MEDICAL EVIDENCE IN FATAL GUNSHOT INJURIES

LESTER ADELSON, M.D.

Laboratory of the Cuyahoga County Coroner's Office and the Institute of Pathology of Western Reserve University School of Medicine, Cleveland, Ohio

Gunshot fatalities comprise a large fraction of the violent deaths that require thorough medicolegal study. At the Cuyahoga County Coroner's Office, which serves Cleveland and the neighboring municipalities, 826 fatal shootings were investigated during the period 1943 through 1951, an average of 92 per annum. These cases represented 13 per cent of all violent deaths. The number and per cent of deaths from gunshot injuries in relation to other types of death from trauma is shown in Table 1.

Forty-nine per cent of the 826 fatal shootings were homicidal, 43 per cent suicidal and 8 per cent accidental.

In order to determine the circumstances surrounding a fatal shooting, whether *apparently* homicidal, suicidal or accidental, several investigative technics may come into play, including ballistics, firearms identification and dermatoglyphics. It is the purpose of this communication to call attention to the vital role played by the pathologist in the investigation of gunshot fatalities. It is his function to note, to acquire and to preserve whatever evidence is present within the body. The results of the autopsy are frequently the basis for accurate reconstruction of the actual fatal episode. In unwitnessed shootings and in cases where conflicting testimony obscures the truth, medical evidence may be the *only* key to the correct solution.

A discerning appraisal of *all* the findings at autopsy will furnish answers to many questions that may be raised in shooting cases:

1. Was death due to gunshot injuries?
   Other varieties of injury may mimic those produced by bullets, and conversely, bullet wounds may resemble those produced by a knife or ice pick.
   Was the victim dead from other causes, natural or violent, before he was shot?
2. What kind of weapon fired the fatal shot?
   Home-made "guns" can produce bizarre effects and wounds.
3. From what distance was the fatal shot (or shots) fired?
4. From what direction was the fatal shot (or shots) fired?
   The *relative* positions of the gun and the body must always be taken into consideration.
5. What are the individual characteristics of the gun used?
   All bullets in the body must be recovered and carefully preserved by the pathologist. They bear on their surface the "autograph" of the gun from which they were fired.
6. If multiple wounds of entrance and exit are present, could they have been produced by a single bullet?
   A single bullet may perforate the head, the trunk or an extremity and then reenter the body or an extremity. Thus, one missile can give rise to several wounds of entrance and of exit.

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Dr. Adelson is Pathologist and Chief Deputy Coroner and Instructor in Legal Medicine.

7. If multiple bullets are involved, were they fired from the same or different weapons?
8. How long did the victim survive?
   What vital structures were injured?
   What was the mechanism of death—rapid exsanguination, slow hemorrhage, shock, asphyxia?
9. How much activity, purposeful or otherwise, could the victim perform following the shooting?

Of the large variety of injuries encountered in forensic practice, none possesses as complex a group of characteristics as the wound inflicted by a firearm. To evaluate properly the varied anatomic findings in gunshot injuries it is essential that one be familiar with the phenomena accompanying the discharge of a firearm.

When the firing pin of a gun strikes the primer or cap of a cartridge it explodes the contents, which in turn ignite the main powder charge. As the powder burns, it produces a large volume of rapidly expanding gases which propel the projectile

TABLE 1

FATAL SHOOTINGS IN CUYAHOGA COUNTY* FROM 1943 TO 1951, INCLUSIVE

	NUMBER OF CASES	NUMBER OF SHOOTINGS	PER CENT OF FATALITIES
Homicide	732	407	55
Suicide	1343	352	26
Accident			
Industrial	519	1	5
Other	944	66	
Totals	3538	826	23.3

* Deaths due to motor vehicular accidents are not included in this table.

from the gun. Black powder burns with considerable flame and smoke, leaving many partly burned and unburned grains of powder. Smokeless powder burns more completely, producing less smoke and flame.

