Gunshot Wounds*

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*Adapted, with permission, from Gunshot Wounds Handout by Vincent J.M. DiMaio

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FIREARM BASICS

Rifling

- Handguns and rifles have rifling; shotguns do not
- Rifling is a series of parallel spiral grooves cut the length of the bore
    - Metal left between the grooves are the lands
    - Number can vary from 2-20
- Rifling imparts a rotational spin on the bullet as it travels down the barrel. The spin imparted to the bullet stabilizes its flight through the air, preventing it from tumbling. (Think about a football pass)
- The spin does not stabilize the bullet in the body. Upon entering the body, a bullet begins to yaw (rotate off its axis). If the wound path is long enough, the bullet may flip 180 degrees and travel base forward.
- Polygonal rifling - the bore of the weapon has a rounded rectangular profile. Ballistic comparison of bullets fired from weapons with polygonal boring may be very difficult.

Regular rifling Polygonal rifling

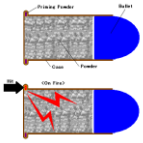
Caliber – Handguns and Rifles

- Theoretically is the diameter of the bore measured from land to land; often not followed
    - Examples: .38Special is .357; .30-06 refers to year of adoption - 1906
- European System: bullet diameter and the cartridge case length 7.62 x 39; often not followed
- Magnum: extra powerful loading in rifles and handguns; increase weight of pellets shotguns
- In shotguns, instead of caliber, gauge is unit of measure: gauge = number of lead balls the diameter of the barrel that adds up to one pound

Ignition

The primer is located at the base of the cartridge. When struck by the firing pin, it ignites, igniting the main powder charge in the cartridge case. Cartridges for rifles and handguns are said to be either **rimfire or centerfire.** This refers to the location and nature of the primer. In r**imfire ammunition** the rim along the base of the cartridge is filled during manufacture with an impact-sensitive primer. When the rim is then crushed by the hammer or firing pin, the primer detonates and ignites the powder charge. In **centerfire ammunition**, the primer is a small brass or copper cup, located in the center of the base of the cartridge case. It contains a stable but

shock-sensative explosive mixture. When the hammer or firing pin strikes the primer, it detonates this material igniting the gunpowder.



Rimfire

Centerfire

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MAIN TYPES OF COMMON FIREARMS

- Handguns
- Rifles
- Shotguns

Handguns

- Rifled barrels
- Muzzle velocities of 750 - 1400 f/s (low velocity)
- Kinetic energy 64 – 550 ft-lbs (low energy)
- Lead or jacketed bullets
- Handguns can be divided into two general categories:
    - Revolvers - cartridges are carried in a cylinder which is rotated by pulling the trigger; most revolvers 5-6 rds
    - Semi-automatic pistols with removable magazines; 7-15 rds

Rifles

- Rifled barrels
- Can be centerfire or rimfire
    - Centerfire
        - Muzzle velocities > 2200 f/s (high velocity)
        - Kinetic energy 1050 – 2500 ft-lbs (high energy)
        - Semi-jacketed or full metal jacketed bullets
    - Rimfire
        - Bullet weight 29-40 gr; 30-50 gr Magnum
            - .22 Short, Long, Long Rifle and Magnum
        - Velocity 830 – 1750 f/s; 1650 – 2200 f/s Magnum
        - Muzzle energy 44 - 200 ft-lbs; 300-325 ft-lbs Magnum Muzzle velocities
        - Similar wound patterns to handguns

Shotguns

- Smooth bore
- Fires multiple pellets down the barrel
- Velocities <1400 f/s
- Pellets are round, usually lead, may be steel or other metals
- Lethal effect is due to multiple pellet hits

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THEORY OF WOUNDING

The extent of injury from a bullet is due to:

1. the mechanical **shredding and crushing of tissue** by the bullet as it perforates the tissue
2. shearing, compression and stretching injuries to the tissue due **to temporary cavity** formation
3. secondary injuries due to **breakup of the bullet**

The location, size, and the shape of the temporary cavity in a body depend on the nature of the bullet, the amount of kinetic energy lost by the bullet in its path through the tissue, how rapidly the energy is lost, and the elasticity and cohesiveness of the tissue. The maximum diameter of the cavity occurs at the point at which the maximum rate of loss of kinetic energy occurs. This occurs at the point where the bullet is at maximum yaw, i.e., turned sideways (at a 90° angle to the path) and/or when it fragments.

