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Characteristics and Wounding Effects of a Black Powder Handgun

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ABSTRACT: Commercial exploitation of the recent increase in interest in American history has led to an increased availability of weapons designed to use black powder (gunpowder). In some states, controls on these weapons are poor or nonexistent. In this study a .44-caliber black powder revolver is described and compared with a .45 ACP modern revolver. The kinetic energies of their missiles were very similar. In addition to the usual wound appearances determined by range and direction of fire, it was noted that the soot associated with wounds from the black powder handgun was much greater than from the control and had a characteristic sulfurous smell. Much more true tattooing was present around the black powder wounds. The spherical shape of the missile and the presence of black powder in crypts in the missile base were both characteristic of a black powder revolver. Striations were well represented on the ball but were easily destroyed during recovery because the lead was so soft. Swabs from around the wounds and from the shooter's hand revealed a large deposit of barium but little antimony. Wounds inflicted by black powder handguns may be detected more or less reliably.

KEYWORDS: criminalistics, ballistics, wound ballistics

Black powder, or gunpowder, is the oldest explosive known to man. Its use in antiquity by the Chinese and Arabs is well documented, and there is a record of its continuous use in Europe for over 1000 years. Although its martial use was initially limited to causing flash and noise to frighten enemy soldiers, its potential as a propellant to hurl rocks and later cannonballs was soon realized. Development of this use of black powder continued through the

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The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense. The experiments recorded herein were conducted according to the principles described in "Guide for the Care and Use of Laboratory Animals" prepared by the Committee on Care and Use of Laboratory Animals of the Institute of Laboratory Animal Resources, National Research Council, DHEW Publication No. (NIH) 78-23, Revised 1978. Product names used in this publication are for descriptive and identification purposes only and do not imply recommendation or endorsement by the authors or any public or private agencies. Received for publication 2 May 1980; revised manuscript received 31 July 1980; accepted for publication 14 Aug. 1980.

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mid-19th century, after which time it was gradually, but almost completely, replaced by nitrocellulose powders. Its use today, however, continues for various military purposes—including charges for salutes—and for fireworks.

Over the many years of the powder's use as a firearm propellant, several different mechanisms were used to ignite it. These ranged from direct ignition with a torch through various types of fuses that had to be lit by the shooter to the flint lock, where the spark was produced by an integral part of the weapon. All of these systems suffered from the disadvantages of unreliability and unpredictability and that at least some of the powder had to be exposed to the possibly inclement elements. The last major development in the technology of black powder weapons was the development of the percussion cap, patented in the United States in 1822. The powder was now totally enclosed and could be ignited by the explosion of the pressure-sensitive fulminate of the cap, caused by its being struck by the falling hammer.

Although some attempts were made to construct ammunition resembling today's modern cartridges, almost all of these weapons remained "muzzle loaders." In the case of long-barrel weapons, both the powder and the load had to be inserted down the full length of the barrel; short-barrel—and a few long-barrel—revolvers could be loaded through the anterior end of the cylinder. The charges were crudely measured by means of a tube on the powder horn, and the loads varied but were often simple spheres of lead.

The Civil War Centennial in 1960 and the Bicentennial of the Declaration of Independence in 1976 have led to a resurgence of interest in American history. Inevitably, the weapons used in both the Revolutionary and the Civil Wars have been included in this movement, and manufacture and sales of working replicas of black powder firearms have increased sharply. Some of the weapons are available intact, while others are sold in kit form; only a few unsophisticated tools are needed to assemble the latter. A common feature of most of these guns, however, is the use of modern materials and modern construction techniques to produce a quality product; although they are apparently replicas of ancient weapons, their reliability and performance are almost certainly superior to their prototypes.

The Federal Gun Control Act of 1968 exempts firearms made prior to 1898 *and replicas thereof* from control by the federal government [*1*]. Since only a minority of states restricts the sale and ownership of such weapons, the availability of handguns designed to use black powder is greater than that of modern cartridge weapons. This availability appears to the authors to suggest a strong probability that such weapons will appear—and indeed may have already appeared—in situations involving the wounding and death of persons accidentally, suicidally, and homicidally. A computer search of the medical literature of the world, however, failed to reveal any published material dealing with the characteristics and wounding effects of black powder handguns and therefore this study was undertaken.

