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Ballistic Characteristics and Wounding Effects of a Tear Gas Pen Gun Loaded with Ortho-Chlorobenzalmalononitrile

As a result of the increase in the number of crimes against the person in urban areas in recent years, there has been public interest in nonlethal protective devices for defensive purposes. The tear gas pen gun is an inexpensive, easily concealed device that is not classified as a firearm. In many communities there are no statutes that restrict the purchase or possession of these devices.

In previous reports [*1–3*] the ballistic characteristics and wounding effects of tear gas pen guns on man and experimental animals, as well as the characteristics of eye injury by tear gas weapons, have been described. Consideration has not been given, however, to protective devices loaded with the chemical agent ortho-chlorobenzalmalononitrile (CS). Furthermore, the ballistic characteristics of a tear gas pen gun in which CS is used as the chemical agent are not described in an authoritative textbook [*4*]. The purpose of this report is to describe the ballistic characteristics of a tear gas pen gun loaded with CS and the pathologic effects it has when fired at experimental animals.

Materials and Methods

The tear gas pen gun used in this study is a relatively simple device, consisting of a metal cylinder 10.4 cm long and 1.2 cm in diameter (Figs. 1 and 2). The open end of the cylinder is threaded to accept a tear gas cartridge. The rear portion of the cylinder contains a spring, with a metal rod 3.3 cm long in front. The tip of this rod is formed into a nipple to act as a firing pin. Attached to the rod is a small knob that moves in a slot machined into the cylinder. This allows the pen gun to be cocked by pulling the knob backward and moving it into a safety notch at the rear of the slot. To use the pen gun, the cartridge is threaded into place and the pen gun is carried cocked and loaded, ready to fire.

The tear gas cartridge used in this study consists of a threaded cylinder 3.9 cm in length. An Alcan "Maxfire" No. 220 shotgun primer is used as a propellant charge. The manufacturer states that the payload of the cartridge consists of 50 to 100 mg of CS, deposited on 3 to 6 grains of colloidal silica dust. The cartridge is sealed with a neoprene sponge-rubber wad, over which a thin layer of liquid neoprene rubber is deposited and dried.

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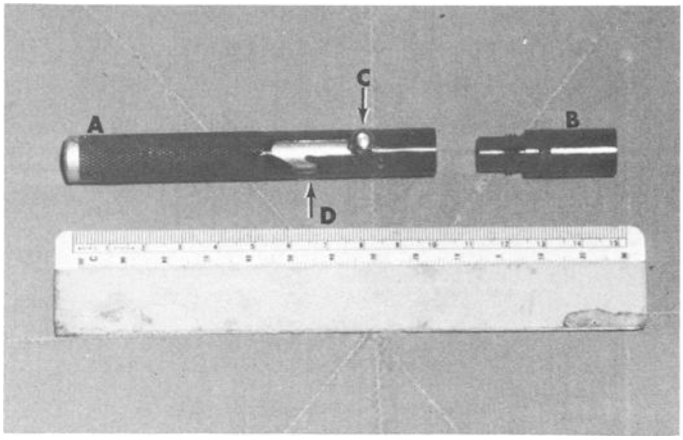

FIG. 1—*Tear gas protective device* A, *with threaded cartridge* B, *cocking knob* C, *and safety notch* D.

CS is a white crystalline powder, insoluble in water and ethanol but soluble in methylene chloride. Many of its chemical properties such as volatility and latent heat of vaporization are unknown. It is a stable, relatively noncorrosive chemical with a pepper-like odor. The median incapacitating dose is 10 to 20 $mg/m^3/min$ and the rate of onset of physiologic effects is rapid [5].

The first part of this study was concerned with determining the velocity of the various components of the tear gas cartridge. The pen gun was clamped in a vise, and high-speed motion pictures were made during the firing sequence. The camera speed was 11,640 frames per second, each frame representing an elapsed time of 0.00008446 seconds. The processed film was magnified in a microfilm reader and the distance traveled by each cartridge component per frame measured. The velocity was determined by dividing the distance traveled by the elapsed time per frame.