The firing of a gun results in the expulsion from the muzzle, not only of the bullet, but also of smoke, flame, fragments of burned, burning and unburned powder and fragments of metal from the bullet and from the interior of the barrel. These substances will be deposited in or on the target if it is less than 18 to 24 inches from the gun, depending on the type of gun and the variety of ammunition. The exact distance can be determined by firing the responsible gun with the same type of ammunition from varying distances against test targets and comparing the powder patterns on the victim and on the test target.

The blast of particulate matter and gas which emerges from the muzzle assumes the shape of a cone. The greater the distance between target and muzzle, the greater will be the area of fouling on the target surface. The heavier fragments from the muzzle are carried farthest (Fig. 1).

Smoke is light and is deposited on the skin as a gray or black film which can be readily wiped off. Powder fragments are heavier, may penetrate the skin and

give a stippled or tattooed effect. Marks due to the powder cannot be wiped away.

The closer the gun is to the skin, the more severe are the flame burns. At close range the powder grains are associated with flame marks as small black and red dots in the skin, crowded into a small area. Flames from revolvers usually reach up to 6 inches from the muzzle. At greater distances, the grains are more dispersed and the flame marks are absent. Appropriate chemical tests will disclose the identity of the powder grains and will differentiate them from other particulate materials. An entrance wound gives an indication of the distance from the

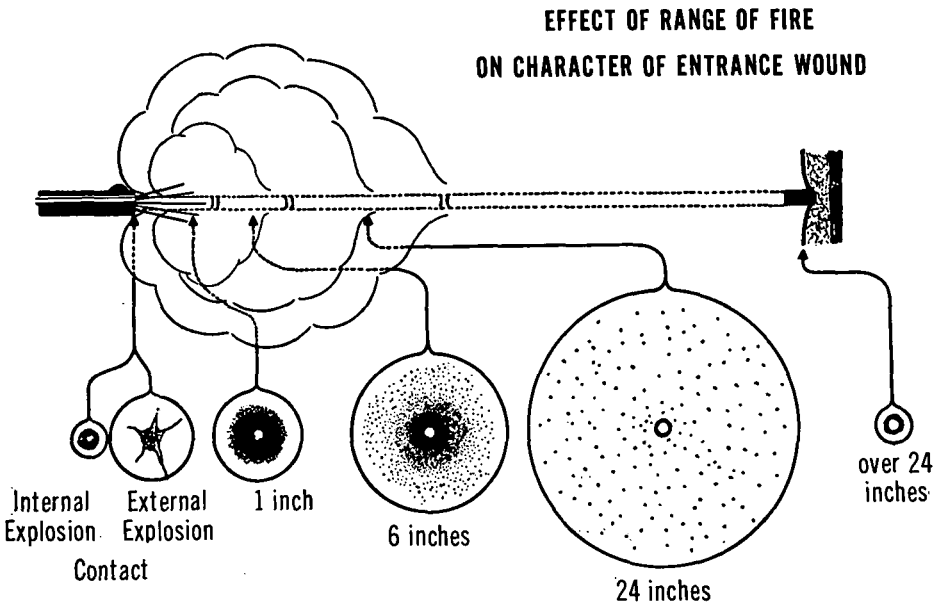

FIG. 1. Diagrammatic representation of powder patterns of entrance wound and skin perforations at different muzzle-target distances. (Courtesy of Dr. Alan R. Moritz. Modified from Moritz, A. R., and Dutra, F. R.: Arch. Path., **37**: 340–349, 1944.)

gun only when the contents of the cartridge have left their mark in or on the target. Entrance wounds may be classified on the basis of the distance of the muzzle from the skin.

ENTRANCE WOUNDS

Tight Contact with the Skin

1. The skin perforation may be large owing to the explosive and expansive force of the gases of the muzzle blast. This is seen in head wounds where the gases may expand between the scalp and skull, resulting in undermined, ragged, stellate and cruciform openings. There may be an enormous explosive type of injury with bursting fractures of the skull (Figs. 2 and 3). The principal damage to the skin is due more to the flame and muzzle blast than to the perforation pro-

duced by the bullet. Such an entrance wound may be much larger than the exit wound produced by the same bullet.