Materials and Methods

The black powder weapon selected for this study was a Ruger "Old Army" .44-caliber revolver (Fig. 1). "Meteor" powder (Size FFFg) was used with percussion caps from "Naval Arms, Inc." This weapon was matched to a Ruger "Blackhawk" .45 ACP revolver, which was used as a control. Both weapons were of modern construction and in excellent condition.

Unlike modern powders, which come in many different shapes such as ball, flake, and cylinder, black powders vary in appearance essentially only in the size of their granules. The granules are graded Fg, FFg, FFFg, and FFFFg, in the order listed, from largest to smallest. The first two are used in shotguns and large-caliber rifles, FFFg is used in handguns, and FFFFg is reserved for primary flintlocks. The formula for gunpowder is well known and has varied little over the last 1000 years. It consists of potassium or sodium nitrate (approximately 75%) with charcoal (approximately 15%) and sulfur (approximately 10%). The first agent acts as a oxidizer, and the second two are combustibles, sulfur being the first to ignite. The grains are glazed with graphite to prevent caking and accumulation of static electricity [2].

FIG. 1—*Black powder handgun used in this study, together with powder horn* (above) *and cap and ball* (below). *(AFIP Negative 78-4648-1.)*

Black powder, particularly when it contains sodium nitrate, is hygroscopic and therefore requires careful storage. The powder horn represents one method of storing small quantities prior to use. The large bulbous portion is hollow and contains the powder. It is separated from the projecting tube by a shutter-like mechanism, which, when closed, acts as a cover. The "tube" method is a crude way of measuring the powder load. The shutter is opened, and a finger is placed over the end of the tube; the horn is then inverted, and when the tube has filled the shutter is closed and the horn is returned to the upright position. Theoretically, each time this procedure is repeated, the same volume (and presumably weight) of powder will remain in the tube. Despite the ingenuity of this design, the loads used in this study (40 grains) were all measured accurately on a balance.

The selected quantity of powder was tipped into each of the chambers in the cylinder through the wide-open anterior end. Then the lead ball was placed over the entrance to the chamber and rammed hard into the chamber with the lever mechanism under the barrel, thereby compressing the powder. The anterior end of the chamber was sealed with grease to prevent loss or accidental ignition of the powder. This procedure was repeated for each chamber in the cylinder.

The posterior ends of the chambers were closed except for the narrow hole through the center of the "nipples"; one of these can be seen in a recess on the posterior aspect of the cylinder (Fig. 1). It was over these nipples that the percussion caps fit. Each cap consisted of a thin copper cup with the ignition charge (usually a fulminate) on the inside of its base. The cup was placed over the nipple, and when the former is struck by the weapon's hammer, it explodes, igniting the powder charge. A schematic representation of a loaded chamber is shown in Fig. 2. The ball is at the right and the percussion cap at the left.

This particular weapon had a 190-mm (7½-in.) barrel, and, like most good-quality black powder weapons, was rifled, having six grooves with a twist of one in 406 mm (16 in.) to the right. The trigger mechanism was single action only.

Missile velocity was measured with an Electronic Counters, Inc. computing chronograph, Model 4001. Each weapon was fired six times, and the missile velocity was recorded as the

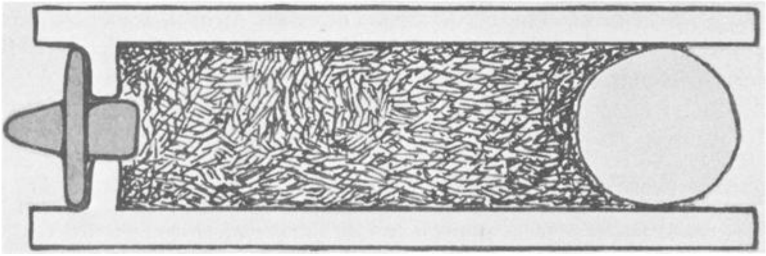

FIG. 2—*Diagram of loaded chamber in black powder weapon. The ball is to the right and the percussion cap to the left. (AFIP Negative 78-4651.)*

average of these six results. Each weapon was also fired at a range of approximately 0.3 m (1 ft) into a cotton-packed bullet trap; the missiles were then recovered. Finally, swabs soaked in 5% nitric acid were used to sample the surface residue from the dorsal and palmar surfaces of the hand firing the black powder weapon after one shot, two shots, and three shots.

