized in 1962 and, like

CS, is a commonly used RCA (Smith & Greaves, 2002). Pepper spray, also known as OC, gains its name from capsaicin, the active ingredient derived from chili peppers responsible for its irritating effects (Vaca et al., 1996). The concentration of OC in pepper spray ranges from 1 to 15% with the most common concentration of OC identified in RCAs being 2%. Bear spray, often considered to be more potent, has the same concentration of capsaicinoid as pepper spray, but delivers a wider and longer-range cloud to deter a charging animal (Wilder et al., 2023). A common mechanism of RCA deployment is through mixing CS with CR or CN along with a pyrotechnic compound that releases a fog of aerosolized solids upon detonation (Henry, 1998). RCAs may also be deployed as ‘pepper balls’, launched projectiles that release a RCA upon impact (Hu et al., 1989).

BIOLOGICAL EFFECTS OF RCAs

Table 2 shows the clinical effects of RCAs on various organ systems. The primary organ systems affected are the eyes (lacrimation [crying], burning, blepharospasm [abnormal eye twitching], and inflammation), respiratory (rhinorrhea, sneezing, cough, dyspnea,

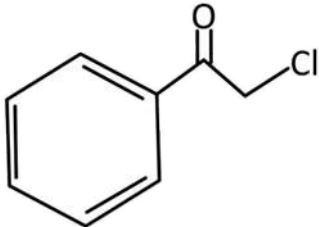
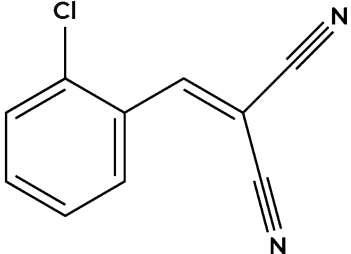
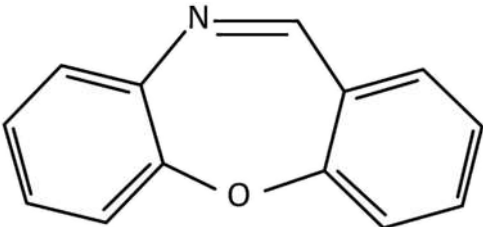
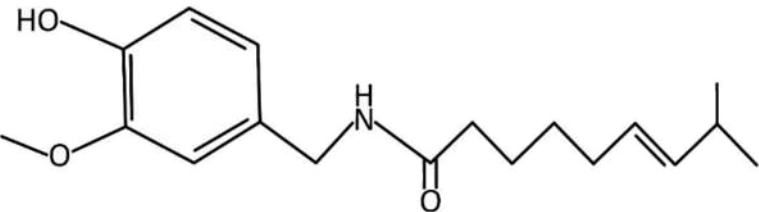
Military Designation	Chemical Name	Common Name	Chemical Structure
CN	2-Chloroacetophenone	Tear Gas	
CS	2-Chlorobenzylidene malonitrile	Tear Gas	
CR	Dibenzo[b, f][1,4]Oxazepine	Tear Gas	
OC*	8-Methyl-N-vanillyl-trans-6-nonenamide (capsaicin)	Pepper Spray (Mace)	

Table 1. Common riot control agents (Hotchkins & Clapham, 2024).
Note: *OC is not a discrete chemical but a mixture of naturally occurring capsaicin compounds. The chemical structure of capsaicin is provided

and pulmonary edema), gastrointestinal (nausea, vomiting, and gastrointestinal discomfort particularly if ingested) and skin (erythema, blisters, chemical burns, and contact dermatitis). It should be noted that unique to OC is loss of the blink reflex (Olajos & Salem, 2001). Most of the effects of RCA are mild and last only a few minutes. A recent review of 9261 RCA injuries found that 74.3% of injuries were minor and transient, 17% moderate (either unexpected injuries or lasting longer than expected) and 8.7% severe (requiring health care system intervention) (Haar et al., 2017). Of severe injuries identified there were 2 deaths; 58 individuals suffered permanent disabilities including loss of limbs, persistent vegetative state, and permanent loss of sight (Haar et al., 2017). Another report describes an infant who required Extracorporeal Membrane Oxygenation (ECMO) due to an accidental exposure to pepper spray from his mother's keychain (Billmire et al., 1996). The potential for more serious reactions from RCA exposure are primarily related to duration of exposure, higher concentration of exposure in an enclosed space, and underlying conditions such as a history cardiac or respiratory disease (Aktan, 2013; Karagama et al., 2003). Prehospital providers should be aware of the risk of prolonged or repeated exposure in the line of duty when caring for multiple patients in a mass casualty incident (MCI).

Secondary effects of RCAs may be related to blunt or penetrating traumatic injury from the delivery vehicle. A review of 10 patients with penetrating head trauma from tear gas canisters in Iraq reported a 100% mortality rate, while a 2013 article from Turkey reports on ten protesters suffering from numerous lacerations, all of whom lost eyes, with one even requiring orchidectomy from the use of tear gas canisters by police (Aktan, 2013). Other reports have documented skull fractures, facial injuries, subarachnoid hemorrhage, and even burns from the pyroelectric chemicals in the delivery process (Agrawal et al., 2009; El Zahran et al., 2021).