The temporary cavity will undulate for 5 to 10 msec before coming to rest as a permanent track. Positive and negative pressures alternate in the wound track, with resultant sucking of foreign material and bacteria into the track from both entrance and exit and ejection of blood and tissue. The expanding walls of the temporary cavity are capable of doing severe damage. There is compression, stretching and shearing of the displaced tissue. Injuries to blood vessels, nerves, or organs not struck by the bullet, and a distance from the path, can occur, as can fractures of bones (rarely).

The size of both the temporary and the permanent cavities is determined not only by the amount of kinetic energy deposited in the tissue but also by the density and elastic cohesiveness of the tissue. Maximum expansion of the cavity does not occur until after the bullet has passed through the target.

In the case of handgun bullets, the bullet produces a direct path of destruction with very little lateral extension within the surrounding tissues, i.e., only a small temporary cavity is produced. As a general rule, the temporary cavity plays little or no role in the extent of wounding. Neither does breakup of the bullet.

In the case of centerfire rifle bullets, the two most important factors in determining the extent of injury are the temporary cavity and breakup of the bullet. Rifle bullets fall into two general categories: hunting bullets and military bullets. Hunting bullets are designed to expand. In the

process at least some fragmentation of the bullet occurs. Thus, with this type of bullet, wounding is due to the combination of the crushed and shredded tissue generated by the bullet perforating tissue, the effects of the temporary cavity on tissue adjacent to the bullet path (shearing, compression, and stretching) and secondary injuries due to fragmentation of the bullet

In the case of full metal-jacketed, non-deforming, bullets such as occur in military ammunition, wounding is due to the combination of the crushed and shredded tissue generated by the bullet perforating tissue, and the effects of the temporary cavity on tissue adjacent to the bullet path (shearing, compression, and stretching). Injury due to breakup of the bullet does not ordinarily occur. The exception is the 5.56 x 45 mm (.223) M-16 round. The maximum disruption of tissue with military bullets occurs at the point yawing of the bullet causes the maximum presentation of the surface area of the bullet to the tissue, i.e at 90 degrees yaw.

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RANGE OF FIRE

Close Range

Contact Wounds

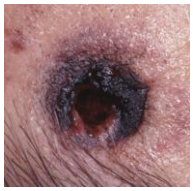
A **contact wound** is one in which the muzzle of the weapon is held against the body at the time of discharge. In contact wounds gas, soot, metallic particles avulsed from the bullet by the rifling, vaporized metal from the bullet and cartridge case, primer residue, and powder particles are all driven into the wound track along with the bullet. In **hard contact wounds**, the muzzle of the weapon is held very tightly against the skin, indenting it so that the skin envelopes the muzzle at the time of discharge. All the materials emerging from the muzzle will be driven into the wound, often leaving very little external evidence that one is dealing with a contact wound. Inspection of the entrance, however, will usually disclose searing and powder blackening (soot) of the immediate edge of the wound. A **loose-contact wound** is produced when the muzzle of the weapon is held in very light contact with the skin at the time of discharge. The skin is not indented by the muzzle. Gas preceding the bullet and the bullet itself can indent the skin, creating a temporary gap between the skin and the muzzle through which gas can escape. Soot carried by the gas is deposited in a band around the entrance. This soot can be easily wiped away.

Contact wounds in regions of the body where only a thin layer of skin and subcutaneous tissue overlies bone usually have a **stellate** or cruciform appearance that is totally unlike the round or oval perforating wounds seen in other areas. The most common area in which stellate wounds occur is the head. The unusual appearance of contact wounds over bone is due to the effects of the gas of discharge. When a weapon is fired, the gases produced by the combustion of the propellant emerge from the barrel in a highly compressed state. In hard contact wounds, they follow the bullet through the skin into the subcutaneous tissue where they immediately begin to expand. Where a thin layer of skin overlies bone, as in the head, these gases expand between the skin and the outer table of the skull, lifting up and ballooning out the skin. If the stretching exceeds the elasticity of the skin, it will tear. These tears radiate from the entrance, producing a stellate or cruciform appearing wound of entrance. The presence of tearing of the skin as well as its extent depends on the caliber of the weapon, the amount of gas produced by the combustion

of the propellant, the firmness with which the gun is held against the body, and the elasticity of the skin. In some contact wounds over bone, instead of the classical stellate or cruciform wound, one finds a very large circular wound with ragged, blackened, and seared margins. In contact wounds, muscle surrounding the entrance may have a cherry-red hue, due to carboxyhemoglobin and carboxymyoglobin formed from the carbon monoxide in the muzzle gas.