For the examination of the wounding characteristics of the black powder handgun, pigs had been selected as animal models because of the relative hairlessness of pigskin and the close histologic similarity between pigskin and human skin. The animals used were female Yorkshire domestic white swine each weighing between 34 and 45 kg (75 and 100 lb). Surgical anesthesia was achieved by intravenous administration of sodium pentobarbital (about 30 mg/kg body weight) by means of an indwelling "butterfly" cannula in a lateral ear vein.

Each anesthetized animal was washed and lightly clipped, care being taken to avoid damage to the skin. In the shooting range, each weapon was fired into an animal at contact and at ranges of 305 and 660 mm (12 and 26 in.). (This procedure formed part of a larger separate project.) Each animal was shot between four and six times, the shoulder and the hindquarter (with the point of impact lateral and anterior to the wing of the ileum) being used as targets. The shots were administered as rapidly as possible, and each animal was subsequently killed by means of further intravenous sodium pentobarbital given under the direction of the attending veterinarian.

The wounds were visually examined, photographed, and X-rayed. Two specimens, each including wound tract, wound edge, and skin surface, were excised and fixed in buffered formal saline and glutaraldehyde for routine histologic examination and scanning electron microscopic studies. The skin around the wounds was swabbed with cotton pledgets moistened with dilute nitric acid for subsequent analysis by flameless atomic absorptiometry; separate samples were obtained in each case from the circular area surrounding the defect (out to a 25-mm [1-in.] radius) and from the circumjacent areas (from 25 to 51 mm [1 to 2 in.] and 51 to 76 mm [2 to 3 in.] from the wound). Finally, the remaining wound tract was excised to an average depth of 25 to 51 mm (1 to 2 in.) and submitted for carbon monoxide analysis.

From the formal-saline-fixed specimens, sections were cut and stained with hematoxylin and eosin and examined by light microscopy. The specimens fixed in glutaraldehyde were coated with gold and examined with an Advanced Metals Research Model 1000 scanning electron microscope. Each specimen was also subjected to energy dispersive analysis of X-rays (EDAX) with that machine and an EDAX Model 711B; each analysis included examination of the wound tract, the wound edge, and the adjacent skin surface. This analysis was strictly qualitative in nature.

The residual blood was expressed from the muscle of the excised wound tracts and analyzed for its carbon monoxide saturation with a Packard Model 417 gas chromatograph.

The swabs taken from the shooter's hand and from around the wounds were submitted to the Forensic Science Branch of the U.S. Treasury Bureau of Alcohol, Tobacco and Firearms, where they were analyzed for barium and antimony with a Jarrell-Ash Model 810 flameless atomic absorptiometer.

Results

The study was divided into three phases: the performance of the black powder weapon, the physical characteristics of the wounds, and certain chemical characteristics.

Weapon Performance

The results of the chronograph studies together with the kinetic energies derived therefrom are given in Table 1. It will be noted immediately that the kinetic energies of the two missiles are similar and in both cases far exceed the so-called casualty criterion of all countries [*3*]. The missile cross-sectional area is included to emphasize the similarity of the results, which underlines the fact that such weapons have all the wounding capability of modern firearms.

Figure 3 shows the results upon recovery of the missiles. The bullet at the top of the picture is from the control weapon, and the ball on the lower right was fired from the black powder weapon; an unfired ball is included (lower, left) for comparison. The irregularity on the right margin of each ball is a casting defect, common in such ammunition; for purposes of reference, it represents the "front" of the fired ball in this particular case.

Two points should be made from the illustrations. First, the striations caused by the missile's passage along the barrel of the weapon are well reproduced in the lead. Many of these balls, however, are cast from ingots of pure lead and are correspondingly soft. Extreme care should therefore be taken in the recovery and, perhaps more important, the packaging and transportation of such missiles to the firearms examiner. Second, inspection of the (left) surface of the fired ball that was next to the powder charge shows the presence of small black spots, actually lying in crypts in the lead. These spots are particles of powder that penetrated the surface of the ball because of the heat from their burning. This finding was consistent; therefore, even if a missile is fragmented within a body, lead fragments bearing these marks should suggest the use of black powder.

