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Medical Aspects of Less Lethal Weapons

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Abstract

A number of "less lethal" weapons have been developed and are commonly used by modern law-enforcement agencies and some military organizations. The intent of these weapons is to subdue or incapacitate violent or dangerous suspects without causing serious harm or death. Commonly used less lethal weapons include chemical irritant agents, explosive distraction devices, kinetic impact munitions, and electrical incapacitation devices. While less lethal weapons are significantly safer than traditional firearms, no weapon can be entirely non-lethal and no weapon can be made entirely safe. Medical providers may treat subjects exposed to less lethal weapons and should presume injury until proven otherwise. The following is a review article on the medical aspects of less lethal weapons.

INTRODUCTION

A number of “less lethal” weapons have been developed and are commonly used by modern law-enforcement agencies and some military organizations. The intent of these weapons is to subdue or incapacitate violent or dangerous suspects without causing serious harm or death. Commonly used less lethal weapons include chemical irritant agents, explosive distraction devices, kinetic impact munitions, and electrical incapacitation devices.

While these weapons are not intended to kill, they can and do cause injuries and occasional deaths. Medical personnel will encounter patients who have been exposed to and sustained injuries from these weapons. In this brief review we will discuss each of the above groups of less lethal weapons and their common injury patterns.

The nomenclature used to describe these weapons varies. The United States military has adopted the term “nonlethal.” While accurate in conveying the intent of the weapons, this term has been criticized as implying that they do not cause death or serious injury, which is not the case. The term “less-than-lethal” has also been used and is subject to the same criticism. Many authors and users of the weapons prefer the term “less lethal,” which may better convey the weapons' reduced likelihood of causing death or serious injury while not excluding the possibility. The latter term will be used here, but any of the above terms may be treated as interchangeable.

CHEMICAL IRRITANT AGENTS

While irritants agents have been used in war for centuries, modern agents were first developed by military organizations in the early 20th century. Also designated “riot control agents,” they can be used against individuals or groups to incapacitate or to deny access to an area. The agents are commonly referred to as “tear gas” due to the prominent lacrimation and blepharospasm they cause. [1]

One of the most commonly used modern riot control agents is CS, so named after the initials of its inventors. Chemically 0-chlorobenzalmalononitrile, CS is an aerosolized powder (Table 1.) This agent has largely replaced the older and more toxic agent CN (Chloracetophenone) which saw extensive use in the Vietnam conflict of the 1960s, though CN is still available and used by some agencies. Another common riot control agent is Oleoresin Capsicum, abbreviated OC and commonly known as “pepper spray.” Originally derived from hot peppers, modern OC is synthetically manufactured and sprayed from pressurized containers. It is widely available in personal defense sprays. While chemically unrelated to CS or CN, OC produces similar clinical effects and is combined with CS in some products.

Irritant agents can be deployed in a number of ways, including hand held sprays, thrown containers similar in appearance to hand grenades, and fired from rifle-like launchers. Containers of riot control agents are conventionally labeled in color coded type to aid in identification. (Table 1.) Some propellants used for riot control agent delivery devices are flammable and may represent an ignition hazard.[2] Numerous preparations of these agents are available to the public in the form of self defense sprays, though law enforcement and military preparations are typically more potent.

Figure 1

Table 1: Common Riot Control Agents

Abbreviation	Common Name	Chemical Name	Color Code
CS	"Tear gas"	O-chlorobenzal-malononitrile	Blue
CN	"Tear gas" "Mace"	Chloracetophenone	Red
OC	"Pepper Spray"	Oleoresin Capsicum	Black

The onset of clinical effects of riot control agents is relatively rapid, within seconds of exposure, but not instantaneous. This brief time between exposure and effects is very important. While riot control agents may be an appropriate choice to modify the behavior of noncompliant individuals, they would not be appropriate for use against a suspect who might fire a weapon, detonate a bomb, or take other deadly actions in the time between exposure and onset of effects. In addition, riot control agents are not uniformly effective. Training and repeated exposures can result in tolerance and reduced effectiveness, and highly combative or intoxicated subjects that do not respond normally to discomfort may not be affected. These agents are reported to be ineffective in approximately 10-15% of civilian law enforcement uses. [1, 3]

