LESS THAN LETHAL WEAPONS

The medical effects of non-lethal weapons - a review[1]

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ABSTRACT

Non-lethal weapons have seen increasing use in the police forces and, more recently, the military forces of various countries around the world. With increased use in military operations in areas such as Panama and Somalia, there is an increasing likelihood of military health service officers coming in contact with the medical effects of these weapon systems.
This review summarises the physiological and psychological effects of these weapons, weapons which will be of increasing interest in the future.

INTRODUCTION

Non-lethal weapons have seen increasing use in the police forces and, more recently, the military forces of various countries around the world. Defined as those weapons which `have a reversible effect on their human targets', the term non-lethal weapons is a misnomer as there will always be an element of risk associated with the use of any weapon system.[1] Historically, these weapons have been classified by their effects, principally whether they disable, disorient, discourage, demobilise or deceive.[1] The medical effects of these weapons do not easily fall into this taxonomy. Any discussion of these effects needs to be based on the target organ system or the specific psychological effect. Some non-lethal technologies aimed at weapon or communication systems may have peripheral effects on personnel. These may include burns from high powered microwaves or supercaustics, or falls on areas coated with very low friction substances. These collateral effects are not included in this review.

The medical effects of non-lethal weapons may be broadly categorised into:

- blunt trauma effects
- eye effects
- auditory effects
- electrophysiological effects
- toxicological/pharmaceutical effects
- psychological effects.

BLUNT TRAUMA EFFECTS

Non lethal riot control ammunition uses rubber, timber or plastic projectiles to deliver a numbing blow and temporarily incapacitate the target. There are two main groups: unconventional ammunition fired from conventional weapons (eg stun bags) and large slow projectiles fired from riot guns and grenade launchers.[1] These projectiles aim to produce the maximum release of blunt trauma to the body without killing. This shock consists of impact shock and neurogenic shock. Impact shock is the mechanical effect of the blow and is caused by the elastic impact of the projectile. It produces localised bruising and, depending on the range, may cause fractures and ruptures of internal organs. Neurogenic shock is due to a temporary partial or complete blockage of the nervous system from high frequency shock waves spreading from the point of contact.[1]

Plastic bullets cause fewer serious injuries to face and chest, although the laryngeal framework is particularly susceptible to injury because of its relatively unprotected position.[2] Plastic bullets, however, produce more serious injuries to skull and brain, and therefore cause more deaths than rubber bullets.[2] Wooden 'Broomstick' rounds may produce internal injury or death at close range and may leave splinters in the target at greater ranges.[3]

Stun bag ammunition may cause serious skull injury, liver damage or death[3] at less than 5 metres, produces contusions and broken bones at 5 - 10 metres and is ineffective over 20 metres. Large slow projectiles have a similar effect to stun bags at close range but only distract at long range.[1]

Other non-lethal weapons systems utilise water, lasers or sound to produce blunt trauma effects. High pressure water sprays, used to knock down targets, may produce blunt trauma.[4]

Pulsed chemical lasers may be used to produce plasma in front of a target. This will create a blast wave and subsequent blunt trauma to the target with a stun effect.[5,6] Acoustic bullets use a high frequency non-

1. Robertson AG. The medical effects of non-lethal weapons – A review. Aust Mil Med 1997; 6(1): 10-14.

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penetrating sound wave to produce a plasma in front of the target, which creates an impact wave that produces incapacitation by blunt object trauma to the target.[5, 7]

EYE EFFECTS

An anti-eye laser weapon has two main applications: temporary visual disablement, such as flashblinding at night, dazzle or veiling glare, or more permanent eye damage (partial or total blindness).[8, 9] Low-energy lasers can be used to dazzle and temporarily blind targets.[1, 10] More powerful lasers can be used to permanently blind human targets.[11] The eye magnifies any laser light hitting the eye by a factor of approximately 100,000. Given that only a low level of energy density is required at the retina to cause severe damage, lasers may produce extensive retinal damage and blindness. If the macula is affected, the target will become functionally blind. Even laser eye hits from oblique angles may produce retinal bleeding into the eyeball and subsequent blindness.[8]