In contact wounds of the trunk, stellate or cruciform entrances in the skin usually do not occur, even when the weapon and ammunition used produce large volumes of gas, because the gas is able to expand into the abdominal cavity, chest cavity, or soft tissue.

In contact gunshot wounds in areas where only a thin layer of skin overlies bone (usually the head), the gas expanding in the subcutaneous tissue may produce effects other than tearing of the skin. The ballooned-out skin may slam against the muzzle of the weapon with enough force to imprint the outline of the muzzle on the skin. Such imprints may be extremely detailed. Imprints of the muzzle of the weapon occur not only in regions where a thin layer of skin overlies bone but also in the chest and abdomen.


Soot and searing


Stellate wound


Muzzle imprint

Near-Contact Wounds

A near contact wound is in a gray zone between contact and intermediate-range wounds. There is an overlap between the appearance of near- and loose-contact wounds making it difficult to differentiate the two. In near-contact wounds, the muzzle of the weapon is not in contact with the skin, being held a short distance away. The distance, however, is so small that the powder grains emerging from the muzzle do not have a chance to disperse and mark the skin, producing the powder tattooing that is the sine qua non of intermediate-range wounds. In near-contact wounds, there is an entrance wound, surrounded by a wide zone of powder soot overlying seared, blackened skin. The zone of searing is wider than that seen in a loose-contact wound. The soot in the seared zone is baked into the skin and cannot be completely wiped away. Small clumps of unburned powder may be present in the seared zones.


Near Contact Wound

Intermediate Range

An **intermediate-range gunshot wound** is one in which the muzzle of the weapon is away from the body at the time of discharge yet is sufficiently close so that powder grains emerging from the muzzle strike the skin producing powder tattooing; this is the sine qua non of intermediate-range gunshot wounds. In addition to the powder tattooing, there may be blackening of the skin or material around the entrance site from soot produced by combustion of the propellant. The

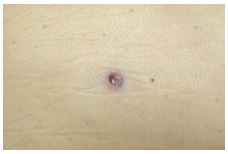
size and density of the area of powder blackening vary with the caliber of the weapon, the barrel length, the type of propellant powder, and the distance from muzzle to target. As the range increases, the intensity of powder blackening decreases and the size of the soot pattern area increases. For virtually all handgun cartridges, soot is absent beyond 30 cm (12 in.).

Powder tattooing

Although soot usually can be wiped away either by copious bleeding or intentional wiping, powder tattooing cannot. Tattooing consists of numerous reddish-brown to orange-red, punctate lesions surrounding the wound of entrance. Powder tattooing is due to the impact of unburned, partially burned, or burning powder grains onto and into the skin. *GENERALLY*, for centerfire handgun cartridges, flake powder produces powder tattooing out to 18 to 24 in. (45 to 60 cm); cartridges loaded with flattened ball out to 30 to 36 in. (75 to 90 cm), and cartridges loaded with true or spherical powder out to 36 to 42 in. (90 to 105 cm). In contrast, .22 Long rifle cartridges produces powder tattooing out to 18 to 24 in. (45 to 60 cm) with flake powder and 12 to 18 in. (30 to 45 cm) with ball powder. The maximum range at which tattooing occurs, as well as the size and density of the powder tattoo pattern, depends not only on the form of the powder but on a number of other variables, including the barrel length, the caliber, the individual weapon, and the presence of intermediary objects such as hair or clothing that will absorb some or all of the powder grains. The greater the range, the larger and less dense the powder tattoo pattern.