Physical Characteristics of Wounds

Gross Examination—Figures 4 to 9 show the skin surface of the wounds; Figs. 4, 6, and 8 depict wounds produced by the control weapon at contact and at ranges of 305 and 660 mm (12 in. and 26 in.), respectively; Figs. 5, 7, and 9 show wounds caused by the black powder weapon at the same ranges.

The contact wounds (Figs. 4 and 5) were examined first. The most obvious difference is

TABLE 1—*Relative performance of the conventional and black powder weapons.*[a]

Weapon	Missile Cross-Sectional Area, in.^{2}	Missile Weight, grains	Missile Velocity, ft/s	Missile Kinetic Energy, ft·lbf
Ruger "Blackhawk" (.45 ACP)	0.16	185	847	295
Ruger "Old Army" (.44 black powder)	0.16	144	821	216

[a] 1 in.^{2} = 6.45×10^{-4} m^2; 1 grain = 6.48×10^{-5} kg; 1 ft/s = 0.30 m/s; and 1 ft·lbf = 1.36 J.

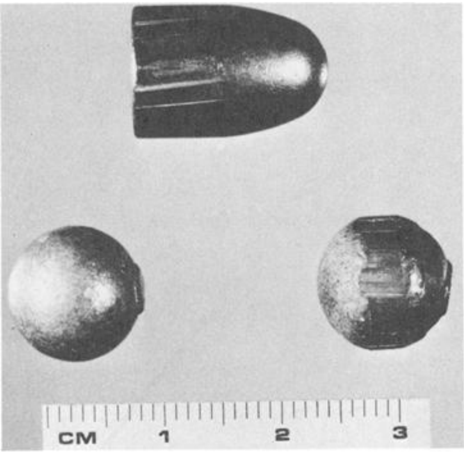

FIG. 3—*Recovered missiles from control weapon* (top) *and black powder weapon* (bottom, right), *together with unfired ball* (bottom, left). *Note good striations on the ball and the dark stippling on its left side. (AFIP Negative 78-4648-2.)*

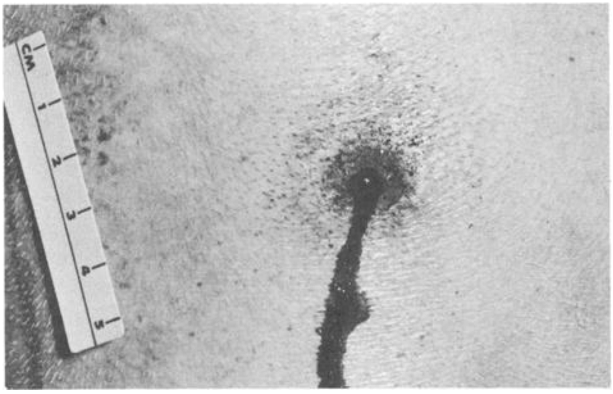

FIG. 4—*Contact entry wound made by control weapon. (AFIP Negative 78-4648-3.)*

that the wound caused by the black powder weapon is a "hard" contact, while that from the modern cartridge weapon is a "loose" contact. Although this may represent an increase in gas production by the black powder weapon, other variables such as skin-muzzle pressure and tissue resistance cannot be excluded, and it is thought that no conclusions can be drawn from this finding. Incomplete muzzle imprints are visible around both wounds, and these may be of value in helping to point to a given type of muzzle configuration. The most striking feature, however, was the amount of soot in the wound tract caused by the black powder weapon; this far exceeded the amount seen in the other tract, and the characteristic slightly sulfurous odor of gunpowder was very noticeable.

As may be expected, the main difference between the wounds inflicted at 305 mm (12 in.) (Figs. 6 and 7) and at 660 mm (26 in.) (Figs. 8 and 9) was to be seen in the quantity, character, and distribution of the powder marks on the skin.