Pyrotechnic Flash devices are devices are formulated to produce intense flashes of temporarily blinding light of 1 to 6 million candela. As 10 million candela is required for temporary blindness, the current devices will only temporarily dazzle targets.[1] There are, however, more powerful devices. These are the optical munitions. There are two types of optical munition. The Omni-directional Radiator or Isotropic Radiator produces a very bright multidirectional broadband burst of visible light. The directional radiator produces a similar intensity uni-directional light.[5] These systems may produce the dazzle, temporary blindness,[8] or, rarely, permanent blindness,[1,12] seen with laser weapons.

Strobing lights, particularly in the red and blue wavelengths, can effect the target's brain alpha patterns. This can create disorientation, vertigo and nausea (Bucha Effect).[1,12] Epileptic seizures may be induced in susceptible personnel.[12] Bright lights can also be used, in conjunction with noise, to prevent rest.[1] They may also be used to disorient a crowd at night by temporarily immobilising their night vision.[3]

AUDITORY EFFECTS

Stun grenades produce temporary hearing loss, aural pain and stunning effect by single or multiple blasts of loud noise. These devices generate noise in the range 140 -170 decibels. Confined spaces, however, may amplify the noise and may produce ruptured ear drums and other inner ear damage at levels above 180 decibels.[1]

High intensity ultra-low frequency sound may disable by producing body organ resonance. The infrasound may be manipulated to produce distress and anxiety,[6] or to produce temporary incapacitation from disorientation, vertigo, nausea, vomiting, bowel spasms or diarrhoea.[10, 13] At frequencies between 50 to 100 Hertz and intensity up to 153 dB, nausea, subcostal discomfort, cutaneous flushing and tingling may be produced. At 60 and 73 Hz, coughing, severe substernal pain, choking, salivation, and pain on swallowing can be produced.[1] At very high intensity with prolonged duration, death may result.[14] The effects cease on turning off the generator.[15] Other effects can also be produced by manipulating sound. Given sufficient intensity, ultrasound may be used to rupture internal organs.[16]

ELECTROPHYSIOLOGICAL EFFECTS

Electrical Stun Guns are weapons which fire electrodes into a target to stun but not kill. The electrodes discharge up to 50 kV at low amperage. This electrical discharge overloads and temporarily disables the peripheral nervous system. A single shock will disable a limb briefly, a one second burst will drop a person to the ground and a 5 second burst will disable a person for up to 15 minutes.[1] These weapons may have effects on cardiac rhythm and respiratory function.[17] In addition, they produce a round erythematous rash, with or without central paleness, which may be accompanied by circumferential abrasions.[18]

TOXICOLOGICAL/PHARMACEUTICAL EFFECTS

These effects include those produced by tranquillisers, soporifics, lachrymators, sternutators and incapacitants. Dart guns, injecting up to 3 ml of tranquilliser, have been developed. The effect is not instantaneous and depends on the route of administration with intramuscular routes being faster than subcutaneous routes.[1] Other routes for administering tranquillisers are less successful. Opiates and strong sedatives are too dangerous on account of their low margin of safety and milder tranquillisers cause little actual loss of performance capability.[19]

Soporifics are sleep inducing or sedative drugs which, when mixed with a solvent like dimethyl sulphoxide (DMSO), are rapidly absorbed through skin or lungs.[1,12] These may be variations of currently available compounds, like Lysergic Acid Amide (a milder form of LSD), or tailored synthetic

neuroactive peptides,[19, 20] like Delta Sleep-inducing Peptide analogues.[21]

Lachrymators are irritants characterised by a very low toxicity (chronic or acute) and a short duration of action.[22] Little or no latent period occurs after exposure. Orthochlorobenzylidene malononitrile (CS) is the most commonly used irritant for riot control purposes. Chloracetophenone (CN) is also used in some countries for this purpose in spite of its higher toxicity. A newer agent is dibenzoxazepine (CR) with which there is little experience.