Not close Range

In **distant gunshot wounds**, the muzzle of the weapon is sufficiently far from the body so that there is neither deposition of soot nor powder tattooing. For centerfire handguns, distant gunshot wounds begin beyond 24 in. (60 cm) from muzzle to target for cartridges loaded with flake powder and beyond 42 in. (105 cm) for cartridges loaded with ball powder. The exact range depends on the particular weapon and ammunition and can be determined exactly only by experimentation with the specific weapon and ammunition. These wounds usually demonstrate none of the characteristics described above, though irregular, cruciform, or stellate entrance wounds can occur in individuals shot at distant range, where gas plays no role in the production of a wound. These occur when the bullet perforates the skin over a bony prominence or curved area of bone covered by a thin layer of tightly stretched skin. The head is the most common site for such wounds. The forehead as it slopes back at the hairline; the top and back of the head; the supraorbital ridges and the cheek bone are common sites



Chest

Top of the head

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ENTRANCE AND EXIT WOUNDS

Entrance Wounds

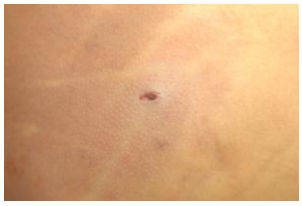
Traditionally, entrance wounds are said to be round to oval in configuration with a reddish, reddish-brown margin of abraded skin — the abrasion ring. In fact, entrance wounds are more varied in their appearance in that they may have a punched out appearance with no abrasion ring. There may also be small tears of the skin margin – micro-tears.

The traditional explanation for the abrasion ring was that as the bullet indents and pierces the skin, the bullet abrades, ("rubs raw") the edges of the hole. High-speed photography, however has demonstrated that the abrasion ring was not caused by friction or overstretching, but by superficial tissue particles being thrown back against the direction of the fire, i.e. the material from the edge of the entrance wound is ejected backwards against the line of fire. As the bullet enters the skin the skin is radially accelerated and displaced centrifugally, so that for a short time the wound is larger than the caliber of the bullet.

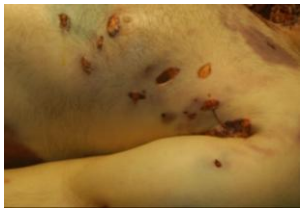
Exit wounds

Exit wounds are typically larger and more irregular than entrance wounds and, with rare exception, do not possess an abrasion ring. Exit wounds can be stellate, slit-like, crescent, circular, or completely irregular. The larger but more irregular nature of exit wounds is due to two factors. First, the spin that stabilized the bullet in the air is not effective in tissue because of the greater density of the tissue. Thus, as the missile travels through the body, its natural yaw is accentuated; if it travels through enough tissue it will eventually tumble ending up traveling base first. Second, the bullet may be deformed in its passage through the body. Both factors result in the presentation of a larger area of bullet at the site of exit, with resultant larger and more irregular exit wounds.

Exit Wound



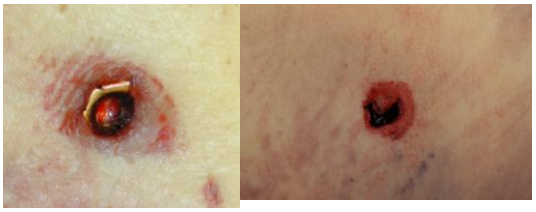
Exit Wound



Multiple Exit Wounds

In unusual circumstances, exit wounds will have abraded margins. These are called **shored exit wounds**. They are characterized by a broad, irregular band of abrasion of the skin around the exit. In such wounds the skin is reinforced, or "shored," by a firm surface at the instant the bullet exits. Thus, individuals shot while lying on the floor, leaning against a wall, or sitting back in a chair may have shored exit wounds. As it exits, the bullet everts the skin, with the everted margin

impacting against the wall, floor, or back of a chair, thus being abraded or "rubbed raw." Shored exit wounds can also occur from tight supportive garments, such as girdles, brassieres, and belts, as well as from tight clothing.



Shored Exits

Other Wound Types

A **graze** wound is one in which a bullet strikes the skin at a shallow angle, producing an elongated area of abrasion without actual perforation or tearing of the skin. In a tangential wound, the injury extends down through to the subcutaneous tissue. The skin is torn, or "lacerated," by the bullet.

Superficial perforating wounds are shallow through-and-through wounds where the bullet passes just under the skin and in which the entrance and exit are close together.