Comparison of Figs. 6 and 7 shows the markedly increased density of powder marks from the black powder weapon. These marks are coarser and larger than those from the modern

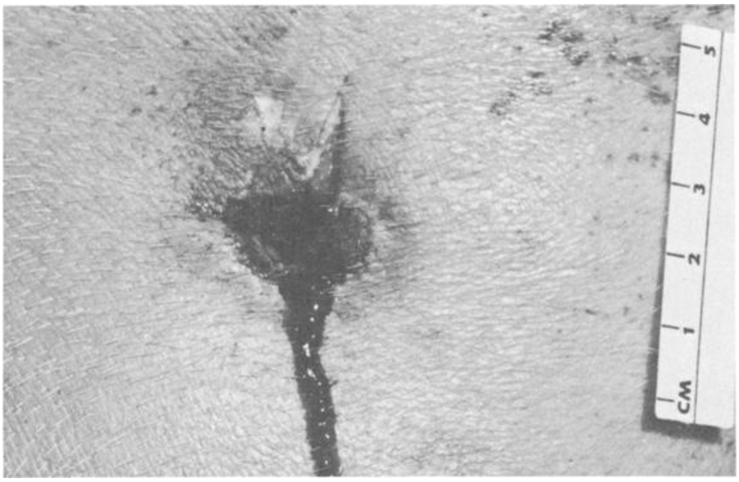

FIG. 5—*Contact entry wound made by black powder weapon. (AFIP Negative 78-4648-4.)*

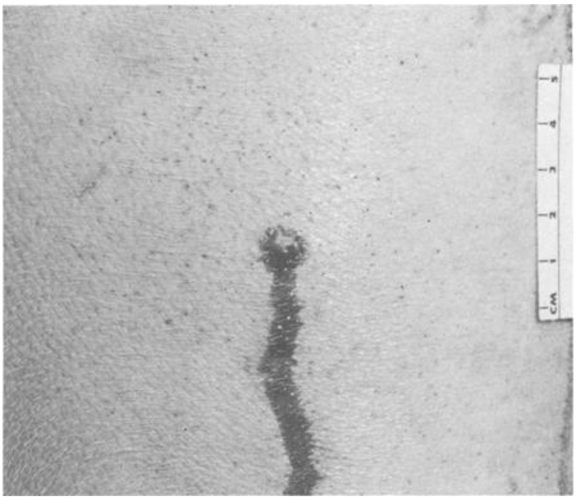

FIG. 6—*Entry wound produced by control weapon at 305-mm (12-in.) range. (AFIP Negative 78-4648-5.)*

cartridge weapon, and careful inspection showed fewer of the particles to be simply resting on the skin surface. With the modern weapon these particles were distinct up to 41 mm from the wound edge, while the distribution from the black powder weapon was up to 186 mm. Similar observations were made concerning the density and character of the powder residues around the wounds inflicted at 660 mm (26 in.) (Figs. 8 and 9). The distribution for the modern cartridge weapon was 8 mm and for the black powder handgun, 100 mm.

Examination by Light Microscopy—Study of the entry wound by light microscopy revealed on approach of the defect the progressive mechanical and thermal epithelial changes, followed by collagenous heat denaturation and varying amounts of powder particles associated with the epithelium and wound tract. As noted elsewhere [*4*], it was not possible to

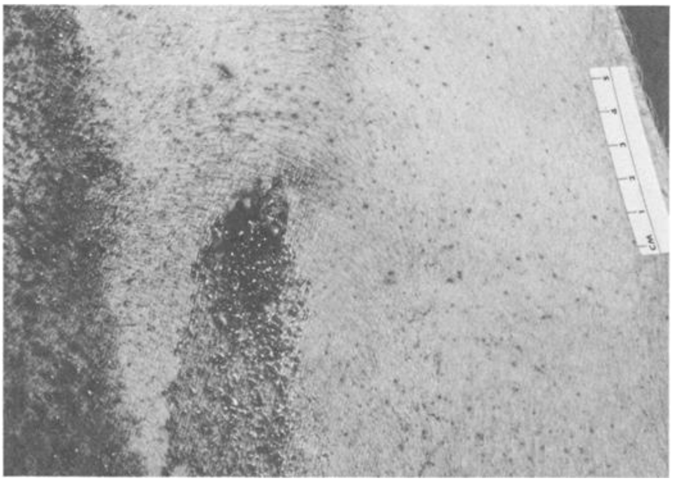

FIG. 7—*Entry wound produced by black powder weapon at 305-mm (12-in.) range. (AFIP Negative 78-4648-6.)*