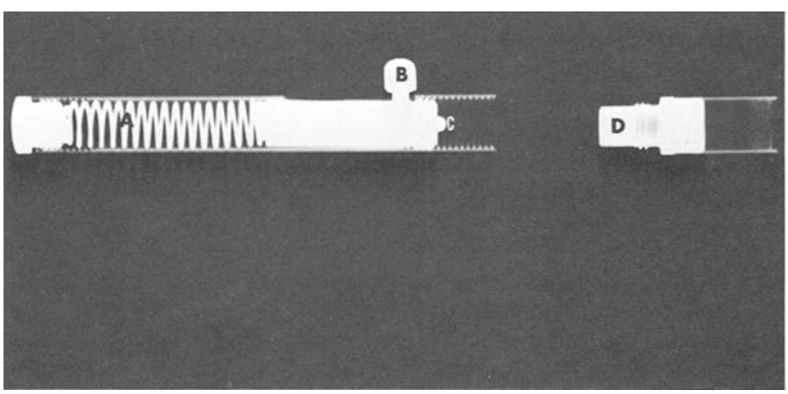

FIG. 2—*Roentgenogram of the pen gun and tear gas cartridge. The spring* A, *cocking knob* B, *firing pin* C, *and primer* D *are shown.*

The second phase of the experiment consisted of firing the pen gun at experimental animals.[2] New Zealand white rabbits ranging in weight from 3.0 to 3.84 kg were used. Prior to the test firing, they were premedicated with atropine sulphate administered subcutaneously. Anesthesia was achieved by the intramuscular administration of a combination of fentanyl and droperidol.[3] The pen gun was fired (*a*) into the right axilla at distances of 2.5 cm and 7.5 cm and (*b*) into the right inguinal and substernal areas at contact range.

In order to perform the test firings with a minimum of hazard to test personnel, a remote firing device was constructed (Fig. 3) that allowed the pen gun to be discharged remotely from any distance.

Results

Utilizing high-speed motion pictures, the velocities of the gas cloud and wad were determined (Fig. 4). The neoprene wad was obscured from view at the muzzle by the gas cloud, preventing measurement of its velocity at the muzzle. The wad emerged from the gas cloud 14.3 cm from the muzzle, and its velocity at this point was determined to be 154.0 m/s. The velocity of the gas cloud was 236.9 m/s at a distance of 2.7 cm from the muzzle, and it decreased rapidly over a short distance. The velocity of the wad decreased less rapidly, until it could no longer be measured more than 34.1 cm from the muzzle (Table 1).

TABLE 1—*Velocity of tear-gas cloud and cartridge wad.*

Distance from Muzzle, cm	Velocity of Gas Cloud, m/s	Velocity of Wad, m/s
2.7	236.9	[a]
4.5	213.1	[a]
8.0	118.3	[a]
14.3	94.8	154.0
21.2	23.8	130.2
34.1	...	118.3

[a] Wad obscured by gas cloud at this distance.

In the experimental phase of the study with animals, the pen gun was fired into the axillary area from a distance of 2.5 cm and 7.5 cm, as previously mentioned. Contact firings were made into the substernal area and the medial surface of the thigh. At a muzzle-to-skin distance of 7.5 cm in the axillary area, there was no apparent damage to the skin or underlying tissues. Several small fragments of wad, as well as some CS-silica aerogel powder, were adherent to the hair in this region after firing. When the muzzle-to-skin distance was decreased to 2.5 cm, several small lacerations 1 to 2 mm in length were produced. There was a small amount of hemorrhage into the subcutis beneath the lacerations. In addition, fragments of the wad and the chemical agent were adherent to the hair in the area. When the muzzle of the pen gun was placed in direct contact with the skin over the medial surface of the thigh directly over the midshaft of the femur, a closed, comminuted fracture of the femur occurred upon firing (Fig. 5). In addition, there was a

[2] In conducting the research described in this report, the investigators adhered to the "Guide for Laboratory Animal Facilities and Care," as promulgated by the Committee on the Guide for Laboratory Animal Facilities and Care of the Institute of Laboratory Animal Resources, National Academy of Sciences-National Research Council.