2. An exception to the above findings is seen occasionally when the muzzle is held against the skin and the underlying organs permit the expansion of the gases. A clean entrance wound is seen which resembles a distant wound (see below). Autopsy will disclose the charring and destruction of the *underlying* organs and tissues by the muzzle blast.

3. The bullet tract is blackened by powder and smoke, and seared and charred by flame. There may be little or *no* powder deposited on the surface of the skin surrounding the perforation. Gross or microscopic examination, or both, will demonstrate powder in the subcutaneous and deeper tissues. The gases and residue of the explosion may be blown so completely into the wound that they are invisible on external examination (Figs. 4 and 6). Serious errors have occurred in such cases when judgments have been made solely on the basis of external examination.

4. Occasionally, the imprint of the muzzle of the gun is found on the skin surrounding the entrance wound. This results from the expansion of the gases in the subcutaneous tissue, which forces the skin against the gun muzzle.

Effect of Distance

A. *Close shot* (1–3 inches, within range of powder blast and flame).

1. The skin perforation is surrounded by smoke ("fouling") and singed by flame (Figs. 5 and 7). Hair is burned and shriveled. The smoke may be readily wiped off the skin.

2. Unburned and partly burned grains of powder will be driven *into* the skin, giving a coarsely peppered pattern ("tattooing" or "stippling"). These grains cannot be wiped off the skin (Fig. 8).

3. The smoke pattern about the skin perforation may show a radial arrangement.

4. Black powder will be deposited on the surface at close range, accompanied by superficial burns, considerable smoke stains and coarse tattooing. The grains of powder are amorphous. Smokeless powder (nitrocellulose with or without nitroglycerine) leaves a much smaller residue. Searing and powder smudging from smokeless powder are relatively slight as compared to those produced by black powder.

B. *Near shot* (within range of powder blast, outside range of flame).

1. Fouling and stippling are spread over a larger area (Fig. 9).

2. No singeing of the skin is present.

3. The skin perforation produced by the bullet acquires the characteristics of a distant wound.

C. *Distant shot* (2 feet or more).

1. The bullet perforation is the only mark on the target caused by the discharge (Fig. 10).

2. If the skin is struck perpendicularly, the peripheral zone of abrasion is uniform in width about the skin perforation (concentric).

3. If the skin is struck obliquely, the zone of abrasion is usually wider on the side *from* which the bullet comes (eccentric) (Fig. 11).

4. There may be a zone of purplish discoloration surrounding the site of perforation as a result of the contusion produced by the bullet.

5. Distant-type entrance wounds are usually neat, round or elliptical holes with a rim of abrasion and a gray ring of soiling surrounding the skin perforation. Comparatively small quantities of blood usually escape from an entrance wound. When the bullet strikes the skin, it indents it. The skin is tough and elastic and stretches. The bullet is rotating and bores its way through. The side of the bullet wipes off smoke and grime, which is deposited as a gray ring around the entrance wound. Tissue destruction is usually not a striking feature of a distant-type entrance wound.

Location. Locate the exact site of the entrance wound from *several* fixed anatomic points and measure the dimensions of the wound, recording all measurements in inches. (Centimeters and millimeters are confusing to an American jury.)

a. The distance of the wound from the heel is a useful figure, and all wounds should be accurately located in relation to the heel, with body and leg extended. However, this figure does not necessarily tell the distance above the floor or ground that the victim was shot. It should not be assumed that the victim was in the erect position when he was struck by the bullet. He may have been lying down, sitting or squatting. Hence, if the bullet has passed through the body, a search for its site of lodgment in the ground, or in the floor, wall or ceiling may yield valuable information in establishing the relative positions of gun and victim.

Bullet "Slaps" and "Grazes"

A projectile may strike the skin tangentially without perforating, producing a red-brown ovoid or triangular furrow or abrasion.