LOGISTICS OF PREHOSPITAL MANAGEMENT IN SITUATIONS OF RCA EXPOSURE

PROVIDER SAFETY

The foremost priority of any prehospital provider called to the scene where RCAs may potentially be used is to ensure that the prehospital team does not become secondarily injured. This includes delaying arrival until the scene is safe from violence and utilization of proper personal protective equipment, preferably with a full-face National Institutes for Occupational Safety and Health (NIOSH) rated air purifying respirator that

Organ System	Biological Effect
Central Nervous System	Fear Anxiety Headache
Ocular	Pain Lacrimation Blepharospasm Conjunctival Inflammation
Respiratory	Rhinorrhea Sneezing Cough Dyspnea Bronchoconstriction
Gastrointestinal	Nausea Vomiting Abdominal Pain
Skin	Pain Erythema Edema Blisters Contact Dermatitis

Table 2. Common effects of RCAs on various organ systems (Morrone et al., 2005; Oaks et al., 1960; Schep et al., 2015; Sommer & Wilkinson, 1999; Torgimson-Ojerio et al., 2021).

has a specific CN/CS/OC chemical filter (Chemical, Biological, Radiological, and Nuclear (CBRN) Respiratory Protection Handbook., 2018).

PATIENT SAFETY

Removal of the patient from the contaminated area should occur as the first step in the primary survey. If inside, extrication to an outdoor space will allow for fresh air to dilute lingering RCAs in the respiratory tract. Aerosolized RCAs tend to accumulate in dependent areas (e.g. close to the ground). Unconscious patients should be lifted as high as possible to limit continued exposure (Schep et al., 2015). Likewise, ambulances or helicopters should be parked at the highest elevation areas available to limit provider exposure. Heavily contaminated patients should have their clothes removed. In situations of dermal or ocular exposure, irrigation with copious amounts of saline is recommended for decontamination. If saline is not readily available, prehospital tap water is an acceptable alternative. Most CBRNE (Chemical Biological Radiological Nuclear and Explosives) can be decontaminated with tap water (Coleman et al., 2019). If symptoms persist for more than a few minutes, rapid transport to a hospital is necessary to prevent/mitigate long-term effects. Prehospital assessment after exposure to a RCA should prioritize identification of the RCA used, symptoms of those exposed, assessment of lung sounds, and documentation of other traumatic injuries (Region 11 Chicago EMS System, 2024).

It is preferable with any CBRNE that the patient be decontaminated prior to transport to the hospital. Transporting an incompletely decontaminated patient risks producing symptoms in the transport crew with potential serious consequences. It also risks contaminating the vehicle, rendering that vehicle out of service until decontamination can be done. If decontamination is unable to be done in the field, after arrival at a hospital patients exposed to RCAs will require decontamination. In a MCI patients will need to be triaged, and a designated area of the hospital will need to be “dirtied” to house patients prior to decontamination. Depending on the scale of the event, prehospital providers may be called upon to monitor patients waiting for decontamination for acute decompensation, with particular care given to those at a high-risk of RCA injury (the very young, the very old, the immunocompromised, and those with asthma or other respiratory diseases). Irrigation with large volumes of water or saline is the preferred method of decontamination; many other compounds have been tried with none showing demonstrable superiority to water/saline (Olajos & Salem, 2001).

ORGAN SYSTEM EFFECTS AND TREATMENT

OCULAR

The ocular system is one of the primary targets of an RCA. Symptoms include pain, blepharospasm, photophobia, conjunctivitis with both conjunctival and scleral injection, periorbital edema, and profuse lacrimation (Schep et al., 2015). Symptoms typically commence within 20 to 60 seconds of exposure. Usually, ocular effects are mild and self-limited but more severe injuries such as corneal abrasion, inflammation of the middle layer of the eye (uveitis), bleeding in the eye (hyphemia), cataracts, and optic neuropathy with loss of sight have been reported (Oaks et al., 1960). Treatment for ocular exposure is copious irrigation with water/saline until symptoms begin to subside. Contact lenses should be removed before eye irrigation. The recommended length of time for irrigation varies from 10-20 minutes. Any persistent symptoms after irrigation should prompt transfer

to a hospital for a full ophthalmologic exam. If Morgan lenses are available in the field, they can be employed to facilitate ocular irrigation. A Morgan Lens is a specialized soft plastic contact lens device that is attached to IV tubing that is utilized for continuous hands-free ocular irrigation. It is commonly used in many Emergency Departments.