CS is used as a riot control agent in many countries. The limit of perception by taste ranges from 0.25-0.5 mg.m^3. The minimal irritant concentration ranges from 0.1-1.0 mg.m^3 , the ICt 50 from 5-10 mg.m^3 and the LCt 50 for man very much larger, estimated as 60,000 mg.min.m^3. This provides a high margin of safety in its use. The CS cloud is white at the point of release and for several seconds after release. Exposure is associated with a pepper-like odour, the presence of intense eye effects, dyspnoea, coughing and rhinorrhoea. During exposure an individual is incapable of effective concerted action.

CR is similar in its effects to CS, but the minimum effective concentration is lower and the LCt50 is higher. CN has a minimal irritant concentration is 0.3 mg.m^3. It has been estimated from experimental data that the LCt 50 for man is 7000 to 14000 mg.min.m^3, but inhalation of 350 mg.m^3 for 5 minutes may be dangerous. The ICt 50 is 20 to 40 mg.min.m^3. CN is more toxic than CS. Exposure to CN primarily affects the eyes, producing a burning sensation, lacrimation, inflammation and oedema of the eyelids, blepharospasm, photophobia and, at high concentrations, temporary blindness.[23] The severest of these symptoms is reached in a few minutes and then gradually decreases. After about one or two hours all symptoms disappear. High concentrations can cause irritation of the upper respiratory tract, inflammation of the skin with vesicle formation, visual impairment and pulmonary oedema. Drops or splashes in the eye may cause corrosive burns, corneal opacity and even permanent visual impairment. Drops or splashes on the skin may cause papulovesicular dermatitis and superficial skin burns. Ingestion of food or water contaminated with CN causes nausea, vomiting and diarrhoea.

Sternutators[22] produce strong pepper-like irritation in the upper respiratory tract with irritation of the eyes and lacrimation. They cause violent uncontrollable sneezing, cough, nausea, vomiting and a general feeling of bodily discomfort. The principal agents in this group are diphenylchlorarsine (DA), diphenylaminearsine chloride (Adamsite (DM)) and diphenylcyanarsine (DC). They are dispersed as aerosols and produce their effects by inhalation or by direct action on the eyes. The onset of symptoms may be delayed for several minutes after initial exposure (especially with DM); effective exposure may, therefore, occur before the presence of the smoke is suspected. Inhalation is followed by a burning sensation in the nose and throat, hypersalivation, rhinorrhea, coughing, sneezing, nausea and vomiting. Mental depression may occur during the progression of symptoms. The paranasal sinuses are irritated and fill with secretions and severe frontal headache results. Prolonged exposure may cause retrosternal pain, dyspnoea and asthma like symptoms. Symptoms reach their climax after 5 to 10 minutes and disappear one to two hours after cessation of exposure. Effects on the eyes are slight and are restricted to a burning sensation and lacrimation. Exposure of the skin to high concentrations will cause erythema and itching, proceeding to a burning sensation and vesicle formation. Ingestion of food and water contaminated by sternutators may cause nausea, vomiting, diarrhoea (sometimes bloodstained) and weakness and dizziness have been reported.

High concentrations are not expected in the open owing to movement of air, but may be met within enclosed spaces (shelters, tents etc), and under these circumstances the skin may show vesicle formation, capillary damage and localised swelling, while corneal necrosis and pulmonary oedema are possible results. Unsteady gait and a positive Romberg sign have been reported. Other neurological results of severe exposure include hyperaesthesia, anaesthesia and paraesthesia, especially in the legs. Loss of consciousness has been reported.

Incapacitants[22] are chemical agents which produces a temporary disabling condition that persists for hours to days after exposure to the agent has occurred. There are two major categories: CNS depressants (anticholinergics) and CNS stimulants (LSD).