Re-entry wounds occur when a bullet has passed through one part of the body and then reentered another part. The portion of the body initially perforated serves as an intermediary target. Most commonly, this occurs when a bullet perforates an arm and enters the thorax. The reentry wound is usually characterized by a large irregular entrance hole whose edges are ragged and a wide, irregular abrasion ring

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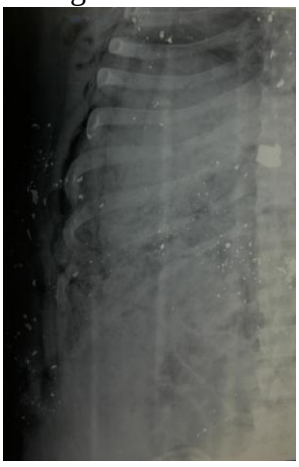
RIFLE WOUNDS

In the case of centerfire rifle bullets, the two most important factors in determining the extent of injury are the temporary cavity and breakup of the bullet. Rifle bullets fall into two general categories: hunting bullets and military bullets. Hunting bullets are designed to expand. In the process at least some fragmentation of the bullet occurs. Thus, with this type of bullet, wounding is due to the combination of the crushed and shredded tissue generated by the bullet perforating tissue, the effects of the temporary cavity on tissue adjacent to the bullet path (shearing, compression, and stretching) and secondary injuries due to fragmentation of the bullet. In the case of full metal-jacketed, non-deforming, bullets such as occur in military ammunition, wounding is due to the combination of the crushed and shredded tissue generated by the bullet perforating tissue, and the effects of the temporary cavity on tissue adjacent to the bullet path (shearing, compression, and stretching). Military bullets, by virtue of their full metal jackets, tend to pass through the body intact, thus producing less extensive injuries than hunting ammunition. Military bullets usually do not fragment in the body or shed fragments of lead in their paths. Because of the high velocity of such military rounds as well as their tough construction, it is possible for such bullets to pass through more than one individual before coming to rest. These bullets may be almost virginal in appearance after recovery from the body.

Range of Fire

In some contact rifle wounds of the head, the entrance may be difficult to locate because of the massive destruction. Contact wounds of the chest and abdomen do not have the dramatic external appearance of such wounds in the head. The wound of entrance is typically circular in shape and usually larger in diameter than those due to pistol bullets. There is almost never tearing of the skin due to gas. The edges of the wound are seared from the effect of the hot gases of combustion. Powder soot is deposited in and around the wound. The amount of soot, however, is less than that seen with most handguns. The imprint of the muzzle of the weapon is commonly present. In contrast to their benign external appearance, contact centerfire rifle wounds of the chest and abdomen produce massive internal injuries.

In intermediate-range gunshot wounds, powder tattooing is present around the wound of entrance. Intermediate range and distant head wounds show a wide degree of severity, depending on the style of bullet and the entrance site in the head. The range out to which powder tattooing occurs from centerfire rifles depends on the physical form of powder in the cartridge cases. Two forms of powder are used in centerfire rifles cartridges manufactured in the U.S.: ball and cylindrical powder. Cartridges loaded with cylindrical powder produce tattooing out to 12 -18 in. Powder tattooing caused by ball powder extends to 2-3 feet.



Distant entrance wounds of the trunk inflicted by centerfire rifle bullets often appear similar to those produced by handgun bullets.

X-rays of individuals shot with hunting ammunition usually show a characteristic radiologic picture that is seen almost exclusively with this form of rifle ammunition—the so-called **"lead snowstorm."** As the expanding hunting bullet moves through the body, fragments of lead break off the lead core and are hurled out into the surrounding tissues. An x-ray shows scores, if not hundreds, of small radiopaque bullet fragments scattered along the wound track (the lead snowstorm). These fragments vary from dust-like to large irregular pieces of metal. A rifle bullet does not have to hit bone for this phenomena to occur. Absence of such a picture does not absolutely rule out the possibility. The lead snowstorm from hunting ammunition is dependent on the velocity of the bullet.