Caliber of Bullet

It is risky to attempt to state the caliber of a bullet from the dimensions of the skin perforation. While the size of an entrance wound corresponds somewhat

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FIG. 2 (left upper). Blasting type of injury produced by tight contact between muzzle and skin. The site of entrance in the left supraorbital area reveals powder and flame effect in the subcutaneous region. The weapon was a 9-mm. Luger.

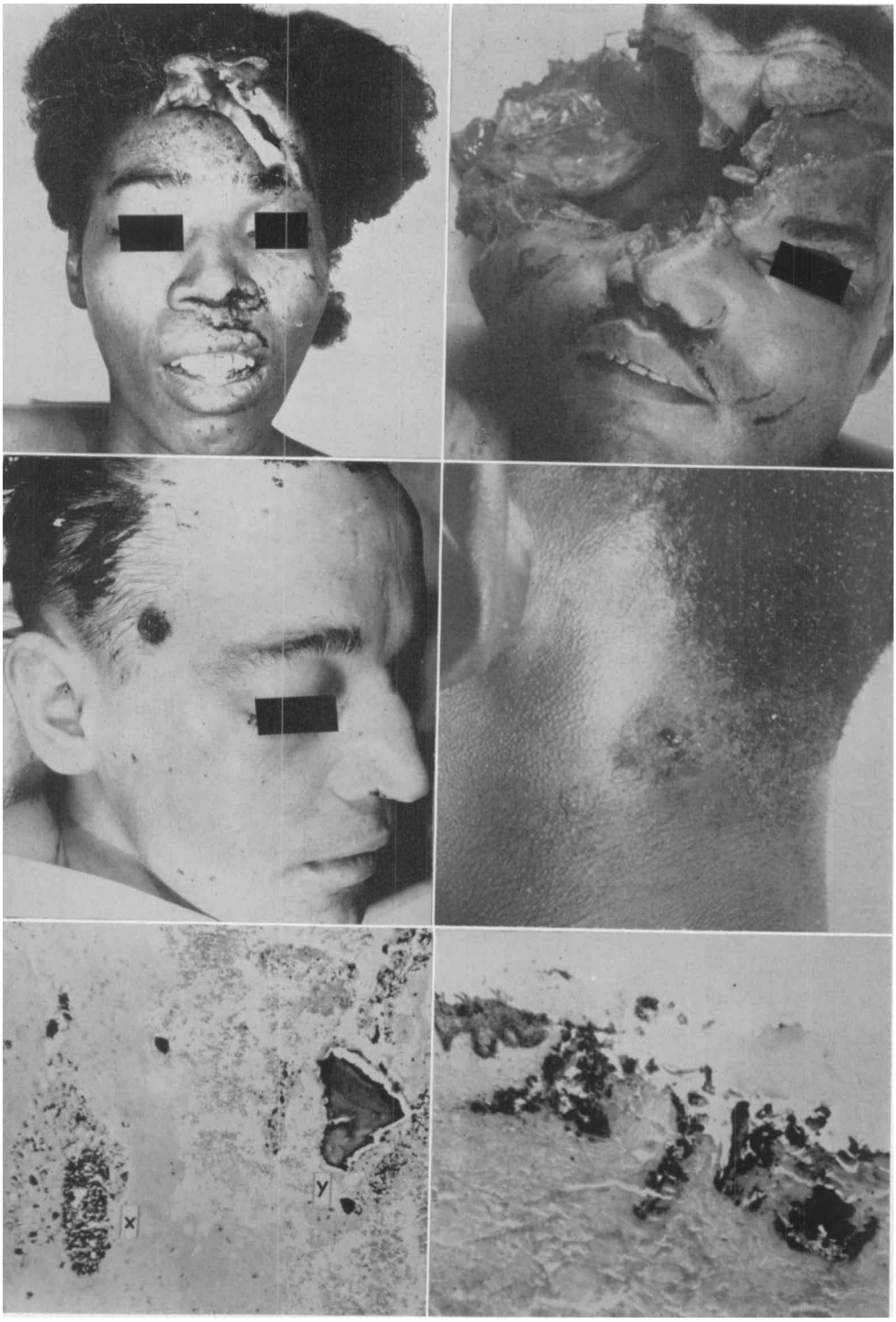
FIG. 3 (right upper). Enormous explosive effect produced by a .30-caliber rifle at contact range. The head has been literally blasted apart.