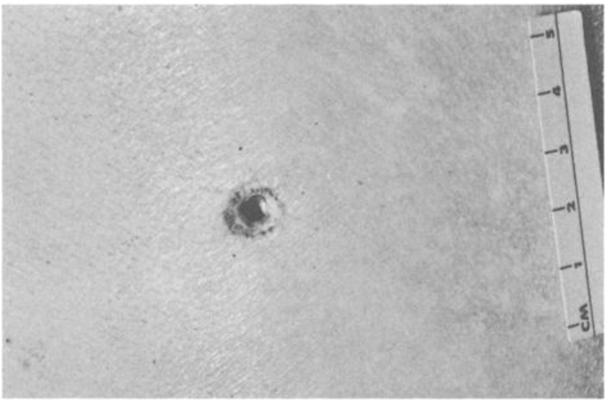

FIG. 8—*Entry wound made by control weapon at 660-mm (26-in.) range. (AFIP Negative 78-4648-7.)*

differentiate histologically the relative ranges of the noncontact wounds; in the case of the test weapon, powder was present on the skin surface in the sections from wounds produced at both 305 and 660 mm (12 and 26 in.), while it was absent in the sections from both wounds caused by the modern control weapon.

One feature we consider useful in differentiating wounds caused by black powder weapons is an extreme degree of tattooing (Fig. 10); epithelial and collagenous thermal changes surrounding the powder indicate its temperature was fairly high at the time of impact and that the powder may indeed have been burning. Penetration into the epidermis with occasional particles of powder extending into the upper dermis is seen with modern ammunition, but the depth of penetration and quantity of powder together with the extent of the epidermal and dermal heat effects with black powder are at least uncommon in the experience of one of the authors (R. C. M.). Therefore a wound with these features should suggest that black powder may have been used as a propellant.

FIG. 9—*Entry wound made by black powder weapon at 660-mm (26-in.) range. (AFIP Negative 78-4648-8.)*

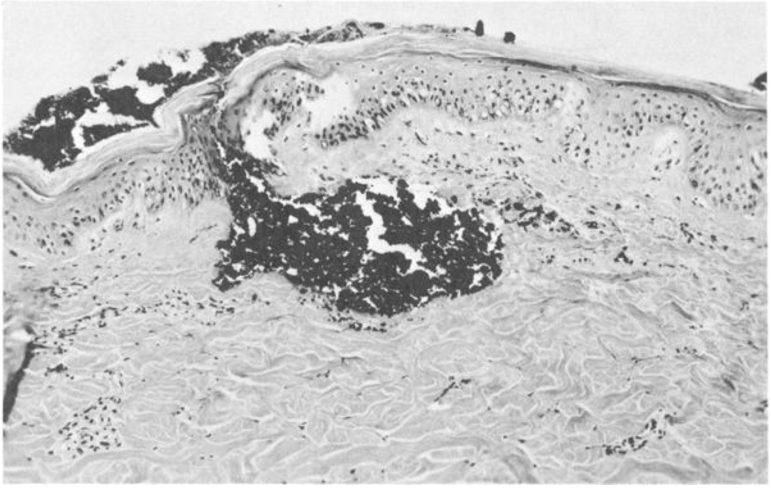

FIG. 10—*Massive intradermal deposition of black powder surrounded by epidermal and dermal heat changes. (Hematoxylin and eosin stain.) (AFIP Negative 78-4648-9.)*

Radiologic Examination—Since roentgenography is considered to be an integral part of the adequate postmortem examination of any gunshot wound, X-ray pictures were taken of each of the wounds. Although the findings were characteristic in all cases of gunshot wounds, no significant differences between the wounds caused by the different weapons were identified.

Examination by Scanning Electron Microscopy—Study of the wounds by scanning electron microscopy (SEM) showed only the characteristic appearances of gunshot wounds [*4*]. There were no distinguishing features permitting identification of the types of powder used to inflict particular wounds.