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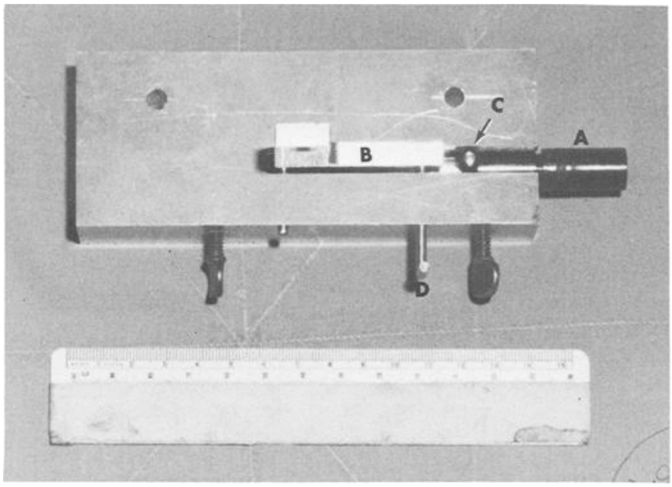

FIG. 3—*Remote firing device with pen gun* (A) *in place. When the cocking knob* (C) *is drawn backwards, it is held in position by the trigger* (B). *The safety pin* (D) *prevents accidental firing of the device.*

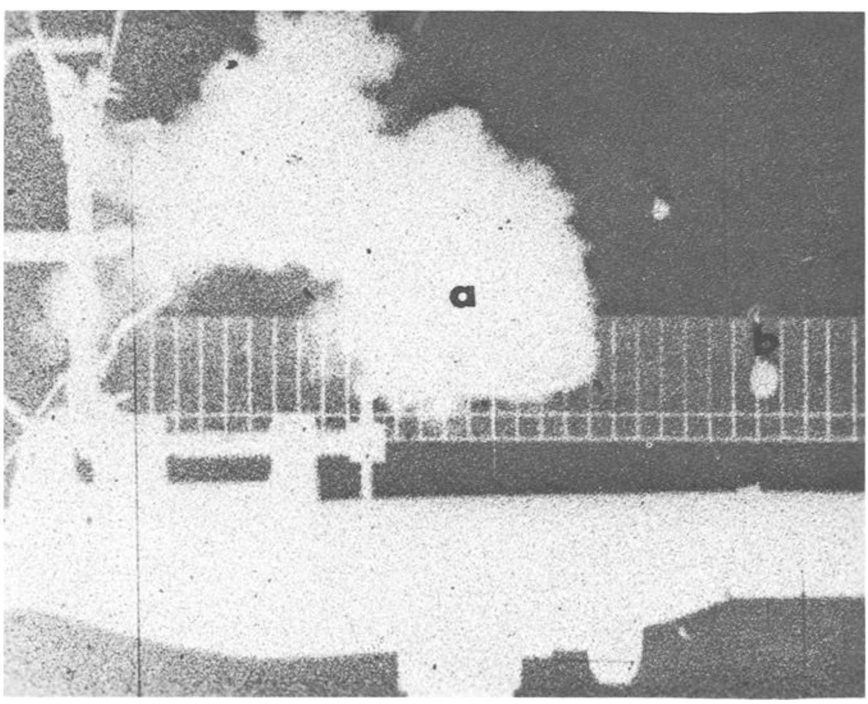

FIG. 4—*High-speed photograph of the pen gun during the firing sequence. The gas cloud* (a) *and the wad* (b) *are seen.*