FIG. 4 (left middle). Entrance wound in temple revealing absence of both fouling and stippling on skin surface. The margins of the skin perforation show charring by flame. The weapon was a .38-caliber revolver.

FIG. 5 (right middle). Close wound of occipitomastoid region produced by .32-caliber revolver with halo of smoke surrounding skin perforation.

FIG. 6 (left lower). Photomicrograph (from Fig. 4) of brain discloses gun powder in cerebral parenchyma, (X) indicating that the muzzle was in tight contact with the skin. A spicule of bone is also present in the brain (Y), carried in by the explosive effect of the muzzle discharge.

FIG. 7 (right lower). Photomicrograph of wound (from Fig. 5) reveals burning of skin surface by muzzle flame with destruction of epithelium. Powder has been deposited in the corium.



FIGS. 2–7

to the diameter (caliber) of the bullet (the hole made by a .22 caliber bullet is smaller than that made by a .45 caliber), no conclusion can be drawn about the exact caliber of the bullet from the dimensions of the skin perforation.

a. Skin stretches as the bullet perforates it and then returns to its original degree of tension. Therefore, the skin opening is *usually* smaller than the transverse diameter (caliber) of the bullet.

b. A bullet may ricochet, "tumble" or "key-hole," striking sideways against the target. In such an event, the skin opening may be larger than the transverse diameter of the bullet.

Effect of Clothing on Characteristics of Entrance Wounds

The presence of clothing between the gun and the skin will alter the above findings. Powder, smoke and flame will leave their marks on the garments instead of on the skin surfaces. The bullet will wipe itself on the clothes rather than on the skin. Clothing, therefore, is extremely valuable from the point of view of evidence in shooting cases and should be carefully preserved for study and possible presentation in court. Employment of soft x-rays, appropriate chemical tests and infra-red photography frequently disclose marks and traces left on clothing by a bullet that are invisible to the naked eye. Fingers, pencils and other objects should not be poked through holes in clothing made by bullets.

Fragments of cloth are occasionally carried into the entrance wound. Such fragments of fabric are useful ancillary evidence to establish that a wound is the site of entrance rather than of exit.

EXIT WOUNDS

Exit wounds vary in size, shape and configuration. They result from a stretching force applied from within, with tearing as the limits of elasticity of the skin are exceeded.

A. Exit wounds are usually larger than the corresponding entrance wounds (if the latter have not been affected by the muzzle blast).

1. The bullet, slowed down by its passage through the body, *tears* rather than perforates. It packs tissue in front of it and *bursts* its way out.

FIG. 8 (left upper). Close shot with stippling surrounding skin perforation in preauricular area for a maximum distance of ⅞ inch. A well-defined smoke halo is also present. The weapon was a 7.65-mm. automatic pistol of Belgian manufacture.

FIG. 9 (right upper). Stippling produced by accidentally inflicted gunshot wound fired at a muzzle-skin distance of 12 to 14 inches. There is no smoke deposited on the skin. The weapon was a .44-caliber revolver.

FIG. 10 (left middle). Distant gunshot wound of zygoma showing no fouling or stippling of the skin. The characteristic concentric rim of abrasion surrounds the skin perforation (.32-caliber automatic).

FIG. 11 (right middle). Injuries produced by pellets from one discharge of a 12-gauge shot-gun. The differences in the sizes of the skin perforations probably result from variation in the missiles consequent to alteration of their shape in passage through the barrel.

FIG. 12 (left lower). Exit wound in scalp taking form of cruciate laceration. (Figure 8 illustrates the entrance wound produced by the same bullet.)

FIG. 13 (right lower). Exit wound in posterior thorax produced by .25-.30-caliber rifle. Here the site of exit takes the form of a triangular laceration. Note that here and in Figure 12 there is no suggestion of the rim of abrasion or contusion of the skin edges seen with entrance wounds.