CNS depressants produce their effects by interfering with transmission of information across central synapses. An example of this type of agent is BZ (3-quinuclidinyl benzoate). Small doses of BZ

cause sleepiness and diminished alertness. Diagnosis can be made by noting increased heart rate, dry skin and lips, drowsiness and a progressive intoxication in the untreated individual as follows:

- 1-4 hours
- Tachycardia, dizziness, ataxia, vomiting, dry mouth, blurred vision, confusion, sedation progressing to stupor.
- 4-12 hours
- Inability to respond to the environment effectively or to move about.
- 12-96 hours
- Increasing activity, random unpredictable behaviour with delusions and hallucination.

The principal CNS stimulant is LSD. The clinical manifestations of LSD (D-lysergic acid diethylamide) intoxication often include an early stage of nausea followed 45-60 minutes after dosage by a confused state in which delusions and hallucinations are common but not always experienced. Subjects intoxicated with LSD show evidence of sympathetic stimulation (rapid heart rate, sweating palms, pupillary enlargement, cold extremities) and mental excitation (nervousness, trembling or spasms, anxiety, euphoria and inability to relax or sleep). Hyperthermia has been reported. Subjectively, feelings of tension, heightened awareness, exhilaration, kaleidoscopic imagery, emotions of every type, hilarity and exultation are characteristic. Paranoid ideas and more profound states of terror and ecstasy may also occur, especially in highly suggestible individuals. True hallucinations are rare, as is homicidal or suicidal behaviour.

Foul smelling gases may be used to dispel crowds. Hydrogen Sulphide and NaS[8] have been proposed. Hydrogen sulphide, however, is a powerful asphyxiant in moderate doses. At lower doses, it may produce nausea, eye irritation, respiratory irritation and pulmonary oedema.[10, 19]

PSYCHOLOGICAL EFFECTS

The psychological effects of non-lethal weapons may vary depending on the physical context in which it is used, whether the target is a crowd or an individual, whether the target is trained or not trained to expect or counter the effects of such weapons or whether it is used in a crowd control, counter-terrorist or battlefield situation. Camouflage and psyops are not part of the non-lethal weapons area as they are conceptually and operationally different.[24]

The use of blinding lasers will have significant psychological impact once personnel realise that observing the terrain as well as looking towards the enemy may entail a significant risk of being blinded.[8] After an attack, medical companies can expect to handle many personnel who think they have been hit by lasers when they have not.[9] These psychological casualties may be reduced by appropriate training.

With regard to other non-lethal weapons agents, obscuration foams may induce panic from a perceived difficulty in breathing coupled with restriction in sight and hearing.[1] There is little documented on the psychological effects of other non-lethal weapons and further research is required in this area.

CONCLUSION

This paper has reviewed the physiological and psychological effects of non lethal weapons.
The definition and classification of non-lethal weapons remains unclear. Many authors use the term Non Lethal Weapons, and other similar terms, to include weapons that affect both weapon, and command and control systems, where there is little or no human element involved. The taxonomy used for military effects does not fit easily with physiological effects and further clarification of both the definition of non-lethal weapons and its categories is required. The health effects vary in severity from the temporary disabling effects of lachrymators, infrasound and stun grenades to the potentially permanently disabling effects of blinding lasers and non-lethal projectiles. In most areas, the information on physiological and psychological effects is limited and further research is required to delineate both short term and long term effects of these weapon modalities.

The Wall Street Journal notes that the 'move into nonlethality could pry open a Pandora's box of chemical, biological, and nuclear weaponry that diplomats have spent much of the 20th century trying to keep closed.' [16] The majority of the chemicals cited are in contravention of the Chemical Weapons Convention and several of the other technologies would probably contravene the Inhumane Weapons Convention because of their indiscriminate effects. Further research is required to identify the legality of these weapon systems in the Australian context.

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