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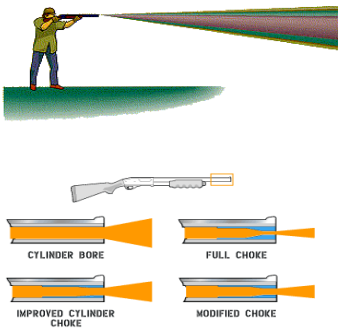
SHOTGUN WOUNDS

Rifles and handguns fire a single projectile down a rifled barrel. Shotguns have a smooth bore. Although they can fire a single projectile, they are usually employed to fire multiple pellets. The archaic term "gauge" is used to describe the caliber of the shotgun. This term refers to the number of lead balls of the given bore diameter that make up a pound. In 12-gauge for example, it would take 12 of the lead balls to make 1 lb.

Gauge	Bore Diameter (inches)
10	0.775
12	0.729
16	0.662
20	0.615
28	0.550
.410	0.410

Most shotgun barrels have some degree of "choke," that is, a partial constriction of the bore of a shotgun barrel at its muzzle so as to control shot patterns. The choke may be permanent and built into the barrel or the barrel may accept choke tubes that when screwed into the muzzle determine the choke of the barrel.



Winchester, Federal and Remington wads

Shotgun shells consist of a plastic body (the tube); a thin brass or brass-coated steel head; a primer; powder; shot and wading. The wading can be either paper/composite or plastic.

Shotgun pellets fall into two general categories: birdshot and buckshot. Birdshot is used for birds and small game; buckshot is used for large game such as deer. Shot size generally ranges from #12 to 000 Buck; the smaller the shot number, the greater the pellet diameter. Lead birdshot ranges from #12 (0.05 inches in diameter) to BB (0.18 inches). Buckshot is usually manufactured in seven sizes, ranging from No. 4 (0.24 in.) to 000 (0.360 in.). The buckshot in a shell is usually packed in granular white polyethylene filler. This filler cushions the shot pellets on firing, reducing shot distortion and improving the shot pattern. The granulated filler is of interest to the forensic pathologist in that it can produce stipple marks (pseudo-tattooing) on the skin identical in appearance to powder tattoo marks.

Shotgun slugs are used for deer and bear hunting in heavily populated areas where the slug's rapid loss of velocity allegedly affords greater protection from shooting mishaps. The wound of entrance from a shotgun slug is circular in shape with an abraded margin. Shotgun slugs produce massive internal injuries comparable in severity to those produced by a centerfire rifle hunting bullet.

Foster, Brenneke and sabot slugs

At close range, the shotgun is the most formidable and destructive of all small arms. For birdshot and buckshot loads, the severity and lethality of a shotgun wound depends on the number of pellets that enter the body, the organs struck by the pellets and the amount of tissue destruction. Like handgun bullets, the extent of tissue destruction from each individual pellet is limited to that tissue they physically shred. Temporary cavities play no significant role in injury.

Contact shotgun wounds of the head are among the most mutilating of firearm wounds. Extensive destruction of bone and soft tissue structures with bursting ruptures of the head are the rule rather than the exception. The severity of the injuries in contact wounds of the head is due to two factors: the charge of shot entering the skull and the gas from combustion of the propellant. Most contact shotgun wounds of the head are suicidal in origin. Intermediate-range and close-range shotgun wounds of the head are almost as mutilating as contact wounds because the pellets are still traveling in a single mass.

Contact wounds of the trunk appear relatively innocuous when compared with the massive destruction produced by such wounds in the head. The wound of entrance will be circular in shape and will have a diameter approximately equal to that of the bore of the weapon. In hard-contact wounds, no soot surrounds the entrance site, but the edges of the wound will be seared and blackened by the hot gases.

As the range increases beyond one to two cm from the muzzle to target, powder tattooing will occur. Powder tattooing from a shotgun is less dense than the tattooing a handgun produces at the same range due to more complete consumption of powder caused by the greater barrel length. The maximum range out to which powder tattooing occurs from a shotgun depends to a great degree on the type of powder, i.e., ball or flake. In shotgun shells loaded with flake powder,

powder tattooing was present out to 24 in. (60 cm) but disappeared by 30 in. (75 cm). Using the same weapon and firing cartridges loaded with ball powder, definite tattooing was present at 30 in. (75 cm), with a very few marks present at 36 in. (90 cm), but absent by 40 in. (125 cm).