FIGS. 8–13

2. The bullet may be deformed in its passage through the body, with resultant increase in its diameter.

3. The bullet may "tumble" and emerge sideways, with the largest diameter of the missile representing the striking face.

B. Exit wounds may take such forms as stellate, cruciate, triangular or crescentic (Fig. 13). They may resemble stab wounds.

C. The skin edges are everted, and the characteristic rim of abrasion of entrance wounds is not seen.

D. Fouling, stippling and burning are not seen.

E. There may be multiple exits, with a single entrance.

1. The bullet may fragment, each fragment making a separate opening as it leaves the body.

2. Bone fragments may act as secondary missiles.

F. More blood usually escapes from the exit wound than from the entrance wound.

G. Tissue destruction is greater at the site of exit than at the site of entrance (when the effects of muzzle blast are eliminated). Shreds of contused and hemorrhagic fat may extrude from the exit wound.

H. Exit wounds should be carefully located with reference to several fixed anatomic points and measured in the same fashion as entrance wounds.

The elasticity of the skin frequently halts the departing bullet in the corium where it may be readily palpable, thus eliminating the necessity of a troublesome search. Always palpate the side of the body *away* from the entrance wound for the bullet, if no exit wound is present.

COURSE OF THE MISSILE

Note the course of the bullet in the 3 planes of space, *i.e.*:

1. Front to back, or back to front.

2. Left to right, or right to left; if the bullet does not traverse the midline,—lateral to medial, or medial to lateral.

3. From above downward, or from below upward.

There may be no deviation from the perpendicular in 1 or 2 planes.

CARE AND PRESERVATION OF THE BULLET

All bullets recovered at autopsy should have an identifying mark (*e.g.*, the initials of the deceased) scratched on them at a site where the "autograph" of the gun will not be marred, *i.e.*, on the base. The bullet should then be placed in an envelope on which the pathologist writes in his own handwriting the name of the victim, the autopsy number, the date and the site of recovery of the pellet. The envelope should be sealed and signed by the pathologist. These precautions will prevent difficulties if and when the bullet is placed in evidence at a trial.

All bullets in the body should be recovered and the location of each bullet, fatal or nonfatal, accurately recorded. If a bullet has struck bone and splintered, the metallic fragments are collected and preserved for later study. Even small

flecks of metal, shaved off the bullet as it passes through bone, should be carefully saved.

Even when it appears that all the facts regarding the circumstances and manner are already known, no efforts should be spared to confirm the facts by objective evidence. In unwitnessed and controversial cases, the accumulation of *all* the medical evidence is required to answer the fundamental question: "Does the autopsy confirm or disprove the story told by the suspect or the witnesses?"

HOMICIDE, SUICIDE OR ACCIDENT?

The pathologist has the function of accumulating and preserving *medical* evidence. The ruling as to the *manner* of death (*e.g.*, homicide, suicide or accident) is the responsibility of the coroner, medical examiner or the medical referee, who renders his verdict after weighing all *evidence*—medical, physical, circumstantial and that of eyewitnesses.

The performance of a *complete* autopsy in cases of gunshot wounds is mandatory. Bullets can and do perform erratically. One should never attempt to reconstruct the direction of fire or to postulate the probable cause of death solely on the basis of the examination of entrance and exit wounds. The entire bullet tract must be explored to determine if there is alteration or deflection in the course of the bullet. The lethal lesions must be visualized. It is hazardous to venture any opinions about fatal gunshot wounds until after a complete autopsy has been performed.

A considered evaluation of the anatomic evidence in cases of death by gunfire, together with indicated toxicologic and chemical studies, will furnish data that are indispensable in reaching a correct opinion about the circumstances in which the fatal wounds were sustained.

SUMMARY

Injuries produced by firearms present complex characteristics, the recognition and interpretation of which are vital in reconstructing the circumstances of the shooting episode. The salient anatomic features of gunshot wounds are outlined.

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