EFFECTS

Patients who have been exposed to riot control agents quickly become acutely uncomfortable and experience an intense burning sensation of the eyes and nasopharyngeal mucous membranes. Lacrimation, blepharospasm, and subjective shortness of breath are prominent. Susceptible individuals may have bronchospasm. Exposed skin may have a burning sensation, and secondary nausea and vomiting may occur. Corneal abrasions can occur after close range exposure to pepper spray powder or eye rubbing.[4]

TREATMENT

The majority of patients exposed to these agents do not require medical evaluation or treatment. Significant ocular, respiratory, and mucous membrane irritation symptoms resolve in 15-30 minutes without intervention. Skin irritation symptoms may last longer, from 30-60 minutes. In general, treatment of symptoms is supportive, and consists of removal from the offending agent, removal of contaminated outer clothing, exposure to moving air (for example from a small fan), and irrigation of the eyes with water or normal saline (preferred). Topical ocular anesthetics and Morgan lenses are quite effective for eye irrigation, if available. Fluorescein staining can reveal occasional minor corneal abrasions. Beta agonist agents should be considered if bronchospasm is present.

Several topically applied “decontaminant” agents are commercially available and advertised to reduce the duration and severity of effects of riot control agents. There are also anecdotal reports that baby shampoo is helpful. However, as yet there have been no published scientific studies that demonstrate their effectiveness.

Medical providers should keep in mind that they may become exposed to residual chemical agents from a patient's skin or clothing.[5] Therefore protective gear should be considered and exposed patients' clothing should be removed if the situation and clinical condition allows. Formal decontamination is usually unnecessary but can be considered if high levels of residual riot control agents are present.

DISTRACTION DEVICES

Specialized explosive devices can be used to temporarily distract and disorient potentially or historically violent suspects. Also called “diversionary devices,” “stun grenades,” or “flash-bangs,” distraction devices explode with a brilliant flash of light and a loud report. These devices are typically used upon initial entry into an enclosed space, to allow entry team members several seconds to enter and secure an area with a decreased risk of resistance. Similar in appearance to hand grenades, these devices are typically deployed by hand. They can also be fired from a distance by a launcher.

The explosive force of these devices can cause major injuries if the device detonates in close proximity to a person. In addition to the explosive charge, distraction devices contain powdered magnesium or aluminum, which burn brightly at high temperatures and represent a significant ignition and burn injury hazard. The flash of light produced is intense (over 2 million candlepower) but lasts just 25-90 milliseconds.[6] This is intended to impair vision briefly, but should not cause permanent damage. The explosion typically produces noise of approximately 175 decibels and a momentary pressure wave of 5 - 7 pounds per square inch at

5 feet, the approximate equivalent of a 200 mile per hour blast of wind.[7] This is unlikely to cause damage at distances of 5 feet or greater, but the pressure wave may rupture tympanic membranes and possibly produce other primary blast injuries at closer distances.

EFFECTS AND TREATMENT

Burns, soft tissue injuries, bony fractures, and major bleeding can be seen in patients who are in close proximity to or in contact with a distraction device when it explodes. Initial management of these injuries is straightforward, though not always easy. Medical personnel should be sure to examine tympanic membranes for possible injury in such patients, and should consider evaluation for occult blast injuries such as pulmonary contusion or GI tract injuries in selected patients. Secondary injuries from falls or secondary projectiles propelled by the blast should also be investigated.

KINETIC IMPACT MUNITIONS

Less lethal kinetic impact munitions include a heterogeneous group of blunt impact projectiles that are aimed and fired from a distance at a suspect. These projectiles are usually fired from 12 gauge shotguns or 37 to 40 mm specialized launchers. The projectiles are intended to strike a suspect and to impart a significant amount of kinetic energy without penetrating the suspect's body. These weapons have been in use at least since the 1970s, when the “rubber bullets” used in Northern Ireland became widely known.[8] Since that time, a number of manufacturers have developed projectiles that include “bean bags” filled with metal pellets and various configurations of wood, rubber, and synthetic projectiles. [9]

Another type of kinetic impact munition launcher includes paintball type weapons. These rifle-like devices are based on recreational paintball guns and powered by compressed air rather than explosive charges. They fire hollow circular plastic projectiles that are designed to rupture upon impact and release their contents. For law-enforcement use the projectiles may contain OC (oleoresin capsicum) powder or a colored marking powder. The medical effects of the OC payload are discussed above.