Chemical and Physicochemical Wound Characteristics

Analysis for Carbon Monoxide—The results of the analysis of blood from the muscle surrounding the wound tracts for carbon monoxide saturation are given in Table 2. The circulating level of carboxyhemoglobin in the animals prior to their being shot was 1.0%. On account of the variation in quantity of the samples, the results are simply quoted as "present" or "absent." It was noted, however, that the saturation with the modern weapon was five times higher than that found with the black powder gun. In view of the wide variation of carbon monoxide saturations recorded in another study [*4*], however, it is felt that no conclusions can be drawn from these findings.

Energy Dispersive Analysis of X-Rays —The elements detected in and around the wounds by EDAX are listed in Table 3. With the exception of the iron and nickel, they are all within the range of skin "normals" as defined by the authors [*4*]. The presence of the iron and nickel was, in the light of the findings for semiautomatic weapons, unexpected. Neither of these weapons had been modified, and neither was used with a silencer. The most likely explanation is that, because the weapons were revolvers, there was sufficient misalignment between the chambers and the barrel to permit wear at the proximal end of the latter; the abraded fragments of steel were therefore found as iron and nickel associated with the wounds.

In any case, no significant differences between wounds caused by the test and control weapons were demonstrated by this technique.

Flameless Atomic Absorptiometry—The total amounts of barium and antimony recovered from around the wounds and measured by flameless atomic absorptiometry are listed in Table 4.

The levels of barium seen in the same relative area are comparable for each weapon, although there appears to be a little more associated with the modern (control) gun. The big difference is seen in the amount of antimony recovered, very little indeed being recovered from around the wounds caused by the black powder weapon.

This finding is mirrored in Table 5, where the total recovery of barium and antimony from the hand of a shooter after firing one, two, and three shots is reported. It will be noted that

TABLE 2—*Results of wound tract carbon monoxide analysis.*

	Range		
Weapon	Contact	305 mm (12 in.)	660 mm (26 in.)
Modern cartridge	+	0[a]	...[b]
Black powder	+	0	0

[a] 0 = carbon monoxide saturation is less than 1.0%.
[b] Insufficient hemoglobin for test.

TABLE 3—*Result of energy dispersive analysis of X-rays from biopsies of the wounds.*

Range	Ruger "Blackhawk" (.45 ACP)	Ruger "Old Army" (.44 Black Powder)
Contact	lead, copper, zinc, barium, iron	lead, copper
305 mm (12 in.)	lead, copper, zinc, iron	lead, copper, zinc, barium, iron
660 mm (26 in.)	lead, copper, zinc, iron, nickel	lead, copper, iron, nickel

TABLE 4—*Total recovery of barium and antimony from swabs taken from around the wounds.*

		Area 1[a]		Area 2[b]		Area 3[c]	
Weapon	Range	Barium, μg	Antimony, μg	Barium, μg	Antimony, μg	Barium, μg	Antimony, μg
Control[d]	contact	>1.50	>0.87	>1.50	0.60	>1.50	0.04
Test[e]	contact	>1.50	nil	>1.50	nil	1.23	nil
Control	305 mm (12 in.)	>1.50	0.56	>1.50	0.47	>1.50	0.30
Test	305 mm (12 in.)	>1.50	0.04	>1.50	0.03	1.32	0.03
Control	660 mm (26 in.)	>3.0	nil	2.28	nil	0.78	nil
Test	660 mm (26 in.)	1.30	nil	0.74	0.01	0.62	nil

[a] Circle with 25-mm (1-in.) radius from center of wound.
[b] Circular band 25 mm (1 in.) wide with inner radius of 25 mm (1 in.) from center of wound.
[c] Circular band 25 mm (1 in.) wide with inner radius of 51 mm (2 in.) from center of wound.
[d] Ruger "Blackhawk" .45 ACP revolver.
[e] Ruger "Old Army" .44-caliber black powder revolver.

TABLE 5—*Total recovery of barium and antimony from swabs taken from the shooter's hand after firing of the black powder weapon.*

Shots Fired Before Sampling, *n*	Dorsum of Hand		Palm of Hand	
	Barium, μg	Antimony, μg	Barium, μg	Antimony, μg
1	0.72	nil	1.02	nil
2	>3.0	0.02	1.08	0.03
3	>3.0	0.01	>3.0	0.07

even after three consecutive shots, the amount of antimony fails to reach the significant level [5] of 0.20 mg.