As the muzzle of the shotgun is moved farther from the body, tattooing disappears and the diameter of the circular wound of entrance increases in size until a point is reached where individual pellets begin to separate from the main mass. From contact to 2 ft, birdshot fired from a shotgun, generally produces a single round entrance wound. By 3 ft, the wound widens and the edges of the wounds will have scalloped margins. By 4 ft, scattered satellite pellet holes are present around the main entrance. By 6 to 7 ft, there is a definite cuff of satellite pellet holes around a slightly irregular wound of entrance. Beyond 10 ft, there is great variation in the size of the pellet pattern depending on the ammunition used, the choke of the gun and most important, the range. At the same range, the pattern for different guns and brands of ammunition may vary from a central irregular perforation with numerous satellite wounds to a pattern of multiple individual pellet wounds. In all deaths from shotgun wounds, the size of the shot pattern on the body should be measured so that the range can be determined accurately. The range determinations by size and appearance of pattern given should be used only as a rough guide in estimating range. The only reliable method of determining range is to obtain the actual weapon and the same brand of ammunition used and then conduct a series of test shots so as to reproduce on paper the pattern of the fatal wound on the body.

At close range, when there is only a single large wound of entrance, the wad from a shotgun shell will be found inside the body. Depending upon the range of fire, as the wad enters the body, the individual arms or "petals" that have peeled back in flight may produce a patterned abrasion around the wound of entrance. These petal marks can occur even if the entrance site is covered with clothing. In 12, 16, and 20 gauges, one will have a circular wound of entrance in the center of a Maltese Cross abrasion. In .410 gauge, shot cups have only three petals; thus, three equally spaced rectangular abrasions radiate from the entrance rather than four. Petal marks are seen at ranges between 1 and 3 ft for 12, 16 and 20-gauge shotguns. Before 1 ft of range, the petals usually have not opened up sufficiently to mark the skin. By one foot, they will have. The increasing air resistance bends the petals back so that after 3 ft they are generally flush with the sides of the wad base and no petal marks are produced.

Shot charges may strike an intermediary target, e.g., glass with a resultant increase in the dispersion of the shot. This occurs secondary to the "billiard ball" effect. Here, the first pellets striking the intermediary target are delayed, allowing the following pellets to catch up and impact the first pellets, causing dispersion of the pellets. If an intermediary target is of sufficient thickness to cause dispersion of pellets prior to striking an individual, estimates of the range from the pattern on the body will be erroneous unless the effects of the dispersion are taken into account.

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OTHER ISSUES

Caliber Determinations

The caliber of the bullet that caused an entrance in the skin cannot be determined by the diameter of the entrance. The size of the hole is due not only to the diameter of the bullet but also to the elasticity of the skin and the location of the wound. An entrance wound in an area where the skin is tightly stretched will have a diameter different from that of a wound in an area where the skin is lax. Similarly, the size of an entrance in bone cannot be used to determine the caliber of the bullet that perforated the bone though it can be used to eliminate bullet calibers.

Cylinder Gap

When a revolver is fired, gas, soot, and powder emerge not only from the end of the muzzle but also from the gap between the cylinder and the barrel. This material emerges, fan-like, at an approximate right angle to the long axis of the weapon. If the revolver is in close proximity to the body at the time of discharge, there may be searing of the skin, deposition of soot or even powder tattooing from gas and powder escaping from the cylinder gap. The tattooing will be relatively scant.

Ricochet Bullets

Entrance wounds due to ricocheting bullets tend to be atypical due to the fact that the bullet has been destabilized, and is yawing or tumbling secondary to the act of ricocheting. This destabilized bullet then produces an irregular entrance wound. While most ricocheting bullets suffer only a small loss in velocity they are invariably destabilized with resultant rapid loss of velocity and reduced penetration in a body. The reduced penetration is due to a combination of reduced velocity at impact and premature/accelerated yawing in the body due to the fact that the bullet was yawing on entering. For both solid surfaces and water there is a **critical angle** of impact (incidence) below which a bullet striking a hard surface will ricochet rather than penetrate. The critical angle of impact below which a bullet will ricochet off a hard surface is 10-30 degrees. The bullet will ricochet off the surface at angle less than that of impact. For water, the critical angle is 3-8 degrees with the bullet ricocheting off at angles greater than impact. Ricochet bullets are rarely encountered.