RESPIRATORY

Effects on the respiratory system include stinging or burning in the nose, chest pain and tightness, dyspnea, cough, sneezing, and breath holding (Schep et al., 2015). Copious rhinorrhea ensues and contaminated saliva may create gastrointestinal (GI) symptoms. Persistent coughing may lead to vomiting. Treatment initially is to remove the patient from the contaminated area into fresh air, with most symptoms subsiding within 15 to 30 minutes. Patients who do not respond quickly should have oxygen saturation monitoring and supplemental oxygen provided. More severe respiratory reactions have been reported including bronchospasm, laryngospasm, coughing up blood (hemoptysis), chemical pneumonitis, pulmonary edema and asphyxia thus it is imperative that prehospital personnel have the resources available for advanced airway techniques (Billmire et al., 1996; Vaca et al., 1996).

CENTRAL NERVOUS SYSTEM

The most common central nervous system (CNS) symptoms are panic and agitation. Other potential CNS symptoms are fever, syncope, headache and dizziness (Schep et al., 2015). Removal from the RCA area to fresh air may calm an anxious patient. However, severe CNS symptoms such as loss of consciousness should prompt ALS interventions.

SKIN

The most common dermal effect after RCA is a tingling or burning sensation. Prolonged or severe RCA exposure can lead to erythema, blistering, and contact dermatitis (Schep et al., 2015). Dermal effects of RCA are often more common with handheld spray products as the solvents may contribute to cutaneous complications ranging in severity from mild erythema to delayed onset acute generalized exanthematous pustulosis (a rare severe skin reaction characterized by rapid widespread onset of small nonfollicular pustules on reddened skin often accompanied by fever and high white count) (Morrone et al., 2005; Sommer & Wilkinson, 1999). Beyond the chemical irritants, RCA delivery devices have been reported to cause burns from contact with the hot metal canisters or by the flame generated from the pyrotechnic launching agents used.

Treatment of dermal effects commences by removal of contaminated clothing and flushing the skin area with cool copious flowing water to remove the contamination and settle the burning sensation. Saline can be used for irrigation in those areas where vesicles have been formed (Schep et al., 2015). Other decontaminating agents such as baby shampoo (Winslow et al., 2006), sodium bicarbonate (Weigernd, 1969), diphoterine (Viala et al., 2005) (chelating agent) or vegetable oil (Jones et al., 1987) have been reported as alternative to water, though there is little evidence of improved benefit.

GASTROINTESTINAL (GI)

The primary GI effects of RCAs come from swallowing crystals; GI effects include nausea, vomiting and GI discomfort. Delayed GI and even menstrual changes have been

reported (Torgrimson-Ojerio et al., 2021). Prehospital providers must always be vigilant to suspect blunt traumatic abdominal injuries in anyone complaining of abdominal pain in situations where RCAs have been employed as blunt impact from tear gas canisters or traumatic injury from violent altercations are possible.

ADDITIONAL CONSIDERATIONS

When dealing with victims of RCAs, many times it is in the context of large protests where there may be a large number of victims, akin to an MCI. Additionally, the use of RCAs at densely populated events runs the risk of bystander injury from panic and subsequent trampling. In October of 2022 at Kanjuruhan Stadium in Indonesia, over 320 people were injured with 135 deaths after fans rushed the field in response to their team losing the soccer match. Law Enforcement arrived on scene and utilized RCAs in an attempt to obtain control of the crowd triggering mass panic, crush injuries and suffocation. The use of RCA is widely attributed as one of the key factors in triggering the stampede ("Major Stadium Disasters over Recent Decades," 2024; Wiyono et al., 2023). It is important for providers to be vigilant and look beyond potential chemical injuries for physical trauma and dangerous situations that may unfold as a result of RCA deployment.

In situations where RCAs are used during/results in an MCI, prehospital providers should utilize established incident command systems, and field triage guidelines designated by an experienced triage officer. Many prehospital triage guidelines exist to classify patients by need for intervention and likelihood of success, with the highest priority patients being those with critical, but treatable injuries (Prehospital Trauma Life Support, 2023). It is worth repeating that the primary goal of a prehospital provider is the safety of themselves and their team. It is imperative they begin to provide care only when it is safe and avoid inserting themselves into an unstable or metastable situation.

LIMITATIONS OF THIS REVIEW

This review did not follow prespecified inclusion and exclusion criteria for chosen studies. While this facilitated a broad overview of the current state of the literature, it may have introduced bias into the findings. This manuscript is meant to serve as an educational adjunct for providers who may be unfamiliar with practicing in settings where RCAs may be employed. The suggestions made in this manuscript are those of the authors based on the cited literature and are not a substitute for good clinical judgment or experience.

SUMMARY

The most common RCAs are CS, CN, CR, and OC referred to in aggregate as 'tear gas' (CS, CN, CR) or 'pepper spray' (OC). Ocular, dermal, respiratory, and GI symptoms are usually mild and self-limited, although more severe reactions can occur. Treatment is focused on the safety of the prehospital provider first and foremost, and then extrication of the patient to a safe area free of exposure to any RCA. Ocular and skin effects are treated with copious irrigation with water, while respiratory and GI effects are treated symptomatically. Most symptoms should subside in 15 to 30 minutes, although persistent symptoms may indicate more serious complications. There is no known antidote to RCA exposure.

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