Discussion

The first general point to be made concerning black powder weapons is that they are capable of firing a missile with more than enough kinetic energy to cause wounding or death. Although the law may consider some modern black powder weapons to be replicas of antiques, the forensic pathologist in the course of his routine practice must be aware that he may see wounds caused by them. Once such awareness is established, the importance of recognizing these wounds and differentiating them from wounds caused by more conventional weapons becomes apparent.

In the case of contact wounds, both "hard" and "loose" contact wounds appear to be possible with black powder, and the principal clues should come from examination of the wound tract, with notation of the gross excess of soot and the characteristic smell. In these wounds—as in all others—conventional techniques such as matching a muzzle imprint to a muzzle configuration and typing blood or tissue on a muzzle should not be ignored when the weapon is available.

Where the wound is not contact but is still within a range that permits the deposition of powder particles on the skin, the density and area of deposition may be helpful. The greatest help, however, is likely to come from the relationship of the powder to the skin surface.

Now conventional wisdom has it that soot ("fouling, smudging") can be wiped away from the surface of a gunshot wound but that the larger particles are impervious to wiping because they lie within or below the epidermis. With modern powders and particularly with the common small-caliber weapon at ranges of more than a few inches, this is simply not true: many of the larger powder flakes simply lie on the skin surface and can be removed by wiping with ease. The authors think, therefore, that the terms "stippling" and "tattooing," which tend to be used interchangeably, merit separate meanings; stippling should be used to describe a condition in which flakes of powder residue lie on the skin surface, and tattooing should be reserved for its true meaning: pigment (in this case powder residue) lying within or under the epidermis. The importance of this distinction is twofold: first, it permits a more precise description of gunshot wounds and second, it underscores the fact that patterns of powder residue are subject to alteration by wiping and perhaps serves as a reminder that while a wound showing no stippling may indeed have been inflicted from a range beyond that at which powder particles reach the skin, it may also have been inflicted at a considerably closer range and subsequently altered.

With this nomenclature, then, the wounds from the black powder weapon showed more tattooing than stippling, while the reverse was true of the modern weapon. The histologically massive nature of this tattooing is also thought to be indicative of the use of black powder.

Examination of the recovered bullet prior to its being sent for full firearms examination may be helpful. With a relatively undistorted missile, its spherical shape may be recognized.

Even when fragmentation has occurred, the black crypts may be recognized as evidence of black powder usage. On account of the softness of the lead used in these missiles, care in recovery and packaging is again urged. In addition to referral of the bullet to the firearms examiner, examination of the black pigment on its base (and, of course, any other recovered powder) by a forensic chemist may be of help.

While obviously remaining mandatory for examination of all gunshot cases, radiologic study is of little value in identifying the use of black powder weapons. Conceivably, the demonstration of a perfect sphere by multiple X-rays in a living patient may be indicative when for any reason the missile cannot be recovered, but in the case of a dead body, missile recovery is essential.

Of the more sophisticated techniques—SEM, analysis for wound carbon monoxide saturation, and EDAX—none appear to have much place in the routine for assessing a possible wounding with black powder. Further work is required to determine the frequency of detection and source of elements suggestive of steel in wounds inflicted with revolvers.

Flameless atomic absorptiometry of the area around the wounds showing, as it does in this case, antimony to be nearly absent may be of great value, particularly when results of hand swabs show high levels of barium but little or no antimony. The usual criteria taken to indicate firing of a weapon are a barium recovery of 0.30 mg and an antimony recovery of 0.20 mg, *together*. By these criteria, the shooter in our study could not be said to have fired his weapon. Evidence from the wound (and possibly the percussion cap) may serve to explain the low antimony in a given case and to permit arrival at a different interpretation of the results of the hand swabs.

Conclusion

The characteristics of a modern black powder weapon (handgun) and its performance have been described. Examination of wounds caused by this weapon and a comparable modern cartridge handgun by various techniques should permit identification of the use of black powder in most cases. The term "tattooing" should be reserved for indelible cutaneous pigmentation and thus differentiated from "stippling," which refers to powder residue lying on the skin surface.

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