Users of less lethal kinetic impact munitions are trained to target the torso and proximal extremities of a suspect while avoiding the head, neck, precordium and groin areas. However the relatively poor aerodynamics of these large surface area projectiles makes these weapons fairly inaccurate. [9] This increases the likelihood of striking an unintended area of the body or missing the target entirely and striking another individual. The force imparted by the projectiles varies widely and is dependent on both distance and the type of munition. It is frequently compared to being struck by a thrown baseball. Empiric testing has revealed this to be a reasonable comparison. [9]

EFFECTS

It is extremely common and expected that these projectiles produce contusions, abrasions, and hematomas at their impact sites (Figure 1). Internal injuries due to blunt impact of the overlying tissues may also occur. These include bony fractures, injuries to intraabdominal organs, and pulmonary contusions. [8, 10,11,12,13,14,15,16] Although uncommon, there have been several fatalities associated with these projectiles. [17,18,19] Fatalities are most common when impact occurs at the head, neck, or precordium. Recent injury modeling research has added to our understanding of these injuries and may lead to development of safer weapons systems. [20]

Figure 2

Figure 1: Contusions from kinetic impact munitions.

Figure 3

Kinetic impact projectiles are designed to deform upon impact to provide maximal surface area and a reduced likelihood of penetrating injury. However, skin penetration does occasionally occur. Intraabdominal, intrathoracic, ocular, intracranial, and extremity penetrations of intact projectiles have all been reported. In addition bean bag type projectiles have been reported to rupture upon impact, releasing their numerous small metallic pellets which then produce penetrating injuries. [12, 21,22,23,24,25]

Another risk of these projectiles, specific to those fired from shotguns, comes from the possibility of accidental substitution of a standard shotgun round for the less lethal ammunition. This has occurred in at least two cases.[17] To reduce the risk of this occurrence, many police agencies that utilize the 12 gauge shotgun launching platform use specially marked weapons that are dedicated to less lethal ammunition use.

TREATMENT

Evaluation of any patient who has been struck with a less lethal kinetic impact projectile should include a careful history and physical examination directed toward revealing underlying injuries. Standard trauma evaluation including X-rays, computed tomography, and ultrasound examinations as indicated can facilitate the diagnosis of the numerous potential injuries that may have been sustained. Careful attention should be paid to the possibility of penetrating injuries related to these projectiles. Secondary injuries caused by falling, a common occurrence after being struck with one of these munitions, should also be specifically sought. Traditional treatment of blunt and penetrating injuries is indicated.

ELECTRICAL INCAPACITATION DEVICES

A unique class of weapons, battery powered electrical incapacitation devices deliver a low current, high voltage electrical charge to temporarily incapacitate a suspect. Early “stun gun” devices relied on a painful stimulus alone, while more modern devices also produce tetany of major muscle groups for the duration of electrical current flow. Several devices are now available, though the Taser® M26 and X26 devices are perhaps best known and most commonly used (Figure 2).

Figure 4

Figure 2: The Taser M26 and Taser X26

Similar in appearance to a pistol, the Taser fires two sharp metal probes toward a suspect using an inert gas propellant. The probes are designed to become imbedded in skin or clothing; barbs similar to those on fishhooks are used to prevent dislodgement. The probes remain attached to the device by thin insulated wires 18 - 21 feet long. If an electrical circuit is completed, a series of very brief (6-12 microsecond) electrical pulses is produced at a rate of approximately 15 pulses per second for five seconds. The electrical shock can be terminated early by the operator, or additional shocks may be delivered by pulling the trigger again. If electrical contact is not made, the device can deliver an electrical charge if placed in direct contact with a suspect, or the single shot device can be reloaded and fired again. [26]

EFFECTS

GENERAL:

The electrical shock delivered by these devices is acutely uncomfortable and usually causes tetany of large muscle groups. These symptoms resolve immediately upon cessation of the electrical shock. There is no loss of consciousness or alteration in awareness during the shock. It is common for subjects to fall during or just after use of this weapon. This may produce secondary injuries from blunt trauma.[27]

The sharp metal probes typically produce minor puncture wounds if they penetrate the skin. The 1/4 inch long probes are unlikely to cause significant damage unless they strike the eyes, other sensitive tissues such as genitalia, or superficial blood vessels. Minor punctate burns may be seen at the site of electrical arcing, typically at or within millimeters of the probe location.[17, 28]

CARDIAC:

The Taser produces a current of 0.36 - 1.76 joules per pulse. This is well below generally recognized ventricular fibrillation thresholds and is not expected to affect cardiac conduction. Animal studies have demonstrated a significant safety margin for the pulses, with a 15-fold to 42-fold increase in current required to affect cardiac rhythm, depending on the body size. [29] No dysrhythmias have been produced in small studies of healthy volunteers. [30] Further, no Taser-related dysrhythmias have been documented in tens of thousands of training exposures and "real world" deployments by law enforcement. However, the high voltage / low amperage pulsed electrical waveform produced by these weapons is unique, its human effects have not been fully characterized, and concerns about electrical safety have not yet been fully addressed.

TREATMENT

Imbedded Taser probes can be removed from most areas by using one hand to stretch the skin surrounding the probe taut and the other to remove the probe with a rapid firm pull. Minor puncture wounds and superficial burns are easily treated with cleansing and topical care. Additional care is needed for probes with possible ocular, genital, or vascular penetration and specialist consultation may be required for removal. Secondary injuries due to falls should be specifically sought by history and physical examination.

The need for 12 lead EKG assessment after Taser exposure is somewhat controversial. Cardiac effects, if any, would be expected concurrent with or immediately after electrical shock. Thus, an EKG performed minutes or hours after Taser exposure would be unlikely to reveal any Taser-related effects, especially in asymptomatic patients. However, until further information is available, EKG assessment may be prudent in elderly patients, those with a cardiac or drug use history, or those reporting symptoms that could be cardiac in nature.

CURRENT CONTROVERSY

At the time of this writing there is concern and discussion about the safety of electrical incapacitation devices. This is based on a number of unexpected deaths in police custody that have occurred after exposure to the Taser.[31] Most of the deaths have been attributed to drug overdose and none have been attributed solely to the Taser. It is unclear whether the deaths are purely due to drug overdose or to a syndrome of "excited delirium" that has become a leading theory of unexpected death in police custody. [32,33,34] It is also unclear whether the Taser exposure was a contributing factor or not. Several recent reviews have addressed the topic of Taser safety based on currently available information. These reviews indicate that the risks of electrical incapacitation devices are, at most, very low. [35,36,37,38] Only well designed future research will be able to definitively address safety questions related to these weapons. Such research is urgently needed.

DISCUSSION

The several classes of less lethal weapons discussed are all intended to inflict as little physical damage as possible while reliably subduing or incapacitating a subject. These are laudable goals that stand in stark contrast to traditional weapons development, which focuses on increasing the lethality of weapons. The availability of these options may decrease the use of lethal force (firearms) and the use of riskier force options such as hand to hand combat or striking suspects with hand held impact weapons, resulting in reduced injuries to suspects and officers alike. This phenomenon has been documented with OC (pepper spray) and Taser use. [3, 39,40,41]

While less lethal weapons are significantly safer than traditional firearms, no weapon can be entirely non-lethal and no weapon can be made entirely safe. Medical providers may treat subjects exposed to less lethal weapons and should presume injury until proven otherwise. They should be familiar with less lethal weapons' actions, effects, and typical injury profiles.

Sonic weapons, olfactory deterrents, directed microwave energy weapons, and a number of other less lethal weapons are under development. Thorough evaluations of the health effects of these weapons should be performed during development and after deployment of the weapons. This will allow full assessment of their risks and benefits. It will also allow medical providers to determine the injury patterns associated with new weapons and help minimize morbidity and mortality due to their use.

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