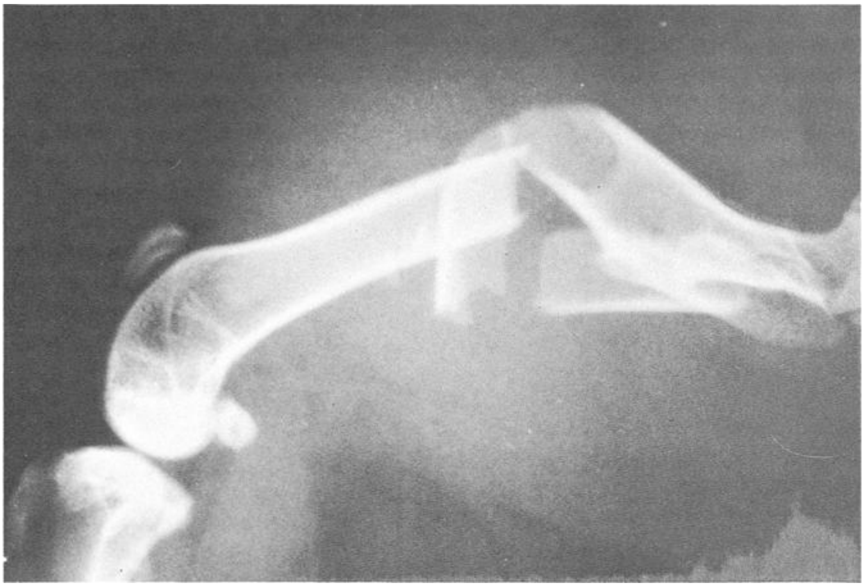

FIG. 5—*Roentgenogram of comminuted fracture of the femur produced by firing the pen gun in contact with the skin of the thigh directly over the bone.*

visible impression of the contour of the wad on the skin at the point of contact. When the muzzle was placed in direct contact with the skin just distal to the xiphoid process and directed slightly anteriorly, the wad penetrated the thorax. The rabbit expired shortly thereafter. Postmortem examination revealed a wound of entry slightly smaller than the diameter of the wad. The edges of the wound were blackened. There was severe hemorrhage as well as deposition of the chemical agent in the subcutaneous tissues. When the thorax was opened, the intact wad was found on the ventral surface of the right lung at a point near the hilus. The right lung was diffusely congested. There was a circular area of hemorrhage 0.8 cm in diameter present on this lung. This was consistent with a contusion resulting from impact of the wad. The remainder of the thoracic viscera was normal.

Discussion

This study confirmed that the wad of these tear gas cartridges is one of the most potentially hazardous components. High-speed motion pictures demonstrated that the velocity of the wad 14.3 cm from the muzzle was 154.0 m/s. At a distance of 34.1 cm from the muzzle the velocity had decreased considerably. In an earlier study of another type of pen gun, the wad velocity at 15 cm was approximately 161.0 m/s and the velocity at 90 cm was approximately 153.0 m/s [*2*]. The velocity at a distance of 15 cm compares favorably with the velocity of the wad at the same distance in the present study. It was observed, however, that the velocity of the wad in the present study decreased much more rapidly in a shorter distance. This effect may be attributed to differences in the nature of the propellant charge.

It was demonstrated that the wad or fragments of the wad were not capable of damaging the skin of the experimental animals at target distances greater than 2.5 cm. When placed in contact with the skin of the thigh and fired, the wad failed to penetrate the skin, but the blast effect caused fracture of the femur beneath the point of contact. This observation is in contrast to previous reports in which pen guns, loaded with chloroacetophenone (CN), caused nonpenetrating wounds of the skin with abrasion, edema, and erythema at 30.0 cm and abrasion and hemorrhage at 15.0 cm from the muzzle. Firing at contact range with both standard and magnum cartridges resulted in penetrating wounds of the axilla [*1*].

In the present study, the most severe injury resulted from firing the pen gun in contact with the skin just below the xiphoid process of the sternum. The wad penetrated the thorax and contused the right lung. It appears that the degree of injury in contact wounds is governed by the nature of the tissues beneath the skin at the point of contact. When the muzzle was placed in contact with the skin distal to the xiphoid process, the wad had only to penetrate the skin, a thin layer of subcutaneous tissue and muscle, and the pleura before entering the thorax. When placed in contact with the skin over the medial surface of the thigh, the nature of the target area was quite different, consisting of skin, subcutaneous tissue, a much thicker layer of muscle, and bone. These tissues may have acted to absorb and dissipate much of the energy. The wad, however, apparently acted as a piston, producing an outline of its contour on the skin at the point of contact.

Summary

The ballistic characteristics and wounding effects of a tear gas pen gun loaded with ortho-chlorobenzalmalononitrile (CS) were determined. The velocity of the wad 14.3 cm from the muzzle was 154.0 m/s. It was demonstrated that the wad or its fragments could not penetrate the skin of experimental animals at distances greater than 2.5 cm. The degree of injury when the pen gun was fired at contact range varied. At contact range the wad penetrated the thorax but did not penetrate the skin of the thigh, even though it caused a fracture of the femur.

Acknowledgments

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